EFFICACY OF AUDITORY-VERBAL THERAPY (AVT) OVER TOTAL COMMUNICATION (TC) FOR LANGUAGE OUTCOMES IN CHILDREN WITH COCHLEAR IMPLANTS: A SYSTEMATIC REVIEW

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ABSTRACT

Children with cochlear implants require intervention for both receptive and expressive language. Auditory-Verbal Therapy (AVT), which primarily focuses on the development of language through the auditory channel, and Total Communication (TC), which allows for the combination of sign, lipreading, and auditory stimuli for language development, are two intervention methods often used for children with CIs. This systematic review presents language outcomes in children using AVT and TC intervention approaches. We hypothesized that the use of AVT would result in better expressive language outcomes compared to the use of TC. We also hypothesized that both intervention approaches would result in equivalent receptive language outcomes. We found that children who received AVT had a higher percentage of favorable outcomes for both receptive and expressive language outcomes compared to children who used TC. Other additional factors were found to be significant for language outcomes such as age at implantation, communication mode, parent/family involvement, age at diagnosis, device differences, additional disabilities, socioeconomic status, and gender. Overall, we found a lack of research literature directly comparing AVT and TC. A large-scale systematic study of the interventions is still needed in order for professionals and families to make firm conclusions on the efficacy of these treatments for children with cochlear implants.

LIST OF ABBREVIATIONS AND SYMBOLS

AVT	Auditory-Verbal Therapy
TC	Total Communication
OC	Oral Communication
CI	Cochlear Implant
ICAVC	International Committee on Auditory-Verbal Communication
NIH	National Institutes for Health
UNHS	Universal Newborn Hearing Screening
ASHA	American Speech-Language Hearing Association
FDA	Food and Drug Administration
CDC	Center for Disease Control
NIDCD	National Institute on Deafness and Other Communicative Disorders
OCEBM	Oxford Centre for Evidence-Based Medicine

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INTRODUCTION

According to the National Institutes of Heath (NIH), two to three of every 1,000 children in the United States are born deaf or hard-of-hearing (2010). Hearing loss can have major effects on child development. Specifically, hearing loss in children typically results in significant delays in language development and academic success (A. Geers, Tobey, Moog, & Brenner, 2008; Tye-Murray, 2004; Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998). Research data suggests the average deaf student graduates from high school with language and academic levels below a fourth-grade reading level (Allen, 1986). Specific delays could include listening, speaking, and literacy skills (Duncan & Rochecouste, 1999; A. Geers et al., 2008; National Institutes of Health, 2010). Evidence has shown early hearing loss identification, proper amplification within 3 months of identification, and intervention within 6 months of identification allows for age-appropriate speech and language milestones by 3 years of age (Fulcher, Purcell, Baker, & Munro, 2012).

Children identified as deaf or hard of hearing early in infancy through Universal Newborn Hearing Screening (UNHS) have shown stronger expressive and receptive language markers, cognitive skills, and social and emotional development (Calderon, 2000; Moeller, 2000; National Institutes of Health, 2010; Pollack, Goldberg, & Caleffe-Schenck, 1997; Yoshinaga-Itano, Coulter, & Thomson, 2000; Yoshinaga-Itano et al., 1998). If a child is identified before the 6-month marker, the gap between language development and cognitive development is less than that for children identified after the marker (Yoshinaga-Itano et al., 1998). Not only will the child display better language and cognition, but a child identified with hearing loss who receives remediation with parent-involvement before six months of age will experience developmentally appropriate emotional and social development (Calderon, 2000). Timeliness in identification of hearing loss permits early initiation of both amplification and intervention (Cole, 1992; Yoshinaga-Itano et al., 2000). Findings have demonstrated that a child enrolled earlier in intervention will consistently perform better than that of a later-enrolled child (Connor, Hieber, Arts, & Zwolan, 2000; Moeller, 2000).

In recent years, there has been a rise in identification of children with hearing loss and a rise in cochlear implantation (Francis, Marlowe, & Niparko, 2010; Williams, Alam, & Gaffney, 2015). According to the American Speech Language Hearing Association (ASHA), a cochlear implant is a complex device that bypasses damaged hair cells within the cochlea by providing stimulation directly to the auditory nerve (American Speech Language Hearing Association, 2013). The cochlear implant has been referred to as the first of its kind as a "neural sensory prosthesis that replaced a human sense" (Svirsky, Robbins, Kirk, & Miyamoto, 2000). The Food and Drug Administration (FDA) approved cochlear implants for children in the early 1990s. Currently there are three manufacturers recognized by the FDA. According to the FDA-approved indications submitted by each manufacturer, in order to receive a CI, children must be 12 months old with profound, bilateral sensorineural deafness (>90 dB) with limited benefit from hearing aids to receive a cochlear implant (Ear, 2015). Despite the approved indications of use, the FDA has allowed for clinician professional judgment to allow for "off-label" usage of the device with the exception of research purposes (Gifford, 2013). Specifically, surgeons have used their clinical judgment to implant children who are younger than 12-months of age.

There are several contraindications for use that focus on the integrity of the inner ear. These include hearing loss originating in the auditory nerve or central auditory pathway, active external or middle ear infections, cochlear ossification preventing electrode insertion, cochlear nerve deficiency, tympanic membrane perforations associated with recurrent middle ear infections, and allergy and/or intolerance of device materials (Gifford, 2013). Other considerations for implantation include chronological age, duration of deafness, medical/radiological information, multiple handicapping conditions, functional hearing, speech and language abilities, family support and structure, expectations of family (parents and child), educational environment, availability of support services, and cognitive learning style (Hellman et al., 1991).

There are several risks that are involved with cochlear implant surgery. Surgical complications requiring revision surgery and the risk for bacterial infections such as meningitis are two such risks (Eter & Balkany, 2009). With the risk for meningitis, national precautions and standards have been established including the Center for Disease Control (CDC)-issued vaccination for Meningitis, recommended for all cochlear implant patients (Advisory Committee on Immunization Practices, 2010). These fears along with the possibility of alternatives, such as hearing aids or sign language, can cause some parents to decide against cochlear implantation.

Other parents, however, see benefits from auditory opportunity for their child with potential verbal communication outweighing the risks of implantation (Sach & Whynes, 2005). In 2012, the National Institute on Deafness and Other Communication Disorders (NIDCD) reported roughly forty percent of children born profoundly deaf receive a cochlear implant, representing a substantial increase from previous years (National

Institute on Deafness and Other Communication Disorders, 2012). Early implantation allows for increased auditory exposure earlier in life before sound deprivation influences critical development periods for language (Caselli, Rinaldi, Varuzza, Giuliani, & Burdo, 2012; Cole, 1992; A. Geers, Nicholas, & Moog, 2007; Marlowe, 1993; Pollack et al., 1997). However, children do not learn to listen simply through this auditory exposure, and must learn to process and incorporate this incoming information into spoken communication (Pollack et al., 1997).

Current research supports early cochlear implantation for increased outcomes in speech perception (Connor et al., 2000; A. Geers, 2004; A. Geers et al., 2008; Hodges, Ash, Balkany, Schloffman, & Butts, 1999; Svirsky, Robbins, Kirk, & Miyamoto, 2000) and expressive and receptive language (Baldassari et al., 2009; Bollard, Chute, Popp, & Parisier, 1999; Brennan-Jones, 2014; Caselli et al., 2012; Connor et al., 2000; Duncan & Rochecouste, 1999; A. Geers, 2004; A. Geers et al., 2007; A. Geers et al., 2008; Nicholas & Geers, 2006; Svirsky, Robbins, Kirk, & Miyamoto, 2000). Language is recognized as the most important outcome measure for benefit from cochlear implantation in children (Svirsky, Robbins, Kirk, & Miyamoto, 2000). In fact, some research has shown children with cochlear implants can achieve a mean rate of language development close to that of children with normal hearing and more than that of deaf children without cochlear implants (Svirsky, Robbins, Kirk, & Miyamoto, 2000). Additionally, it has been found that children with profound prelingual hearing loss who received cochlear implants at an average age of 33 months scored higher language comprehension skills over their peers with hearing aids. They also scored within one standard deviation of their normal hearing peers (Baldassari et al., 2009). Caselli et al. (2012) found evidence for normal acquisition for overall language in children with cochlear implants compared to children with normal hearing who were matched for hearing age. For expressive language, the results of this study revealed word productions for children with cochlear implants comparable to their same-age peers with normal hearing (Caselli et al., 2012). In contrast, two studies found remaining component deficits in language. A study of 4- and 5-year-old children with hearing impairment revealed a deficit in age-appropriate morphemes despite the normal increase in morphemes between the ages of 4 to 5 in their peers with normal hearing (Duncan & Rochecouste, 1999). In addition, a longitudinal study of children who received cochlear implants in their preschool years found deficits in their reading skills persisting from elementary grades to high school despite improved speech perception and overall language scores (A. Geers et al., 2008). Contradicting results appeared in a 1993 study of children with cochlear implants who received auditory-verbal therapy and achieved reading abilities comparable to their normal-hearing peers (Robertson & Flexer, 1993).

Despite the significant evidence to support cochlear implantation for better outcomes in speech and language, a large amount of variability is observed in performance. Considerable differences across study participants are noted in a variety of studies with some children achieving well-above average scores and other receiving significantly poor scores for language outcomes within a single sample (Brennan-Jones, 2014; Eriks-Brophy, 2002; Kaipa & Danser, 2016; Rhoades, 2010). This variability of performance contributes to difficulties establishing an appropriate evidence basis for treatment of language within the CI population (Caselli et al., 2012; A. Geers, 2004; A. Geers et al., 2007; A. Geers, Spehar, & Sedey, 2002).

Considering the above-mentioned less than ideal outcomes after cochlear implantation, professionals must be wary of generalizations regarding the success of these treatments when discussing this option for their patients and their families. According to the Oxman and Group. (2004), professionals should consider the following four factors when making recommendations for treatment after reviewing the evidence:

1. *The trade-offs, taking into account the estimated size of the effect for the main outcomes, the confidence limits around those estimates, and the relative value placed on each outcome.*
2. *The quality of evidence.*
3. *Translation of the evidence into practice in a specific setting, taking into consideration important factors that could be expected to modify the size of the expected effects, such as proximity to a hospital or availability of necessary expertise.*
4. *Uncertainty about baseline risk for the population of interest.*

Ultimately, it is the decision of the parent or caregiver for cochlear implantation or other methods, and the role of professionals to review and analyze the evidence basis regarding the available options for children who are deaf or hard-of-hearing.

In the past, children were diagnosed with hearing loss well into the toddler years but now are being diagnosed within a few months of birth. Consequently, parents are forced to make decisions about their child's method of communication ideally before the child is six months old (Decker, Vallotton, & Johnson, 2012). Along with the limited time to make a decision, parents face pressure to conform to one system or approach of communication (Cole, 1992; Pollack et al., 1997). Professionals must be prepared to aid parents by providing appropriate evidence-based materials and information regarding treatment options. There is evidence to support oral communication (OC) over the use of sign for children with cochlear implants to improve outcomes in speech and language (Connor et al., 2000; Hodges et al., 1999; Percy-Smith, Cayé-Thomasen, Breinegaard, & Jensen, 2010; Watson, Archbold, & Nikolopoulos, 2006).

Aural rehabilitation for the pediatric cochlear implant population consists of several different approaches, some with their own specific therapies identified within each approach. Two major approaches are oral communication (OC) and total communication (TC). OC focuses on the auditory component of communication, and TC includes the simultaneous use of manual and visual components of language. In a longitudinal study of 176 children who received cochlear implants from a single center in the United Kingdom (UK), researchers found a significant correlation between children who were implanted at a younger age and the choice for OC over other modes ($p = 0.001$). These children were more likely to change modes from the use of sign to more oral approaches compared to children who were implanted later (Watson et al., 2006). Research has shown support for the OC approach for higher outcomes in the area of speech perception and expressive and receptive language (Connor et al., 2000; Hodges et al., 1999; Percy-Smith et al., 2010). However, it is unwise to classify children to either approach (OC or TC) based on the fact that they are deaf as other factors such as degree of deafness play a role (Pollack et al., 1997).

With the choice for OC, parents can ascribe to a specific therapy approach. Ling, Pollack, and Beebe as the International Committee on Auditory-Verbal Communication (ICAVC) developed what is now known as the auditory-verbal approach and auditory-verbal therapy (AVT). Early audiologists were instrumental in the development of AVT and have contributed to its wider use (Pollack et al., 1997). The approach was centered around the expectation that young children with hearing impairment can be educated to use even minimal amounts of amplified residual hearing as they learn to listen, process verbal language, and speak (Goldberg, 1993). According to the ICAVC, "the goal of auditory-verbal practice is that children with hearing impairment can grow up in regular learning and living environments that enable them to become independent, participating, and contributing citizens in mainstream society" (Goldberg, 1993), 182). According to Pollack, Goldberg, and Caleffe-Schenck (1993), "hearing is a prerequisite for normal personality development… there is no substitute for hearing, yet we have been trying to educate deaf children without this all important information. Without hearing, it is true the deaf can make an adjustment to the world, but it is not the same world" (19). As the primary sensory modality, audition is essential to AVT and its practice and outcomes, while the use of spoken language nurtures the child's personal, social, and educational development (Ling, 1993; Rotfleisch, 2009). For this approach to produce desired outcomes for oral language, the child must have the appropriate amplification, abundant language stimulation, and adequate opportunities to develop residual hearing (Eriks-Brophy, 2002).

There are two specific goals behind AVT, specifically the integration for personality development of the child and overall social independence (Pollack et al., 1997). The concept of integrating AVT in the personality development of the child is based on the work of Myklebust (1960) who associated sensory deprivation with differences in behavior including personality, realism, and understanding and forming contact with the environment around the child. From this prior research, Pollack et al. (1997) concluded that hearing is required for normal personality development providing a key component to the principles of AVT. The basic principles of AVT are as follows: early identification of hearing impairment and auditory management; appropriate amplification for maximum benefit; familial support and education; listening integration into the child's personality and environment; improving communication for the use of social interaction with models of spoken language and one-to-one teaching; following developmental emergence of listening, speech, and language through auditory, perceptual, linguistic, and cognitive stimulation; ongoing evaluation and prognosis; and supporting mainstreaming and educational integration (Goldberg, 1993; Pollack et al., 1997). The components of an effective and successful auditory-verbal session according to Simser (1993), founding member of ICAVA and past president of Auditory-Verbal International, can be seen in Table 1. The principles and components of AVT cannot be compartmentalized to therapy or education but must become a way of life for the child and family for successful outcomes (Estabrooks, 1993).

Table 1. Components of an effective auditory-verbal therapy session

Components of an effective auditory-verbal therapy session *Adapted from (Simser, 1993), pg. 219*	
Components: integrated into natural, meaningful play activities	**Aspects: planned for and considered**
Amplification check Development of listening skills Speech processing and production Language and cognitive development Communication competence Assessment and setting goals Discussion with parent	Child and parent participation Aims and materials Parent-child-therapist relationship Integration of components Unplanned learning and flexibility Pace and motivation

Overall, the evidence for AVT for the development of language in children with CIs is positive across research studies. In a systematic review of the efficacy of AVT from 1993-2015, fourteen studies were deemed eligible for review according to the inclusion criteria regarding the effects of AVT on one or more of three areas – receptive and expressive language, auditory/speech perception, and mainstreaming (Kaipa & Danser, 2016). The results of this study were positive in all three areas for AVT outcomes of children with CIs (Kaipa & Danser, 2016). In the early beginnings of AVT, Goldberg and Flexer (1993) led a study on its social validity with 157 graduates of AVT programs. Most impressively, 152 of the 157 participants with severe to profound hearing loss stated they completed high school with 95% of the 152 completing post-secondary education. It is interesting to note that approximately 75% of participants identified as part of the "hearing" world when given the option of current participation in the "hearing," "deaf," or both worlds. Goldberg and Flexer (1993) identified the main goal of aural rehabilitation as independent functioning in the community. In order to be qualified as achieving this goal of independent functioning, the participant must be mainstreamed into local schools, attend a post-secondary institution(s), and be involved in typical community activities. If these parameters are truly representative for the goal of aural rehabilitation, then AVT provides the participants the appropriate skills to achieve this goal. In recent years, there has been a rise in the prevalence of AVT for hearing-impaired children. Rhoades (2006) attributed this rise of AVT with young children to early identification through the UNHS, cochlear implantation, and parent Internet communications.

In comparison to AVT, TC includes the simultaneous use of speech and manual components of communication. Tye-Murray (2004) defines the total communication approach as a "combined use of sign and speech," but does not define a separate therapy technique under this approach (529). The goal of both TC and AVT is to expand the speech, listening, and language abilities of the child; however, the emphasis of TC is on overall language development (A. Geers et al., 2002; Pollack et al., 1997). Factors that led to the development of total communication included the limited success of early oral education in its beginnings, lack of knowledge for the use of residual hearing with amplification, minority rights within society and the Deaf culture, and financial resources and implementation (Pollack et al., 1997). In the 1970s, total communication was growing in popularity through government financial support and approval from the deaf community, which sparked its widespread use in the pediatric deaf and hard of hearing population (Pollack, 1993).

Research has been done to support the use of TC and in efforts to increase its use in the deaf and hard of hearing community. In a 2002 study, results suggested children using TC achieve higher auditory speech perception scores and speech intelligibility with better comprehension and syntax than children who used little or no speech. They were also more likely to be mainstreamed (A. Geers et al., 2002). The authors of the study also suggested a circular relationship among speech use, speech intelligibility, speech perception, language comprehension, and language use. Children enrolled in a study of TC in 2000 were reported to have higher scores in receptive spoken vocabulary than children enrolled in an OC program, while the children in the OC program demonstrated higher performance in consonant-production accuracy with higher improvement over time (Connor et al., 2000).

Opinions regarding both AVT and TC remain polarized with passionate arguments for child language success on both sides. Geers and Schick (1988) reported that TC offered exposure to a code allowing for the development of native competence in language in a spontaneous and natural manner over spoken English alone. Soon after, Doreen Pollack in her *Reflections of a Pioneer* (1993) compared TC to “educating all children who wore glasses as if they were blind” (202). Though proponents of each method firmly believe in their respective theories. Research has shown success in both approaches and further research is required to judge which is best for children with cochlear implants in the development of both receptive and expressive language.

The aim of the current study was to demonstrate that children who use CIs and are exposed to auditory-verbal therapy (AVT) will have better expressive language outcomes compared to children who use total communication (TC). A systematic review was used to analyze articles focused on language outcomes to compare and contrast the two approaches for efficacy. As mentioned above, there is limited evidence for the efficacy of each specific approach in comparison to the other. In fact, only one article is known to have directly compared the two approaches for children with cochlear implants alone. Yanbay (2014) compared AVT and TC along with the auditory-oral approach; however, the majority of the current literature studied the approaches separately. As direct-comparison research was limited, we used the research available to infer exploratory hypotheses. Research has shown that improved speech perception skills increase expressive outcomes (Connor et al., 2000; A. Geers, 2004; A. Geers et al., 2008; Hodges et al., 1999; Svirsky, Robbins, Kirk, & Miyamoto, 2000). AVT has been shown to increase speech perception skills (Dettman, Wall, Constantinesu, & Dowell, 2013; Dornan, Hickson, Murdoch, & Houston, 2009; Dornan, Hickson, Murdoch, Houston, & Constantinesu, 2010; Fairgray, Purdy, & Smart, 2010), while TC has not shown such improvement. Therefore, we hypothesized that auditory-verbal therapy would produce greater expressive language outcomes in comparison to total communication therapy within the analyzed research for children with cochlear implants.

As with expressive language, speech perception is related to improvement of receptive outcomes, which again has been shown to benefit from AVT (Tallal, Stark, & Mellits, 1985; Tsao, Liu, & Kuhl, 2004). Also, the additional use of sign language has been shown to bring increases to language for infants and toddlers with typical language development, and TC utilizes sign language for the language intervention (Goodwyn, Acredolo, & Brown, 2000; Thompson, Cotnoir-Bichelman, McKerchar, Tate, & Dancho, 2007). Therefore, we hypothesized that auditory-verbal therapy and total communication therapy would produce equivalent receptive language outcomes within the analyzed research for children with cochlear implants.

METHODS

A systematic review involves combining qualitative data from multiple studies selected through systematic review of available literature in order to provide a summary conclusion. For this study to be completed, a thorough literature search was conducted of available databases for both AVT and TC evidence separately. Once the articles were selected the data was combined and analyzed to address our hypotheses.

Literature Search - Inclusions & Exclusions

Articles were searched within three databases including ASHAWire, PubMed, and EbscoHost from July 25, 2016 to September 1, 2016. To best narrow the available research to relevant articles for our study, keywords were determined based on relevance to the included treatments and the research objectives. The following keywords were used as search parameters: “auditory verbal therapy,” “total communication,” “cochlear implant,” “language,” and “deaf education.” Combinations of keywords used within Boolean operators with corresponding search results can be seen below. In addition, references were gathered from individual articles found within database searches and followed up for potential inclusion. A visual breakdown of the search process can be seen in Figure 1 as a Prisma Flow Diagram (Moher, Liberati, Tetzlaff, Altman, & Group, 2009). After individual analysis, all sources were examined and determined valid or invalid. In determining inclusion, articles were required to be within peer-reviewed journals published prior to search and written in English.

Participants in articles included children with cochlear implants from 0-18 years of age who received speech and language treatment by the auditory-verbal therapy approach or total communication approach. Results of studies included specific language outcomes in receptive and/or expressive domains in relation to a specific approach. Studies including children with hearing aids or other devices within the sample were not included as the purpose of this study was to determine efficacy for children with cochlear implants, specifically. Studies that provided individual data for children with cochlear implants within the sample of children with hearing impairment were included in the primary analysis, and the cochlear implant participant data was extracted and used separately.

Auditory-Verbal Therapy (AVT) Search Results

In ASHAWire, "auditory verbal therapy" and "cochlear implant" and "language" yielded 330 potential sources, and "auditory verbal therapy" and "deaf education" yielded 671. In PubMed, "auditory verbal therapy" and "cochlear implant" and "language" yielded 97 potential sources, and "auditory verbal therapy" and "deaf education" yielded 21. In EbscoHost, "auditory verbal therapy" and "cochlear implant" and "language" yielded 108 potential sources, and "auditory verbal therapy" and "deaf education" yielded 81. After removal of duplicates and irrelevant articles, the above searches were funneled to 93 articles for screening. After removal of articles that did not include specific language outcomes for AVT (n = 68), the above articles were funneled to 26 full-text articles assessed for eligibility regarding the AVT. Studies including assistive devices other than CI (n = 20) were excluded. A total of 6 articles met inclusion criteria for our systematic review of auditory verbal therapy language outcomes.

Total Communication (TC) Search Results

In ASHAWire, “total communication therapy” and “cochlear implant” and “language” yielded 328 potential sources, and “total communication therapy” and “deaf education” yielded 674. In PubMed, “total communication therapy” and “cochlear implant” and “language” yielded 137, and “total communication therapy” and “deaf education” yielded 102. In EbscoHost, “total communication therapy” and “cochlear implant” and “language” yielded 49, and “total communication therapy” and “deaf education” yielded 35. After removal duplicates, irrelevant articles, and articles which did not include specific language outcomes for TC, the above articles were funneled to 37 full-text articles assessed for eligibility regarding the total communication approach. A total of 16 articles met inclusion criteria for our systematic review of total communication language outcomes.

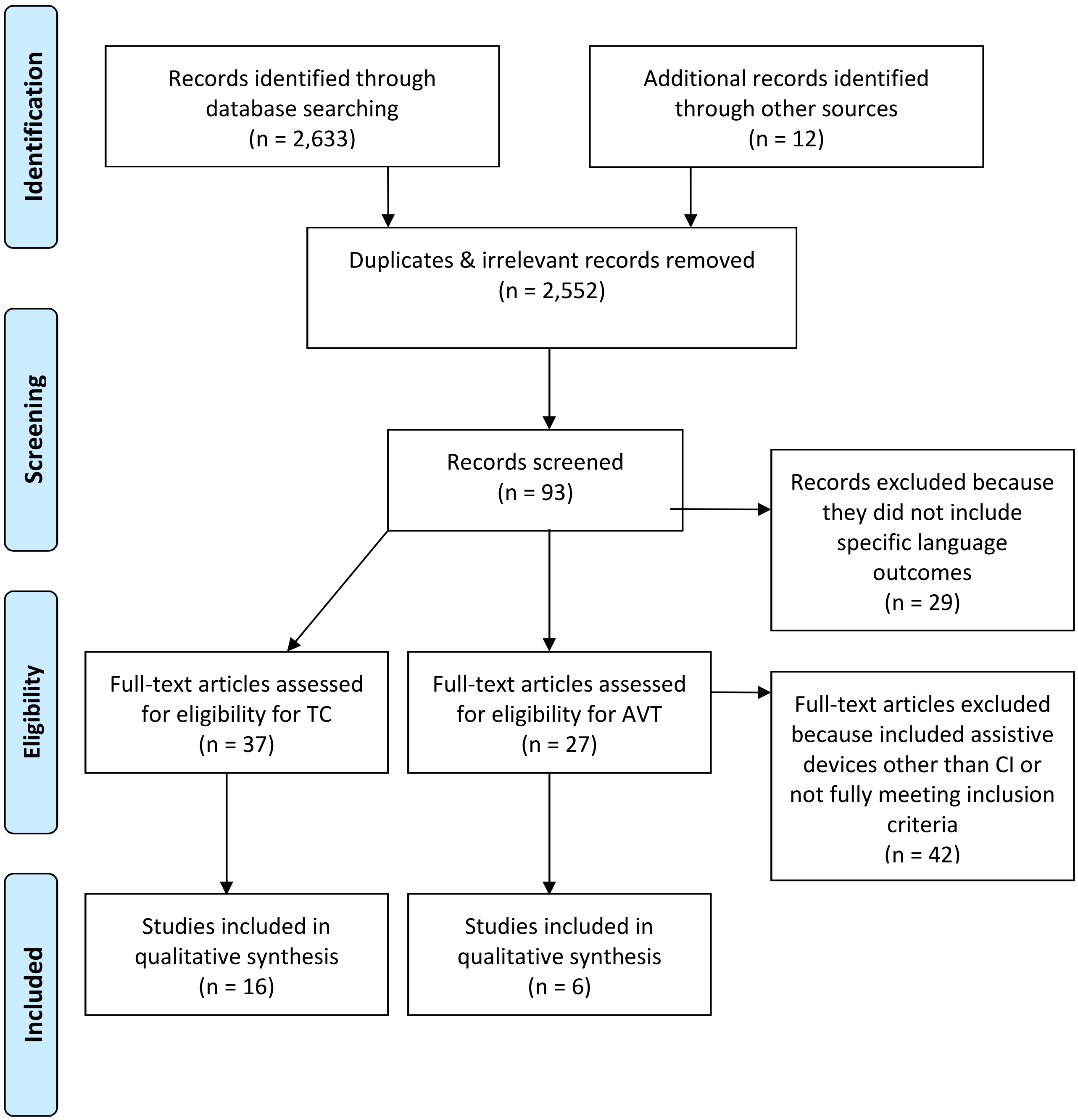
Analysis

The individual sets of articles for both auditory-verbal therapy and total communication were analyzed and compared to determine differences in language outcomes (expressive and receptive) between the two approaches. When specific language outcomes were given for participants, the outcomes for the specific approach group (i.e. AVT or TC) were isolated for comparison. If the article did not separate the outcomes for the approach group, the article was not included in the receptive or expressive language comparisons. Once the language outcomes were compared, significant factors, such as age at implantation or communication mode, were taken from each article and combined to show trends.

Figure 1. Article Search Breakdown as PRISMA 2009 Flow Diagram

PRISMA 2009 Flow Diagram

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). *P*referred *R*eporting *I*tems for *S*ystematic Reviews and *M*eta-*A*nalyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097



Oxford Centre for Evidence-Based Medicine's (OCEBM) Levels of Evidence

The Oxford Centre for Evidence-Based Medicine's (OCEBM) Level of Evidence tool was used to systematically examine the quality of the evidence from the articles used within this study (Phillips et al., 1998). The levels and their definitions can be seen in the Appendix. In summary, the OCEBM includes five levels of evidence with the highest level being a systematic review of homogeneous randomized control trials (level 1a) and lowest being an expert opinion without explicit critical review (level 5). Most of the research studies included in this study fell under level 2c as outcomes research. The U.S. Department of Health and Human Services, Agency for Healthcare Research and Quality described outcomes research by saying it "seeks to understand the end results of particular health care practices and interventions. End results include effects that people experience and care about, such as change in the ability to function" (2000). In fact, all six articles for AVT were outcomes research studies falling in level 2c and receiving a B grade of recommendation from the OCEBM. Nearly all of the sixteen articles for TC were also level 2c studies with the exception of Hasenstab and Tobey (1991) which fell into level 4 as a case-series study. The OCEBM levels of evidence tool is only meant to help define the "likely" best evidence, but the following considerations are mentioned by the authors (Howick et al.) for consideration despite the associated level and recommendation:

1. Do you have good reason to believe that your patient is sufficiently similar to the patients in the studies examined?
2. Does the treatment have a clinically relevant benefit that outweighs the harms?

3. Is another treatment better?

4. Are the patient's values and circumstances compatible with the treatment?

It is important to keep these questions and underlying principles in mind as the results of this systematic review are presented, especially when analyzing outcomes research as it is meant to demonstrate effects of healthcare practice on the patient's wellbeing.

RESULTS

Twenty-two studies were found through systematic review examining language outcomes for children with cochlear implants receiving auditory-verbal therapy (AVT) or total communication (TC). Each article reported different outcome measures using a variety of assessment materials, and consequently, it was not possible to perform reliable statistical analyses. Thus, a qualitative analysis and comparison was completed using the data obtained from each therapeutic approach. Language outcome data extracted from AVT articles is presented in Table 2 and data from TC articles is presented in Table 3.

Receptive Language

Eleven of the 22 articles reported receptive language outcomes for participants with CIs. There was variation in reporting mean age at testing or mean age at cochlear implantation. Also, the outcome measures differed by use of different assessments and different score types (i.e. total language quotient, age-equivalent, etc.). A qualitative summary of receptive language outcomes from the AVT and TC articles is presented below. A qualitative comparison of the two approaches is also provided.

Auditory-Verbal Therapy (AVT).

All six articles for AVT reported receptive language outcomes (Baldassari et al., 2009; Dettman et al., 2013; Fairgray et al., 2010; Hogan, Stokes, & Weller, 2010; Hogan, Stokes, White, Tyszkiewicz, & Woolgar, 2008; Yanbay, Hickson, Scarinci, Constantinesu, & Dettman, 2014). A variety of tests were used among the six articles including the Test for

Auditory Comprehension of Language (TACL), Bracken Basic Concept Scale (BBCS), Peabody Picture Vocabulary Test (PPVT), Clinical Evaluation of Language Fundamentals – 4th Ed. (CELF-4), Preschool Language Scale -3rd Ed. (PLS-3), and Preschool Language Scale – 4th Ed. (PLS-4).

Factors affecting the outcomes from these articles include mean age at implantation, mean age at testing and duration of individual therapy sessions. Four of the six articles reported mean age at testing. The mean age at testing for the 67 participants was 6.3 years with a standard deviation (SD) of 3.1 years. Five of the six articles reported mean age at cochlear implantation of 2.09 years with a SD of 0.76 years. The minimum number of reported therapy sessions was 20, and across the studies, therapy could have taken place within a 6-month period or up to one-year. The articles by Baldassari et al. (2009) and Dettman et al. (2013) did not report durations of intervention.

Four of the six AVT articles revealed receptive language outcomes within one SD of the normal mean or typical language growth (Fairgray et al., 2010; Hogan et al., 2010; Hogan et al., 2008; Yanbay et al., 2014). Fairgray et al. (2010) reported pre- and post-therapy receptive language scores from the CELF-4 *Australian* for five children with CIs who received AVT across 20, 1-hour sessions. The mean age at entry to the program was 10.72 years. A SD was not reported. Before receiving AVT, participants scored a mean core language score of 90.0, and after receiving AVT, they scored a mean core language score of 94.2. Means for both pre- and post-therapy core language scores were within normal limits for children with normal hearing and language development. Means were also derived for the Word Classes subtest of the CELF-4. The receptive Word Classes pre-therapy mean score was 8.2 with a post-therapy mean score of 7.8. Therefore, there was not an increase in receptive ability for word classes with AVT; in fact, the mean score decreased.

Hogan et al. (2008) reported pre- and post-therapy total language scores from the PLS-4 *UK* including receptive outcomes for five children with CIs who received AVT for one year. The mean age at testing for participants was not reported. The researchers used a derived outcome measure developed by Strong, Clark, and Walden (1994) to find the predicted and actual Rate of Language Development (RLD). The RLD represents the age-equivalent language score from the PLS-4 divided by the chronological age of the participant at testing. The researchers predicted language growth by multiplying the initial RLD by chronological age at each testing interval. The final RLD was calculated by subtracting the initial language age-equivalent by the final language age then dividing the difference by the duration of intervention. Typical language growth is represented with an RLD of 1.0 (12 months growth of age equivalent score over 12 months of time). The participants scored a RLD score of 0.2 prior to AVT with a SD of 0.2 and scored a RLD of 1.1 after AVT with a SD of 0.3. Therefore, the participants exceeded not only predicted RLD scores but also typical RLD for children with normal hearing.

Hogan et al. (2010) led a follow-up study to Hogan et al. (2008) looking for an impact of the program Reach Out. This study consisted of 12 children with hearing loss whose families had a household income of less than £30,000 a year (an estimated $46,373 according to the average exchange rate of 2010 from GBP to USD). According to the UK Office of National Statistics (ONS) in 2013, the median household income ranged from £32,600 to £37,900 from 2008-2012. The purpose of the Reach Out study was to dispel the idea that AVT was only available for wealthy families. Of the 12 children included in this sample, five children had CIs and received AVT for a minimum of one year. The researchers used the same outcome measure of RLD used in the previous study. The range of pre-program RLD was 0.0-0.4 and the final range of RLD was 0.8-1.4. Therefore, participants were approaching or exceeded typical RLD of children with normal hearing. The RLD for the previous study could not be compared statistically to this study; however, both studies showed an accelerated RLD compared to children with typical hearing.

Yanbay et al. (2014) reported receptive language scores for 18 children with CIs who received AVT for a minimum of 10 months. The tests used in this study were the PLS-4 and PPVT. The mean age at testing was 3.64 years with a SD of 1.16 years. On the PPVT, the participants scored a mean standard score of 91.14 with a SD of 20.98 and a range of 45-125. For the PLS-4 auditory comprehension measure, the participants scored a mean standard score of 90.78 with a SD of 22.81 and a range of 55-138. The normative sample mean standard score is 100 for both the PPVT and the PLS-4, and the normal SD for this standard score is 15. Therefore, the mean standard scores of the participants for both tests were within one SD of the normative mean, with 57.14% and 55.55% of the participants' scores within one SD of the normative mean for the PPVT and PLS-4, respectively.

The remaining two articles found a delay in age-equivalent versus chronological age for receptive language scores from the TACL and PPVT measures of 1.2 years and 8.4 months, respectively (Baldassari et al., 2009; Dettman et al., 2013). Baldassari et al. (2009) used the TACL and BBCS to report receptive language outcomes on 36 children with CIs and who received AVT. The mean age at testing was 5.5 years. Data was collected retrospectively from a private oral school where children received AVT between 1994-2004. Thirty-one of the participants were given the TACL and scored a mean age-equivalent score of 4.3 years with a SD of 1.6 years. A difference of 1.2 years between mean chronological age and mean language age-equivalent was observed. Twenty-three of the participants were given the BBCS and scored a mean standard score of 84.1 with a SD of 15.0 and a range of 55 to 108. BBCS standard scores in the range of 85 to 115 are associated with typical language development. Therefore, scores for the participants of this study were within one SD of children with normal hearing and language development.

Dettman et al. (2013) reported receptive language using the PPVT scores for eight children with CIs who received AVT. The mean age at testing was 5.4 years with a SD of 1.7 years. The length of AVT intervention was not reported. The participants scored a mean age-equivalent score of 4.7 years with a SD of 2.3 years. A mean delay of 13 months with a SD of 17 months (range from 41 months behind to 27 months ahead of chronological age) was reported. The difference in the mean chronological age and mean language age-equivalent was 8.4 months. The mean rate of language growth was 1.1 years with a SD of 0.3 (range: 0.2-2.4). A mean rate of language growth for a typical child is 1.0 year.

Total Communication (TC).

Five of the 16 articles examining TC reported receptive language scores for children with CIs (Connor et al., 2000; Cullington, Hodges, Butts, Dolan-Ash, & Balkany, 2000; A. E. Geers, Nicholas, & Sedey, 2003; Hasenstab & Tobey, 1991; Robbins, Bollard, & Green, 1999). Other articles did not provide outcome measure data (Boons et al., 2012; Dunn et al., 2014; A. Geers, 2002; Hay-McCutcheon, Kirk, Henning, Gao, & Qi, 2008; Holt & Svirsky, 2008; Kirk, Miyamoto, Ying, Perdew, & Zuganelis, 2000; Miyamoto, Kirk, Svirsky, & Sehgal, 1999, 2000; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000; Tomblin, Barker, Spencer, Zhang, & Gantz, 2005) or provided outcome data for expressive language only (A. Geers et al., 2002). As with AVT, a variety of assessments were used to test for receptive language including the Reynell Developmental Language Scales (RDLS), PPVT- Revised, 3rd Ed., TACL, CELF, PLS-3, and PLS-4. However, a mean age at testing was included for only one TC article reporting receptive outcomes (Cullington et al., 2000). Unlike the AVT articles, duration of treatment using TC was not provided in any of the five articles reporting receptive scores.

Two of the five articles revealed language delays in participant scores (Connor et al., 2000; Cullington et al., 2000). Connor et al. (2000) reported receptive language scores from the PPVT-R/III for 66 children with CIs who used TC. The study was longitudinal with multiple data points. For our analysis, we used the 2 to 3 year interval range post-cochlear implantation where the mean chronological age was 8.6 years. Participants scored a mean age-equivalent for receptive language of 6.1 years for PPVT-R/III. Therefore, a receptive language gap was found between the mean age-equivalent score and the mean chronological age. With similar results, Cullington et al. (2000) reported receptive language scores from the PPVT-III and TACL-R for 12 children with CIs who were using TC in mainstream school settings. The mean age at testing was 11.3 years with a SD of 3.2 years. Participants scored a mean standard score of 65 on the PPVT-III with a SD of 21, yielding a mean language delay of 5.1 years and a SD of 3.9 years. When given the TACL-R, participants had a mean language delay of 5.3 years with a SD of 3.3 years.

Another two of the five articles reported an increase in language scores with the use of TC (Hasenstab & Tobey, 1991; Robbins et al., 1999). Hasenstab and Tobey (1991) reported receptive language scores using the PPVT-R for a single case study of a child with a CI who used TC. The child received a cochlear implant at 5 years, 5 months and was tested 6 months post-implantation. When given the PPVT without signs, the participant scored an age-equivalent score of 2.1 years but increased to 2.2 years when signs were used in conjunction with verbal communication. On a larger scale, Robbins et al. (1999) reported receptive language outcomes on the RDLS for eight children using TC with CIs both before implantation and 6-months post-implantation. The average age-equivalent score at the pre-implant interval was 20 months with a SD of 11 months (1.7 yrs ± 0.9 yrs) and at the 6-months post-implantation interval was 28 months with a SD of 6 months (2.3 yrs ± 0.5 yrs). Therefore, using TC, the children included in this study increased by 8-months in language age over a 6-month time interval with an average learning rate of 125%.

Lastly, Geers, et al. (2003) used the TACL to report receptive language scores on 89 children with CIs who used TC. Participants scored a mean language comprehension score of 15.5 with a SD of 37.0. These scores were well below the normative mean of 50 and SD of 10. Mean age at testing was not reported.

Comparison.

Overall, 11 articles reported receptive language outcomes for children with CIs, with six articles including children using AVT and five articles including children using TC. The mean age at testing for children using AVT was 6.3 yrs ± 3.1 yrs (excluding participants from Hogan et al. (2008) and Hogan et al. (2010) which did not report mean age at testing). Only one TC article reported a mean age at testing for participants, and consequently, a group mean could not be calculated. The mean age at cochlear implantation for children using AVT was 2.09 yrs ± 0.76 yrs (excluding participants from Hogan et al. (2010), which did not report this outcome) and for children using TC was 5.16 yrs ± 1.49 yrs (excluding participants from Geers, et al. (2003), which did not report this outcome). Consequently, a large gap in age at cochlear implantation between samples was observed. This gap in age at cochlear implantation could account for differences in language delay in receptive language outcomes, as seen in TC articles.

Additionally, the most recent article reporting receptive outcomes for TC was published in 2003 (range, 1991-2003) with the most recent article for AVT being published in 2014 (range, 2008-2014). Five articles for AVT were able to report receptive language scores within one SD of the normative mean, while no articles for TC were able to do so (Baldassari et al., 2009; Fairgray et al., 2010; Hogan et al., 2010; Hogan et al., 2008; Yanbay et al., 2014). Again, due to variability in outcome measures and assessment materials, statistical analysis was not completed.

Expressive Language

Nine of the 22 articles for both therapy approaches reported expressive language outcomes. As with receptive language, variation was present in the outcome measures and assessment materials used. Expressive language outcomes are presented for AVT and TC separately below with a qualitative comparison of the two approaches.

Auditory-Verbal Therapy (AVT).

Four of the six articles for AVT reported expressive language outcomes(Fairgray et al., 2010; Hogan et al., 2010; Hogan et al., 2008; Yanbay et al., 2014). Of these four articles, the mean age at testing for the 67 participants was 6.3 years with a SD of 3.1 years (range, 3.64 – 10.72 years). A variety of tests were used among the six articles including the CELF-4 *Australian*, PLS-3, and PLS-4.

All four of the studies found language outcomes or growth to be the same as that observed in typically developing children with normal hearing. Two of the articles reported RLD measures similar to the above receptive language results (Hogan et al., 2010; Hogan et al., 2008). The other two articles reported specific expressive language data (Fairgray et al., 2010; Yanbay et al., 2014). Fairgray et al. (2010) reported expressive language outcomes for the same sample mentioned above using the Australian version of the CELF-4. Means for both pre- and post-therapy core language scores were within normal limits for children with normal hearing and language development. The mean score for the expressive portion of the Word Classes subtest was 8.8 prior to AVT and increased to 9.4 after 20, 1-hour sessions of AVT. Additionally, Yanbay et al. (2014) found expressive communication scores from the PLS-4 to be within normal limits according to typically developing children with normal hearing. The mean standard score reported for expressive communication was 91.71 with a SD of 20.89. This score was within normal limits based on the normative mean (M, 100; SD, 15).

Despite a lack of specific language test scores, Hogan et al. (2008) reported expressive language outcomes for the same sample mentioned above using the UK version of the PLS-3. Participants achieved a RLD score, which included expressive outcomes, of 0.2 with a SD of 0.2 prior to therapy and a RLD of 1.1 with a SD of 0.3 after receiving one year of AVT. A RLD of 1.0 represents typically developing language for children with normal hearing, and consequently, the mean post-therapy score falls within normal limits. In a follow-up study, Hogan et al. (2010) reported updated expressive language RLD scores. Participants achieved a RLD within a range of 0.0 to 0.4 prior to AVT and a range of 0.8 to 1.4 after a year of AVT. These scores approach and exceed the typical RLD.

Total Communication (TC).

Five of the 16 articles for TC reported expressive languages outcomes for children with CIs (Connor et al., 2000; Cullington et al., 2000; A. Geers et al., 2002; A. E. Geers et al., 2003; Robbins et al., 1999). The remaining articles did not report outcomes specific to the TC sample (Boons et al., 2012; Dunn et al., 2014; A. Geers, 2002; Hay-McCutcheon et al., 2008; Holt & Svirsky, 2008; Kirk et al., 2000; Miyamoto et al., 1999, 2000; Svirsky, Robbins, Kirk, Pisoni, et al., 2000; Tomblin et al., 2005) or reported receptive outcome data only (Hasenstab & Tobey, 1991). Of these five articles, two reported a mean age at testing. The mean age at testing was 10.2 years with a SD of 1.5 years. The other three studies were longitudinal in nature or did not report mean age at testing (Cullington et al., 2000; A. Geers et al., 2002). The mean age at cochlear implantation was 4.8 years with a SD of 1.7 years. These data do not include participants from the A. E. Geers et al. (2003) study that did not report mean age at cochlear implantation. A variety of assessment materials were used including language samples, Woodcock Johnson Tests of Cognitive Ability (WJTCA), Grammatical Analysis of Elicited Language (GAEL), Expressive Vocabulary Test (EVT), and RDLS.

Two of the five articles revealed a delay in expressive language compared to children with normal-hearing (Connor et al., 2000; Cullington et al., 2000). Connor et al. (2000) reported expressive language outcomes for 66 children with CIs using TC by the Picture Vocabulary subtest of the WJTCA. For this longitudinal study, the mean age-equivalent expressive language score for the two to three year post-implantation testing session was 6.3 years. The mean chronological age at this testing interval was 8.4 years. Consequently, these data revealed a mean language age delay of 2.1 years. In addition, Cullington et al. (2000) reported expressive language outcomes from the EVT and GAEL of 12 children with CIs who used TC. The mean age of testing was 11.3 years with a SD of 3.2 years. The participants scored a mean standard score of 68 on the EVT with a SD of 18. These scores reveal a language delay of 4.7 ± 3.3 years. The GAEL is a test designed for children with hearing loss and administered during structured play and with pictures. The language scores were obtained from prompted and imitated productions. For the GAEL, the participants in this study scored a mean prompted language quotient of 71 with a SD of 25 and a mean imitated language quotient of 73 with a SD of 28.

In a study by Geers, et al. (2002), data were reported from 22 children with CIs who used TC. Expressive language outcomes were obtained using a 20-minute language sample. The mean age of testing was 9.14 years with a SD of 0.53 years. Participants had a mean use of root words of 0.50 with a SD of 0.38 and a mean use of bound morphemes of 0.10 with a SD of 0.13. However, these scores were not compared to a normative population.

In a more in-depth study, Geers, et al. (2003) reported expressive language outcomes for 89 children with CIs who used TC. In this report, a mean age at testing and a mean age at implantation were not provided. Language outcomes were reported for the child's ability to use speech alone and with the use of speech and sign. For these children, the mean length of utterance when using speech only was 3.3 ± 1.6. This value increased to 4.4 ± 1.8 when speech and sign were conjoined. Mean lexical diversity was 9.6 ± 5.0 when using speech only but increased to 12.0 ± 3.6 when sign was incorporated. Mean use of bound morphemes was 0.05 ± 0.03 with speech only and did not increase with the use of sign. The Index of Productive Syntax (IPSyn) developed by Scarborough (1990) was used to determine the syntactic complexity of the language sample obtained from these children.

The mean IPSyn total score for the speech only interview was 57.3 ± 24.0 and increased to 61.4 ± 17.4 for the simultaneous use of speech and sign. All expressive language components showed increases with the use of speech and sign except the use of bound morphemes.

Robbins et al. (1999) was the only study out of the five to show an increase in rate of expressive language growth while using TC. An expressive language outcome for eight children at two separate intervals – a pre-implant interval and a 6-months post-implantation interval – was reported. The mean age-equivalent score for the RDLS at the pre-implantation interval was 18 months with a SD of 11 months. The mean age-equivalent score 6-months after implantation was 25 months with a SD of 5 months. Therefore, children using TC achieved an average learning rate of 117%. This rate of growth, however, was less than that observed for the growth in receptive language over this time period.

Comparison.

For the nine articles reporting expressive language outcomes for children with CIs, four articles included children who used AVT and five articles included those who used TC. The mean age at testing for children who used AVT was 6.3 yrs ± 3.1 yrs, and for those who used TC was 10.2 yrs ± 1.5 yrs. Three studies did not report age at testing (Connor et al., 2000; A. E. Geers et al., 2003; Robbins et al., 1999). The mean age at cochlear implantation for children using AVT was 2.00 yrs ± 0.92 yrs, excluding Hogan et al. (2010) which provided a range of ages. For children who used TC, the mean age at implantation was 4.8 yrs ± 1.7 yrs, excluding Geers, et al. (2003) which did not report these data. As with receptive language results, a gap can be seen in the mean age at testing and cochlear implantation. Four of the AVT articles reported language to be within normal limits for children with normal hearing. Two of the four reported normal expressive language outcomes (Fairgray et al., 2010; Yanbay et al., 2014), and the other two reported RLD for overall language growth, including expressive outcomes (Hogan et al., 2010; Hogan et al., 2008). The AVT studies produced favorable outcomes for expressive language growth, and only one article of the five that reported data for children who used TC was able to show an increase in expressive language (Robbins et al., 1999).

Table 2. AVT Language Outcomes
*N = number of children included in outcomes

Citation	N	Mean Age at Testing	Age at CI	Language Measure	Tests	Results	SD
Baldassari, et al. (2009)	36	5.5 yrs	2.75 yrs ± 1.27	Receptive	TACL (n=31)	Mean age equivalent score of 51.7	19.7
				Receptive	BBCS (n=23)	Avg. standard score of 84.1	15.0
Dettman, et al. (2013)	8	5.4 yrs ± 1.7	1.7 yrs ± 0.7	Receptive	PPVT	Mean age equivalent score of 4.7 yrs	2.3
Fairgray, et al. (2010)	5	10.72 yrs	2.88 yrs	Receptive Expressive	CELF-4 *Australian*	Mean pre-therapy CORE language score of 90.0	NR
						Mean post-therapy CORE language score of 94.2	NR
Hogan, et al. (2008)	5	NR	2.08 yrs	Receptive Expressive	RLD by PLS-3 UK	Mean pre-program RLD of 0.2	0.2
						Mean program RLD of 1.1	0.3
Hogan, et al. (2010)	5	NR	1.6 yrs – 2.42 yrs	Receptive Expressive	RLD by PLS-4 UK	Range of pre-program RLD of 0.0 - 0.4	NR
						Range of program RLD of 0.8 - 1.4	NR
Yanbay, et al. (2014)	18	3.64 yrs ± 1.16	1.04 yrs ± 0.48	Receptive	PPVT	Mean standard score of 91.14	20.98
				Receptive Expressive	PLS-4	Mean standard score for auditory comprehension of 90.78	22.81
						Mean standard score for expressive communication of 91.72	20.89

*NR = not reported
*Fairgray breakdown in receptive and expressive: Mean score for Word Classes pre-therapy: Receptive (8.2) & Expressive (8.8)
Mean score for Word Classes post-therapy: Receptive(7.8) & Expressive (9.4)

Table 3. TC Language Outcomes

Citation	N	Mean Age at Testing	Age at CI	Language Measure	Tests	Results	SD
Boons, et al. (2012)	166	Long.	2.17 yrs ± 1.08	Receptive	RDLS	Specific Scores for TC Group Not Reported	
				Expressive	SELT		
Connor, et al. (2000)	66	Long.	5.69 yrs ± 2.20	Receptive	PPVT-R/III	Mean age equivalent of 6.1 at a mean chronological age of 8.6 and 2 to 3 yrs post-op	NR
				Expressive	Vocabulary	Mean age equivalent of 6.3 at a mean chronological age of 8.4 and 2 to 3 yrs post-op	NR
Cullington, et al. (2000)	12	11.3 yrs ± 3.2	6.8 yrs ± 2.8	Expressive	EVT	Mean Standard Score of 68	18
						Language Delay in months of 56	39
				Receptive	PPVT-III	Mean Standard Score of 65	21
						Mean Language Delay in months of 61	46
				Receptive	TACL-R	Mean Language Delay in months of 63	39
				Expressive	GAEL	Mean Prompted Language Quotient of 71	25
						Mean Imitated Language Quotient of 73	28
Dunn, et al. (2014)	32	NR		Receptive Expressive	CELF	Specific Scores for TC Group Not Reported	
Geers (2002)	69	9 yr s± 0.17	3.5 yrs ± 0.75	Expressive	Language Sample	Specific Scores for TC Group Not Reported	
				Receptive	TACL-R		
Geers, et al. (2002)*	22	9.14 yrs ± 0.53	3.68 yrs ±0.66	Expressive	Language Sample	Mean use of root words used of 0.50	0.38
						Mean use of bound morphemes of 0.10	0.13
				Receptive	TACL-R	Specific Scores Not Reported	
Geers, et al. (2003)*	89	NR	NR	Expressive	Language Sample	Sp only: Mean Utterance Length of 3.3	1.6
						Sp&Sign: Mean Utterance Lengtsenstab h of 4.4	1.8
						Sp only: Mean Lexical Diversity of 9.6	5.0
						Sp&Sign: Mean Lexical Diversity of 12.0	3.6
						Sp only: Mean of Bound Morphemes of 0.05	0.03
						Sp&Sign: Mean of Bound Morphemes of 0.05	0.03
						Sp only: IPSyn Total Score of 57.3	24.0
						Sp&Sign: IPSyn Total Score of 61.4	17.4
				Receptive	TACL	Mean Language Comprehension score of 15.5	37.0
Hasenstab, & Tobey	1	NR	5 yr, 5 mo	Receptive	PPVT	Age equivalent score of 2.1 yr without signs and 2.2 yr	

(1991)							with signs	
Hay-McCutcheon, et al. (2008)*		10	Long.	4.48 yr ±1.61	Expressive	CELF	Specific Scores for TC Group Not Reported	
					Receptive	RDLS		
Holt, & Svirsky (2008)*		9	7.8 yrs ± 4.3	2.4 ± 1.4 yrs	Receptive	PPVT	Specific Scores for TC Group Not Reported	
					Expressive Receptive	CELF		
					Expressive Receptive	PLS-4		
Kirk, et al. (2000)	CI < 2 yrs	6	NR	1.72 yrs	Receptive Expressive	PPVT-III RDLS	Specific Scores for TC Group Not Reported	
	CI 2-4 yrs	33		3.19 yrs				
	CI ≥ 5 yrs	11		5.78 yrs				
Miyamoto, et al. (1999)*		14	4.5 ± 0.3 yrs	< 3 yrs	Receptive	PPVT-III	Specific Scores for TC Group Not Reported	
		11	4.7 ± 0.1 yrs	3.0-3 yrs, 11 mo	Expressive	RDLS		
		8	4.5 ± 0.2 yrs	4.0-5 yrs, 3 mo				
Miyamoto, et al. (2000)*		14	<3 years	<6 years	Receptive Expressive	RDLS	Specific Scores for TC Group Not Reported	
Robbins, et al. (1999)*		8	Long.	3 yrs, 2 mo	Receptive	RDLS	Average age equivalent score of 20 mo at pre-implant interval	11
							Average age equivalent score of 28 mo at the 6-month interval	6
					Expressive	RDLS	Average age equivalent score of 18 mo at pre-implant interval	11
							Average age equivalent score of 25 mo at the 6-month interval	5
Svirsky, et al. (2000)		11	Long.	NR	Receptive Expressive	RDLS	Specific Scores for TC Group Not Reported	
Tomblin, et al. (2005)		26	Long.	21 mo ± 7 d	Receptive Expressive	PLS-3	Specific Scores for TC Group Not Reported	

N = number of participants using total communication
Long. = Longitudinal data points
*Geers (2002), Hay-McCutcheon, et al. (2008), Holt & Svirsky (2008), Miyamoto, et al. (2000), Robbins, et al. (1999) ages for entire sample, not TC group only

Significant Factors

Specific numeric language scores for receptive and expressive language were not presented in all of the AVT and TC studies. However, each article presented significant factors related to language growth. Significant factors data extracted from AVT articles are presented in Table 4 and in Table 5 for the TC articles. Factors included age at implantation, communication mode, parent/family involvement, age at diagnosis/age at onset, device differences, additional disabilities, socioeconomic status, and gender. The most commonly reported factor was age at implantation with 68.2% of the articles reporting significance for language outcomes.

Age at Implantation.

Fifteen of the 22 total articles (68.2%) reported age at implantation to have a significant effect on language outcomes. The findings for both receptive and expressive language are provided here.

Receptive Language.

Hogan et al. (2008) was the only article of the six AVT articles (16.7%) to report age at implantation as statistically significant for receptive language outcomes. Earlier implantation was associated with better language growth. Six of the 16 TC articles (37.5%) found earlier age at implantation/first fitting to be statistically significant for receptive language (Boons et al., 2012; Connor et al., 2000; Dunn et al., 2014; A. E. Geers et al., 2003; Hay-McCutcheon et al., 2008; Tomblin et al., 2005). It is important to note that Dunn et al. (2014) could not find significant differences between language scores based on age at implantation once children were in the older age range of 10-11 years. The authors explained that the children implanted later (after age 2 but before age 4) were able to show similar growth patterns as the children implanted earlier (before age 2) attained several years of CI experience by age 10 or 11.

Expressive Language.

As with receptive language, only one of the six AVT articles (16.7%) reported age at implantation to be statistically significant for expressive language outcomes (Yanbay et al., 2014). Seven of the 16 TC articles (43.8%) found earlier age at implantation/first fitting to be statistically significant for expressive language (Boons et al., 2012; Connor et al., 2000; A. E. Geers et al., 2003; Hay-McCutcheon et al., 2008; Kirk et al., 2000; Tomblin et al., 2005). As with receptive language, Dunn et al. (2014) did not find significance once the children reached the older age range of 10-11 years.

Communication Mode.

Six of the 22 total articles (27.3%) reported communication mode to be significant for expressive and receptive language outcomes. The articles did not always compare AVT and TC. Some compared oral communication (OC), which is a broader term for approaches focusing on verbal input with similar principles to AVT, with TC. However, Dettman et al. (2013) did compare AVT with auditory-oral (AO) and bilingual-bicultural (BB) approaches and found communication mode to significantly affect PPVT age-equivalent scores ($p = 0.001$) and the delay in months ($p = 0.022$) but not the rate of growth in receptive language.

Receptive Language.

Two of the 16 TC articles (12.5%) reported communication mode as a significant factor for receptive language (Boons et al., 2012; Dunn et al., 2014). Of these two articles, Boons et al. (2012) did not find communication mode to have a significant effect on receptive language until three years after cochlear implantation ($p = 0.006$) and reported specific differences for OC compared to TC ($p < 0.001$) and OC compared to sign language ($p = < 0.001$). The use of OC produced better outcomes. For the TC studies, Connor et al. (2000) reported the effect of TC on receptive spoken vocabulary compared to the use of OC in preschool, early elementary, and middle elementary and found the use of TC within the preschool years produced higher receptive age-equivalent scores ($p \leq 0.05$). For the "Understanding Spoken Paragraphs on the CELF-4, Fairgray et al. (2010) found children who used AVT had a significantly higher scores ($p = 0.043$). No other significant effects were found for the other subtests or core language scores.

Expressive Language.

Three of the 16 TC articles (18.8%) reported communication mode as a significant factor for expressive language development (Connor et al., 2000; A. Geers, 2002; Miyamoto et al., 1999). None of the AVT articles reported communication mode as a significant factor for expressive language outcomes. In addition, the effect of TC for all age groups was significant for better expressive vocabulary scores when compared to OC (Connor et al., 2000). Geers, et al. (2003) examined communication mode's effect on expressive language components such as utterance length, lexical diversity, bound morpheme usage, and syntax.. All of the children who used OC had significantly better outcomes on these language outcomes. Also, the use of OC was found to be a significant predictor of greater spoken language ($p = 0.0001$) and total language ($p = 0.02$) (A. E. Geers et al., 2003). When a child was using TC, Geers, et al. (2002) found the percentage of speech used during a language sample analysis and the TACL significantly affected scores and grammar usage ($p \leq 0.01$). Specifically, sign use was associated with poorer receptive language scores, and speech use was associated with better syntax.

Parent/Family Involvement.

Three of the 22 articles (13.6%) reported increased family involvement to be significant factors affecting language outcomes. Yanbay et al. (2014) was the only AVT study that reported family involvement as having a significant effect on receptive language outcomes. Family involvement was measured using the Family Participation Rating Scale (FPRS) developed by Moeller (2000)where the interventionist designates a global rating for each family. Specifically, the post-implantation PPVT standard scores and PLS-4 Auditory Comprehension standard scores ($p < 0.001$) were significantly better for children who came from families with increased family involvement. Similarly, only one TC study found family involvement to be significant for greater receptive and expressive language outcomes (Boons et al., 2012). Boons et al. (2012) did not find parental involvement as a significant factor for receptive language until two years after cochlear implantation ($p = 0.010$) with a continued effect at three years after cochlear implantation ($p = 0.017$). The expressive language outcomes from this study presented a significant effect of parental involvement for word development at two ($p = 0.005$) and three years ($p = 0.035$) after cochlear implantation but not for sentence development (Boons et al., 2012). Yanbay et al. (2014) was the only AVT article to report family involvement as a significant factor for expressive language outcomes. Post-implantation PLS-4 Expressive Communication standard scores ($p < 0.001$) were better for children with more family involvement. In regards to family involvement, Geers, et al. (2003) examined family size as a significant predictor of both spoken ($p = 0.001$) and total ($p = 0.001$) language with smaller family size producing greater language competence.

Age at Diagnosis.

Three of the 22 articles (13.6%) reported age at diagnosis to be significant for language outcomes. For children who received AVT, Hogan et al. (2008) reported age at diagnosis as a significant factor for receptive language. PLS-4 Auditory Comprehension standard scores were better for earlier age at diagnosis. Furthermore, Yanbay et al. (2014) reported earlier age at diagnosis as a significant factor for expressive language outcomes obtained from the PLS-4. Related to age at diagnosis, Geers, et al. (2003) found that for children who used TC, age at onset was a significant predictor of receptive and expressive language ($p = 0.004$).

Device Differences.

Three of the 22 articles (13.6%) found differences in type of stimulation that children received to have an effect on language outcomes. Specifically, Boons et al. (2012) found children who used bilateral CIs had better receptive and expressive language outcomes compared to children who used a unilateral CI. Also, they found children who used a unilateral CI with contralateral stimulation from a hearing aid performed better than children with a unilateral CI alone. Geers (2002) found children with a larger number of active electrodes within the CI had significantly greater spoken language ($p < 0.01$) and total language ($p < 0.05$) outcomes. A wide dynamic range and optimal loudness growth were also found to be significant for both spoken language and total language (A. Geers, 2002). Furthermore, Connor et al. (2000) reported the use of new technology as a significant factor for both receptive and expressive language outcomes. New technology for the time of the study included the Clarion, Med-El Combi 40+, and Cochlear – Nucleus 24M sound processors compared to the Cochlear - Nucleus 22 sound processor.

Additional Disabilities.

Two of the twenty-two articles (9.1%) reported that additional disabilities had a significant effect on language outcomes. Baldassari et al. (2009), an AVT study, reported that additional disabilities, such as attention-deficient disorder, autism spectrum disorder, apraxia, cerebral palsy, or a developmental delay, significantly decreased language outcomes ($p < 0.05$). Likewise, Boons et al. (2012), a TC study, reported significance of additional disabilities for receptive language and expressive language. In comparison, Geers, et al. (2003) found a higher performance IQ to significantly predict higher scores for spoken ($p = 0.005$) and total ($p = 0.001$) language.

Socioeconomic Status (SES).

Two of the 22 articles (9.1%) reported socioeconomic status (SES) as a significant factor for language outcomes. One article for children who used AVT and one article for children who used TC reported on SES. Hogan et al. (2008) found SES to be a significant factor for PLS-4 receptive scores. Geers, et al. (2003) found SES could predict whether a child would have higher or lower spoken ($p = 0.001$) and total language ($p = 0.0001$), with higher SES correlated with better language outcomes.

Gender.

Geers, et al. (2003) found gender to be a significant predictor of language competence for spoken language ($p = 0.001$) and total language ($p = 0.002$). This was the only study to report a significant effect for gender in all of the 22 articles reviewed. This study reported that girls were more likely to show greater language competence than boys.

Table 4. AVT Significant Variables

Citation	N	Outcome	Variable(s)	Significance P-value
Baldassari, et al. (2009)	36	Test of Auditory Comprehension (TAC)	Children with CI vs HA	<0.05
		Test for Auditory Comprehension of Language (TACL) and Bracken Basic Concept Scale (BBCS)	Age at Implantation*	NS
			Sex	NS
			Ethnicity	NS
			Economic Status	NS
			Etiology of Deafness	NS
			Additional Disabilities	<0.05
Dettman, et al. (2013)	39	Factors related to PPVT age-equivalent scores	Communication Mode (AV, AO, BB) for age-equivalent	0.001
			AV compared to BB	<0.05
			AV compared to AO	NS
			Communication Mode (AV, AO, BB) for delay in months	0.022
			Age of Assessment Difference and Length of Device Experience of AV versus AO, BB groups	0.001
			Communication Mode for Rate of Growth	NS
Fairgray, et al. (2010)	7	Effect of AVT on CELF-4 Outcomes	Concepts and Following Directions (Receptive) Subtest	NS
			Understanding Spoken Paragraphs (Receptive) Subtest	0.043
			Word Classes (Receptive) Subtest	NS
			Word Classes (Expressive) Subtest	NS
			Formulated Sentences (Expressive) Subtest	NS
			Recalling Sentences (Expressive) Subtest	NS
			Core Language Score	NS
		Effect of AVT on HAPP-3 Outcomes	Phonological Processing Error Score	0.028
		Effect of AVT on NZAT (Articulation)	Word Error Score	0.018
		Effect of AVT on WIAT-II (Reading)	Word Reading Subtest	NS
			Pseudoword Decoding Subtest	NS
			Reading Comprehension Subtest	NS
		Effect of AVT on LNT	Improvement of Speech Perception Scores (Easy & Hard)	0.046
			Improvement of Speech Perception Scores on Hard Words	0.018

Hogan, et al. (2008)	37	Effect of AVT on Rate of Language Development (Age Equivalent/Chron.Age)	Compared to typical development of children with hearing impairment	<0.001
		Age at Beginning of AVT	Age of Hearing Aid Fitting	NS
			< 2 years commencement	<0.0001
			2-3 years commencement	<0.01
			> 3 years commencement	<0.01
			Severity of Hearing Loss for children with HA	<0.05
			Severe Hearing Loss compared to other degrees with cochlear implant participants included	<0.01
			Children with CIs compared to children with moderate-severe hearing loss and HAs	NS
		Differences amongst age groups (<2, 2-3, >3)	Pre-program RLD	NS
			Program RLD	NS
		Effects on Rate of Language Development Growth (Pre-program to Program)	Age of Hearing Aid Fitting	NS
			Amplification Type: Hearing Aids group	<0.001
			Amplification Type: Hearing Aids to Cochlear Implant group	<0.001
			Amplification Type: Cochlear Implant group	<0.01
			Difference between RLD at entry and intermediate RLD prior to implantation for HA-CI group	<0.05
			Difference between intermediate RLD and end of therapy RLD	<0.001
			Actual vs. Predicted language age	<0.05
Hogan, et al. (2010)	49	Variables between control group of children with hearing impairment and group of children in Reach Out (low SES) study	IMD Score	<0.005
			Age at Diagnosis	<0.001
			Age at first fitting	<0.01
			Age at start of AVT	NS
			Period of Non-AVT Intervention	NS
			Language Gap at the Start of AVT	NS
			Number of PLS Assessment	NS
			Initial RLDs	NS
			Program RLDs	NS
		Reach Out Study Participant RLD Growth	Mean Initial RLDs & Mean Program RLDs	<0.001
Yanbay, et al.	42	Differences in three groups (auditory oral (AO), auditory	Gender	NS

(2014)		verbal therapy (AVT) and sign and spoken language (SS)) Continuous Variables	Age at Diagnosis of Hearing Loss	NS
			Hearing Loss	<0.05
			Age at Hearing Aid Fitting	NS
			Age at Cochlear Implantation	NS
			Duration of Cochlear Implant Use	NS
			Number of Implants	NS
			Age at Enrollment into Communication Program	NS
			Length of Participation in Communication Program	NS
			Socio-economic Status	NS
			Family Involvement in the Intervention Program	NS
		Factors for Post-Implant PPVT Standard Score	Gender	NS
			Number of Implants	NS
			Socio-economic status	0.03
			Family Involvement	<0.001
		Factors correlated with Age of Diagnosis of Hearing Loss (PPVT)	Age of Hearing Aid Fitting	<0.01
			Age at Cochlear Implantation	<0.01
			Age of Enrollment for AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age at Hearing Aid Fitting (PPVT)	Age at Cochlear Implantation	<0.01
			Age at Enrollment for AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age at Cochlear Implantation (PPVT)	Age of Enrollment for AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age of Enrollment for AVT (PPVT)	of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors for Post-Implant PLS-4 Auditory Comprehension	Gender	NS

		Standard Scores	Number of Implants	NS
			Socio-economic Status	0.04
			Family Involvement	<0.001
			Age at Diagnosis of Hearing Loss	<0.01
			Age at Hearing Aid Fitting	<0.01
			Age at Cochlear Implantation	<0.01
			Age at Enrollment for AVT	NS
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age of Diagnosis of Hearing Loss (PLS-4-AC)	Age at Hearing Aid Fitting	<0.01
			Age at Cochlear Implantation	<0.01
			Age at Enrollment for AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors Correlated with Age at Hearing Aid Fitting (PLS-4-AC)	Age at Cochlear Implantation	<0.01
			Age at Enrollment for AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors Correlated with Age at Cochlear Implantation (PLS-4-AC)	Age at Enrollment for AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age at Enrollment for AVT (PLS-4-AC)	Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Duration of AVT (PLS-4-AC)	Amount of Cochlear Implant Experience	<0.01
			Hearing Loss	NS
		Factors correlated with Amount of Cochlear Implant Experience (PLS-4 -AC)	Hearing Loss	NS
		Factors for Post-Implant PLS-4 Expressive Communication Standard Scores	Gender	NS
			Number of Implants	NS
			Socio-economic Status	NS
			Family Involvement	<0.001

			Age at Diagnosis of Hearing Loss	<0.01
			Age at Hearing Aid Fitting	<0.01
			Age at Cochlear Implantation	<0.01
			Age at Enrollment of AVT	NS
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age at Diagnosis of Hearing Loss (PLS-4-EC)	Age at Hearing Aid Fitting	<0.01
			Age at Cochlear Implantation	<0.01
			Age at Enrollment of AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age at Hearing Aid Fitting (PLS-4-EC)	Age at Cochlear Implantation	<0.01
			Age at Enrollment of AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age at Cochlear Implantation (PLS-4-EC)	Age at Enrollment of AVT	<0.01
			Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Age at Enrollment for AVT (PLS-4-EC)	Duration of AVT	NS
			Amount of Cochlear Implant Experience	NS
			Hearing Loss	NS
		Factors correlated with Duration of AVT (PLS-4-EC)	Amount of Cochlear Implant Experience	<0.01
			Hearing Loss	NS
		Factors correlated with Amount of Cochlear Implant Experience (PLS-4-EC)	Hearing Loss	NS

Table 5. TC Significant Variable

Citation	N	Outcome	Variable(s)	Significance P-value
Boons, et al. (2012)	288	Receptive language at 1 yr after CI	Age at first fitting	<0.001
			Bilateral vs. Unilateral CI	<0.001
			Unilateral CI with contralateral HA vs. unilateral CI	0.042
			Contralateral Stimulation	0.021
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.015
			Children with learning disability in addition scored lower than children with motor or balance disorder	0.042
			Children with learning disability in addition scored lower than children without an additional disability	0.003
			Oral Multilingualism	0.047
			Parental Involvement	NS
			Communication Mode (OC vs. TC)	NS
		Receptive language at 2 yr after CI	Age at first fitting	<0.001
			Bilateral vs. Unilateral CI	<0.001
			Unilateral CI with contralateral HA vs. unilateral CI	0.001
			Contralateral Stimulation	0.005
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.019
			Children with learning disability in addition scored lower than children with motor disorder	0.004
			Children with learning disability in addition scored lower than children without an additional disability	<0.001

			Oral Multilingualism	0.032
			Parental Involvement	0.010
			Communication Mode (OC vs. TC)	NS
		Receptive Language at 3 yr afer CI	Age at first fitting	<0.001
			Bilateral vs. Unilateral CI	<0.001
			Unilateral CI with contralateral HA vs. unilateral CI	<0.001
			Contralateral Stimulation	0.005
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.024
			Children with learning disability in addition scored lower than children with motor disorder	0.014
			Children with learning disability in addition scored lower than children without an additional disability	<0.001
			Oral Multilingualism	0.024
			Parental Involvement	0.017
			Communication Mode	0.006
			Communication Mode (OC vs. TC) - OC	<0.001
			Communication Mode (OC vs. sign language)	<0.001
		Expressive Language at 1 yr after CI Word Development	Age at first fitting	<0.001
			Bilateral CIs vs. Unilateral CI	0.001
			Unilateral CI with contralateral HA vs. unilateral CI	<0.001
			Contralateral Stimulation	0.001
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.016
			Oral Multilingualism	0.026
			Parental Involvement	NS
			Communication Mode	NS
		Expressive Language at 2 yr after CI	Age at first fitting	<0.001

		Word Development	Bilateral CIs vs. Unilateral CI	NS
			Unilateral CI with contralateral HA vs. unilateral CI	<0.001
			Contralateral Stimulation	0.018
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.022
			Additional Learning Disability	<0.001
			Oral Multilingualism	0.006
			Parental Involvement	0.005
			Communication Mode	NS
		Expressive Language at 3 yr after CI Word Development	Age at first fitting	<0.001
			Contralateral Stimulation	0.002
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.008
			Multilingualism	0.014
			Parental Involvement	0.035
			Communication Mode	0.040
			Communication Mode (OC vs. TC) – OC	<0.001
			Communication Mode (OC vs. Sign Language) – OC	0.001
		Expressive Language at 1 yr after CI Sentence Development	Age at first fitting	<0.001
			Bilateral CIs vs. Unilateral CI	0.001
			Unilateral CI with contralateral HA vs. unilateral CI	<0.001
			Contralateral Simulation	0.006
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.013
			Children with learning disability in addition scored lower than children with motor disorder	0.013
			Children with learning disability in addition	0.005

			scored lower than children without an additional disability	
			Multilingualism	NS
			Parental Involvement	NS
			Communication Mode	NS
		Expressive Language at 2 yr after CI Sentence Development	Age at first fitting	<0.001
			Contralateral Stimulation	0.001
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.040
			Multilingualism	NS
			Parental Involvement	NS
			Communication Mode	NS
		Expressive Language at 3 yr after CI Sentence Development	Age at first fitting	<0.001
			Contralateral Stimulation	0.001
			HA before CI	NS
			Gender	NS
			Etiology	NS
			Additional Disabilities	0.015
			Multilingualism	NS
			Parental Involvement	NS
			Communication Mode	NS
Connor, et al. (2000)	147	Hierarchical Linear Modeling Results for Receptive Vocabulary Scores (unconditional model) in age-equivalent years and controlling for preoperative performance using hearing aids – Fixed Effects	Intercept for Receptive Vocabulary	<0.001
			Intercept for linear trend, age in years centered at the gran mean (7.48)	<0.001
			Intercept for Preoperative Status	NS
		Hierarchical Linear Modeling Results for Receptive Vocabulary Scores (unconditional model) in age-equivalent years and controlling for preoperative performance using hearing aids – Random Effects	Intercept	0.000
			Age in Years	0.000
			Preoperative Status	0.000
		Receptive Vocabulary Scores on PPVT-III	Communication Mode (OC vs. TC) over time	NS
		Hierarchical linear modeling results for receptive vocabulary controlling for age at implantation, incomplete electrode array, use of new technology, preop aided speech detection thresholds, and preop performance using hearing aids – fixed effects of Intercept for Receptive Vocapulary	Intercept for Receptive Vocabulary	<0.001
			Communication Mode (OC vs. TC)	NS
			Age at Implantation	<0.05
			Incomplete Electrode Array	NS
			Use of New Technology	NS

			Preop aided speech detection thresholds dB HL	NS
		Hierarchical linear modeling results for receptive vocabulary controlling for age at implantation, incomplete electrode array, use of new technology, preop aided speech detection thresholds, and preop performance using hearing aids – fixed effects of Intercept for linear trend, age in years centered at the grand mean (7.48)	Intercept	<0.001
			Communication Mode (OC vs. TC)	NS
			Age at Implantation	<0.001
			Incomplete Electrode Array	NS
			Use of New Technology	<0.05
			Preop aided speech detection thresholds dB HL	NS
			Intercept for Preop Status	NS
		Hierarchical linear modeling results for the unconditional model for expressive vocabulary in age-equivalent years and controlling for preoperative performance using hearing aids	Intercept for expressive vocabulary, intercept	<0.001
			Intercept for linear trend, age in years centered at the grand mean (7.30), intercept	<0.001
			Intercept for preop status, intercept	<0.05
		Hierarchical linear modeling results for expressive vocabulary controlling for the age at implantation, incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, and preop performance using hearing aids, intercept for expressive vocabulary	Intercept for Expressive Vocabulary	<0.001
			Communication Mode (OC vs. TC)	<0.001
			Age at Implantation	<0.05
			Incomplete electrode array	NS
			Use of New Technology	<0.05
			Preop Aided Speech detection thresholds dB HL	NS
		Hierarchical linear modeling results for expressive vocabulary controlling for the age at implantation, incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, and preop performance using hearing aids, intercept for linear trend, age in years centered at the grand mean (7.30)	Intercept	<0.001
			Communication Mode (OC vs. TC)	NS
			Age at Implantation	NS
			Incomplete Electrode Array	NS
			Use of New Technology	<0.05
			Preoperative Performance using hearing aids	<0.05
		Hierarchical linear modeling results for expressive vocabulary controlling for the age at implantation, incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, and preop performance using hearing aids, intercept for preop status	Intercept for Preop Status	NS
		Hierarchical linear modeling results for receptive spoken vocabulary (age-equivalent in years) by length of cochlear implant use in years comparing OC and TC groups within	Intercept for Receptive Spoken Vocabulary, intercept	<0.001
			Total communication within preschool	≤0.05

		preschool, early elementary, and middle elementary groups, with grouping based on the age in years at which children received their implants and controlling for incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, as designated, and preoperative performance using hearing aids, intercept for receptive spoken vocabulary	Total Communication within early elementary	NS
			Total Communication within middle elementary	NS
			Early Elementary	≤0.01
			Middle Elementary	<0.001
			Incomplete Electrode Array	NS
			Preop Aided Speech Detection thresholds dB HL	NS
			Use of New Technology	NS
		Hierarchical linear modeling results for receptive spoken vocabulary (age-equivalent in years) by length of cochlear implant use in years comparing OC and TC groups within preschool, early elementary, and middle elementary groups, with grouping based on the age in years at which children received their implants and controlling for incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, as designated, and preoperative performance using hearing aids, intercept for linear trend, length of use centered at 3 years	Intercept for linear trend, length of use centered at 3 years, intercept	<0.001
			Total Communication within preschool	NS
			Total Communication within early elementary	NS
			Total Communication within middle elementary	NS
			Early Elementary	NS
			Middle Elementary	<0.001
			Use of New Technology	NS
		Hierarchical linear modeling results for receptive spoken vocabulary (age-equivalent in years) by length of cochlear implant use in years comparing OC and TC groups within preschool, early elementary, and middle elementary groups, with grouping based on the age in years at which children received their implants and controlling for incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, as designated, and preoperative performance using hearing aids, intercept for preop status	Intercept for Preop Status	NS
		Hierarchical linear modeling results for expressive vocabulary by length of CI use, comparing OC and TC groups within preschool, early elementary, and middle elementary groups, with grouping based on the age in years at which children received their implants and controlling for incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, as designated, and preoperative performance using hearing aids, intercept for expressive vocabulary	Intercept	<0.001
			Total Communication within preschool	<0.001
			Total Communication within early elementary	<0.05
			Total Communication within middle elementary	≤0.01
			Early Elementary	<0.05
			Middle Elementary	<0.001

			Incomplete Electrode Array	NS
			Preop Aided Speech Detection Thresholds dB HL	≤0.01
			Use of New Technology	NS
		Hierarchical linear modeling results for expressive vocabulary by length of CI use, comparing OC and TC groups within preschool, early elementary, and middle elementary groups, with grouping based on the age in years at which children received their implants and controlling for incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, as designated, and preoperative performance using hearing aids, intercept for linear trend, length of use centered at 3 years	Intercept	<0.001
			Total Communication within preschool	<0.05
			Total Communication within early elementary	NS
			Total Communication within middle elementary	NS
			Early Elementary	NS
			Middle Elementary	NS
			Preop Aided Speech Detection Thresholds dB HL	NS
			Use of New Technology	NS
		Hierarchical linear modeling results for expressive vocabulary by length of CI use, comparing OC and TC groups within preschool, early elementary, and middle elementary groups, with grouping based on the age in years at which children received their implants and controlling for incomplete electrode array, use of new technology, preoperative aided speech detection thresholds dB HL, as designated, and preoperative performance using hearing aids, intercept for preop status	Intercept for preop status	NS
Cullington, et al. (2000)	24	Oral Children Vs. Total Communication Children	Expressive vs. Receptive Standard Scores on EVT vs. PPVT	OC: 0.0235
				TC: NS
			Language Delay on EVT	0.032
			Language Delay on PPVT	NS
			Language Delay on TACL-R	NS
			GAEL: prompted language quotient	NS
			GAEL: imitated language quotient	NS
Dunn, et al. (2014)	83	Receptive Language Outcomes	Earlier vs. Older Implantation at age 7	0.04
			Earlier vs. Older Implantation at age 8	NS
			Communication Mode	0.026
		Expressive Language Outcomes	Earlier vs. Older Implantation at age 7	0.01
			Earlier vs. Older Implantation at age 10 & 11	NS
			Communication Mode	NS

Geers (2002)	69	Effect on Spoken Language	Duration of Speak	<0.05
			Number of active electrodes	<0.01
			Dynamic Range	<0.01
			Loudness Growth	<0.01
			Hours of Therapy	NS
			Therapist Experience	NS
			Parent Participation	NS
			School Setting	NS
			Type of Class	<0.05
			Communication Mode	<0.001
		Effect on Total Language	Duration of SPeak	<0.01
			Number of Active Electrodes	<0.05
			Dynamic Range	<0.01
			Loudness Growth	<0.05
			Hours of Therapy	NS
			Therapist Experience	NS
			Parent Participation	NS
			School Setting	NS
			Type of Class	<0.05
			Communication Mode	NS
Geers, et al. (2002)	22	Use of Speech and Sign	Negative Correlation	<0.001
		Auditory, Speech, and Language Skill	Positive Correlation with Use of Speech	<0.01
			Negative Correlation with Use of Sign	<0.01
		Percentage of Speech used with Measures	McGarr/BIT Sentences	≤0.01
			WIPI	≤0.01
			IPSyn	≤0.01
			Words per Utterance	≤0.01
			Bound Morphemes per Utterance	≤0.01
			Different Words per Minute	≤0.01
			TACL Total Score	≤0.01
Geers, et al. (2003)	181	Differences in CI group performance in speech only vs. speech/sign interview	Utterance length (speech/sign)	<0.0001
			Lexical diversity (speech/sign)	<0.003
			Bound Morphemes	NS
			IPSyn Noun Phrases	NS
			IPSyn Verb Phrases	NS
			IPSyn Questions/Negatives	NS
			IPSyn Sentence Structure	NS

			IPSyn Total Score	NS
		Cochlear Implant vs. Normal Hearing Effects on Spontaneous Language Sample Measures	Utterance Length	<0.0001
			Lexical Diversity	<0.0001
			Bound Morphemes	<0.0001
			IPSyn Noun Phrases	<0.0001
			IPSyn Verb Phrases	<0.0001
			IPSyn Questions/Negatives	NS
			IPSyn Sentence Structure	<0.0001
			IPSyn Total Score	<0.0001
		Communication Mode Effects on Language Outcome Measures	Language Comprehension	NS
			Verbal Reasoning	NS
			Narrative Ability Scores (OC)	<0.0009
		Factors affecting Utterance Length	Communication Mode (OC)	<0.0001
			Interview Type (speech/sign) – for both OC and TC	<0.0001
			Interaction between communication mode and interview type	NS
		Factors affecting Lexical Diversity	Communication Mode (OC)	<0.0001
			Interview Type (OC)	<0.003
			Interaction between communication mode and interview type	<0.01
		Factors affecting Bound Morpheme Usage	Communication Mode (OC)	<0.0001
			Interview Type	NS
			Interaction between communication mode and interview type	NS
		Factors affecting Syntax	Communication Mode (OC)	<0.0001
			Interview Type	NS
			Interaction between communication mode and interview type	NS
		Inter-correlations among language scores	All inter-correlations including: Sp IPSyn, Sp WPU, Sp BndM, Sp Diff WPM, Sp/S IPSyn, Sp/S WPU, Sp/S BndM, Sp/S Diff WPM, TACL T-Score, WISC similarities, Narrative ability	<0.0001
		Child and Family factors predictive of language competence for spoken language	Age	NS
			Age at Implantation	NS

			Age at Onset	NS
			Performance IQ	0.005
			Family Size	0.001
			Socio-Economic Status	0.001
			Gender	0.001
		Child and family factors predictive of language competence for total language	Age	NS
			Age at Implantation	NS
			Age at Onset	0.004
			Performance IQ	0.001
			Family Size	0.001
			Socio-Economic status	0.0001
			Gender	0.002
		Educational Factors predictive of language outcome for spoken language	Hours of therapy	NS
			Therapist Experience	NS
			Parent Participation	NS
			Public/Private School	NS
			Special education/mainstream	0.01
			Communication Mode	0.0001
		Education Factors predictive of language outcome for total language	Hours of therapy	NS
			Therapist Experience	NS
			Parent Participation	NS
			Public/Private School	NS
			Special Education/Mainstream	0.01
			Communication Mode	0.02
		Speech and Hearing Factors predictive of language outcome for spoken language	Speech Perception	NS
			Speech Production	0.0001
Hasenstab & Tobey (1991)		Case Study	No Variables Analyzed for Significance. Study suggested benefits of CI experience to language development regardless of communication mode.	
Hay-McCutcheon, et al. (2008)		Receptive Language	Increase in Gap between normal-hearing and CI kids over 1 year	<0.0001
			Communication mode	NS
			Age of Implantation	0.01
		Expressive Language	Increase in gap between normal-hearing and CI kids over 1 year	<0.0001
			Communication Mode	NS

			Age of Implantation	0.008
Holt & Svirsky (2008)	45	Family Environment Scale – 4th ed. Scores of Parents of children with CI elevated compared to normal hearing peer parents	Achievement Orientation	0.003
			Active-Recreational Orientation	0.034
			Cohesion	0.001
			Expressiveness	0.001
			Moral-Religious Emphasis	<0.0001
			Organization	<0.0001
			Mean Score of Conflict	<0.0001
		Language Outcomes Below Norm-Referenced Mean	Language Outcomes on the PPVT-4	<0.0001
			CELF-4 Core Language Scores	0.002
			PLS-4 Auditory Comprehension Scores	<0.0001
			PLS-4 Expressive Comprehension Scores	0.001
			PLS-4 Total Language Scores	<0.0001
		Family Environment and Language Development Correlations	Age at Implantation and FES-4 Expressiveness	0.003
			Maternal Education and FES-4 Intellectual-Cultural Orientation	0.05
			Family Size and FES-4 Active-Recreational Orientation	0.039
			Families scored as less controlling on FES-4 had children with higher PPVT-4 scores	0.002
			Families scored as less controlling on FES-4 had children with higher PLS-4 Expressive Scores*	NS
		Executive Functioning Outcomes Below Norm-Referenced Mean	Global Executive Composite Score	0.017
			Inhibit Score	0.008
			Working Memory	0.004
		Family Environment and Executive Function Correlations	Families scoring higher achievement orientation scores on FES-4 had children had higher GEC scores	0.047
			Families scoring higher achievement orientation scores on FES-4 had children with higher scores for working memory	0.049
			Families scoring higher achievement orientation scores on FES-4 had children with higher plan/organize scale scores *	NS
			Families scoring higher organization	0.006

			subscale scores on FES-4 had children with higher inhibit scale scores	
			Families scoring higher organization scores on FES-4 had children with higher GEC* and Plan/Organize Subscale scores*	NS
			Families scoring higher on independence on FES-4 had children with higher inhibit scale scores*	NS
Kirk, et al. (2000)	106	GAEL-P Scores Closed-set spoken word Recognition Task	Length of Device Use	NS
			Age at Implantation* - children tested at an older age	NS
			Communication Mode (OC vs. TC) - OC	<0.02
		Variables for Improvement in Spoken Word Recognition	Length of Device Use	<0.0001
			Age at implantation	<0.02
			Communication mode	<0.01
		Language Quotients derived from PPVT-III Age Equivalents	Length of Device Use	<0.001
			Children implanted at 5 years of age or older had higher language quotients than children in the younger age of implantation groups*	<0.03
			Interaction between age at implantation and length of device use	<0.0001
			Children implanted prior to 2 years of age had faster rates of growth in PPVT-III scores than children implanted between 2 and 4 years of age	<0.0001
			Children implanted prior to 2 years of age had faster rates of growth in PPVT-III scores than children implanted at 5 years or older	<0.0001
		RDLS Receptive Language Quotient Scores	Overall increase in receptive language skills over time	<0.0001
			Age at Implantation	NS
			Communication Mode	NS
			Interaction between age at implantation and length of CI use	<0.0001
			Faster improvement for children implanted prior to the age of 2 years than those	<0.0001

			implanted between 2 and 4 years	
			Faster improvement for children implanted prior to the age of 2 years than those implanted at 5 years or older	<0.0001
		RDLS Expressive Language Quotient Scores	Improvements with increased CI use	<0.0001
			Age at Implantation	<0.01
			Children implanted prior to 2 years of age had higher quotients than children implanted between 2 and 4 years	<0.01
			Children implanted prior to 2 years of age had higher quotients than children implanted at 5 years or older	<0.04
			Communication Mode	NS
			Interaction between age at implantation and length of CI use	NS
Miyamoto, et al. (1999)	33	Receptive Language Quotients for PPVT and RDLS	Age at Implantation	NS
			Communication Mode (OC vs TC)	NS
		Expressive Language Quotients for RDLS	Age at Implantation*	NS
			Communication Mode (OC vs. TC) - OC	0.05
Miyamoto, et al. (2000)	33	RDLS Scores	Age at Implantation	NS
			Communication Mode (OC vs. TC)	NS
Robbins, et al. (1999)	23	RDLS Scores	Improvement in receptive and expressive language over time	<0.001
			Communication Mode (OC vs. TC)	NS
		Rate of Language Improvement	CI versus normal hearing	NS
			Communication Mode (OC vs. TC)* - OC	NS
Svirsky, et al. (2000)	70	RDLS Expressive Language Quotients	Increased language development compared to average predicted rates	<0.001
			Correlation of language quotient with word recognition performance for OC users	<0.01
			Correlation of language quotient with word recognition performance for TC users	NS
Tomblin, et al. (2005)	29	Peri-Implantation Period	Association of age at initial stimulation with MCDI	NS
			Association of age at initial stimulation with PLS-3	NS

		1-year post-implantation	Association of age at initial stimulation with MCDI	0.004
			Association of age at initial stimulation with PLS-3	0.0005
		1 yr, 10 mo post-implantation	Association of age at initial stimulation with MCDI	<0.009
			Association of age at initial stimulation with PLS-3	<0.0009
		Comparison of children implanted between 12 and 20 mo and children implanted between 21 and 48 mo	Language quotients lower for children implanted later in life at 1 year post-stimulation	0.03
		Conditional Model of Expressive Language Growth for Age at Stimulation	Association of age at stimulation with the intercept	<0.001
			Association of age at stimulation with the linear growth rate	<0.005

DISCUSSION

The purpose of this systematic review was to demonstrate that children who use CIs and are exposed to AVT would have better expressive language outcomes compared to children who use TC. Additionally, we hypothesized that AVT and TC interventions would produce equivalent receptive language outcomes. Due to a lack of quantitative data, a qualitative analysis was completed with the results of the 22 studies. To support our analysis, we examined the significant expressive and receptive language outcomes presented in the articles for both AVT and TC. Additionally, we examined other factors, such as age at implantation and family involvement, to determine their effects on language outcomes. Overall, we found that AVT when compared to TC had a higher percentage of favorable outcomes for both receptive and expressive language within the analyzed research.

Expressive Language

To answer our hypothesis related to expressive language, a comparison of results from both AVT and TC studies was required. Four of the six articles for AVT and five of the 16 articles for TC presented specific expressive data. We hypothesized that children with CIs who received AVT would have higher expressive language outcomes compared to those who use TC. In analysis of this subset of articles, AVT had a higher percentage of favorable expressive language outcomes with four of the six reporting expressive outcomes within normal limits for children with normal hearing (Fairgray et al., 2010; Hogan et al., 2010; Hogan et al., 2008; Yanbay et al., 2014). In comparison, only one of the five articles providing TC data was able to show an increase in expressive language (Robbins et al., 1999). As speech perception is closely linked to language development, and children who receive AVT have demonstrated higher speech perception outcomes, it might have been possible to use these perception skills to develop their expressive language (Connor et al., 2000; Hodges et al., 1999; Percy-Smith et al., 2010).

Receptive Language

We hypothesized that AVT and TC would produce equivalent receptive language outcomes. Six of the AVT articles and five of the TC articles reported receptive language outcomes. For the AVT articles, with the exception of the results from Dettman et al. (2013), it was found that receptive language outcomes were within normal limits for children with normal hearing. None of the TC articles reported receptive language outcomes within normal limits. However, two articles did report increases in receptive language scores over time for the children who used TC (Hasenstab & Tobey, 1991; Robbins et al., 1999). Likewise, one of the TC studies showed higher receptive scores for children who used TC compared to the scores obtained for children who used OC (Connor et al., 2000).

Despite the inclusion of the visual modality and iconicity of some signs, children who used TC did not seem to have a clear advantage for receptive language, as one might instinctively think. In fact, Robbins et al. (1999) explained that children who used auditory-only programs like AVT took better advantage of their CI compared to children who used TC. Additionally, differences exist between the structure and usage of American Sign Language (ASL) and spoken English when used simultaneously. This simultaneous use of ASL and speech can be termed as bimodal bilingualism. In a recent study of adults, researchers found bimodal bilinguals prefer to blend the two modes rather than code-switch (Emmorey, Borinstein, & Thompson, 2005). Specifically, they found only 5% of signs were used without speech, and 94% of the signs were semantically equivalent to the accompanying speech. One noted speech difference was longer lengths of vowel productions to provide more time for sign productions (Emmorey et al., 2005). Confirming this finding for speech differences, Marmor and Petitto (1979) led a study presenting the time differences in speech only, sign only, and speech-sign/TC and found longer duration for speech and sign. Integration of the two modes is also restrained by syntax, as facial expression plays a syntactic role in ASL but not in English and can lead to misinterpretations of affect or meaning (Pyers & Emmorey, 2008). It should also be noted that many deaf children born to hearing parents would not be exposed fully to ASL as the parents would be new learners of the language. Some studies, such as Connor et al. (2000), allowed for children to respond in signs, but did not accept iconic gesture, which may have caused children of hearing parents (non-fluent in ASL) more difficulty. Overall, these differences could hinder a bimodal bilingual child using TC for language.

Significant Factors

Several additional factors related to language outcomes for children with CIs were examined in the 22 articles for this study. Factors included the following: age at implantation, communication mode (including modes other than AVT and TC), parent/family involvement, age at diagnosis/age at onset, device differences, additional disabilities, socioeconomic status, and gender.

Age at implantation was the most frequently reported significant factor for language with 68.2% of the articles reporting an earlier age at implantation as beneficial for language. This finding agrees with current research showing early cochlear implantation benefits both expressive and receptive language (Baldassari et al., 2009; Bollard et al., 1999; Brennan-Jones, 2014; Caselli et al., 2012; Connor et al., 2000; Duncan & Rochecouste, 1999; A. Geers, 2004; A. Geers et al., 2007; A. Geers et al., 2008; Nicholas & Geers, 2006; Svirsky, Robbins, Kirk, & Miyamoto, 2000). In fact, studies have reported that the plasticity of the central auditory system is dramatically reduced after age 6 or 7, but maximally plastic for a window of 3.5 years (Manrique et al., 1999; Sharma, Dorman, & Spahr, 2002). Therefore, early age at implantation of approximately less than 3.5 years is recommended.

Other than age at implantation, factors include communication mode, family involvement, age at diagnosis, and the use of particular devices. Communication mode was a frequently reported significant factor with 27.3% of articles reporting varied significance for OC, TC, and AVT. Though this study focused on AVT and TC alone, the term communication mode also includes OC in this regard. In addition, family involvement, age at diagnosis, and device differences were all found in three of the 22 articles showing the importance of increased family participation, early identification of deafness, and appropriate mapping of the cochlear implant speech processor to meet the needs of the individual child. All factors excluding gender were found to be significant for receptive language skills, and all eight factors including gender were found significant for expressive language.

Although we found trends for the above significant factors within the 22 articles, there were several other considerations that could have contributed to the language outcomes.   For instance, the degree of deafness and age at diagnosis could affect language outcomes for children who use either AVT or TC for language development (A. E. Geers et al., 2003; Hogan et al., 2008; Yanbay et al., 2014). Specifically as UNHS has allowed for earlier diagnoses of deafness, initiating amplification, and intervention will also occur earlier, and consequently, this early intervention will have positive outcomes for receptive and expressive language development regardless of the intervention method (Calderon, 2000; Moeller, 2000; National Institutes of Health, 2010; Pollack et al., 1997; Yoshinaga-Itano et al., 2000; Yoshinaga-Itano et al., 1998). However, the degree of deafness would still have major implications. A greater degree of deafness could impact success in intervention and potentially the age at cochlear implantation (Pollack et al., 1997). Parents of children with more severe hearing loss could decide for cochlear implantation sooner than parents whose children have better residual hearing and benefit from hearing aids.

The age at cochlear implantation of the children across studies could have also had an impact on the findings. That is, a participant with an older age at implantation was more likely to have an older age at testing. For example, the mean age at cochlear implantation for AVT articles was 2.09 ± 0.76 years, while the mean age at cochlear implantation was 3.87 ± 1.57 years for the TC articles. A higher chronological age and age at cochlear implantation could have potential negative effects for language outcomes. Critical periods for language development were likely to have been missed without exposure to language for those children who were implanted at later ages.

As previously mentioned, language development relies on both auditory exposure and the cognitive processing of the incoming speech signal (Pollack et al., 1997). However, if auditory exposure is limited and not available within the critical period of 1 to 3 years of age, the child is likely to experience a language delay (National Institutes of Health, 2010).

Therefore, as the TC articles showed a higher mean age at testing and older age at cochlear implantation than the AVT articles, the participants in the AVT articles started with a smaller delay and therefore could have made better progress towards normal language development.

Other underlying factors for language outcomes with a CI could have an effect on the findings. Specifically, the age at which treatment began has been shown to have an effect on outcomes (Moog & Geers, 2010). An earlier age at treatment allows for more years of intervention exposure and parent education. The recommended age for intervention to begin is between 1 and 2 years of age (Moog & Geers, 2010). The frequency and intensity of the services can differ and cause changes in intervention experience for the child and family. A lower frequency of services would lower the exposure of the intervention, and a lower intensity of the services would take away from the quality of the intervention. Yanbay et al. (2014) was the only article of the 22 that assessed duration of AVT for significance. They did not find significance for duration of treatment for language outcomes; however, more studies should be completed to determine the appropriate duration, frequency, and intensity for language intervention.

In addition, other accommodations such as FM systems effect language outcomes by allowing for increased exposure to the auditory signal and for the increase in speech perception skills (Schafer & Thibodeau, 2003). As previously mentioned, speech perception has been shown to aid in expressive language outcomes (Connor et al., 2000; Hodges et al., 1999; Percy-Smith et al., 2010). Besides additional accommodations, the wear-time of the implant itself could cause differences in language outcomes. These factors differed amongst the research studies and often were not reported.

Although the treatment approach may have a large potential effect on language outcomes, language development relies on many overlapping factors, some of which could have no direct correlation to deafness or cochlear implantation. For instance, maternal education has been shown to be an important factor affecting speech and language developmental differences (Calderon, 2000; Dollaghan et al., 1999; Parkes, Sweeting, & Wight, 2015). Specifically, Dollaghan et al. (1999) found that speech and language skills were significantly higher in children whose mothers were high school graduates over children whose mothers had not graduated from high school. Additionally, early reading skills have been shown to be positively affected by parent involvement in a child's school education program, and specifically, are dependent on maternal communication skills (Calderon, 2000). Other factors such as maternal functioning and coping, problem-solving skills, positivity, and use of additional resources such as counseling, sign language classes, support groups, etc. are shown to be directly related to child functioning and development (Calderon, 2000).

Finally, methodological factors could have had an effect on the outcomes from the studies. When testing children using TC, standardized procedures must be changed to allow for sign to be incorporated. As an example, the MacArthur Communicative Development Inventory (CDI) for English (Fenson et al., 1994) underwent a revision to allow for ASL (Anderson & Reilly, 2002). The researchers changed several content questions including questions for or about animal noises, signs with similar form (e.g. EAT and FOOD) but different grammatical function, and additional grammatical allowances such as fingerspelling, facial expression, and longest sign productions. Therefore, with significant changes required to assessment materials, outcome data cannot be easily compared for children using speech only (AVT) versus speech and sign (TC).

Similarly, Geers, et al. (2002) noted in their study of TC that a major difficulty for studying the language development of children using TC is the influence of either speech or sign separately, as they are both used simultaneously and often from an early age. With this difficulty, some studies decided to test using both speech-sign simultaneously in administration or strictly speech, impeding children using TC. Therefore, language outcomes could vary based on these methodology concerns.

LIMITATIONS & RECOMMENDATIONS

A few limitations of this study need to be mentioned. Specifically, due to a lack of research literature directly comparing AVT and TC, the number of articles included for analysis was limited. Additionally, it was possible that because a single reviewer completed the article search for this study, articles could have been overlooked or inaccurately excluded. When conducting searches, a significant body of evidence was found comparing OC to TC; however, the purpose of this study was to demonstrate the efficacy of AVT, which included a specific set of principles and practice. In fact, a recent Cochrane Review for AVT searched 2233 titles with no studies meeting research design criteria for review (Brennan-Jones, 2014). Cochrane Reviews are internationally known systematic reviews of primary research and are used to investigate the effects of interventions. It should be noted that no Randomized Control Trials (RCT) or quasi-RCTs have been completed for AVT or TC; however, ethical concerns and parental involvement for decision-making require sensitivity and care in planning a large trial for children with CIs. No other known systematic reviews for AVT have been completed, aside from an article by Eriks-Brophy (2002) providing an overview of current research at the time and calling for more evidence to support the effectiveness of AVT.

For the articles reviewed in this study, reported scores varied in type and format (total language score, subtests scores, etc.); however, age-equivalent scores were the most frequently reported. Age-equivalent scores are not adequate for interpreting language outcomes, as they do not account for change in performance due to cochlear implantation.

Also, large differences were seen amongst studies due to age at testing, and age-equivalents provide few elements of comparison. Therefore, qualitative analysis of age-equivalents compared between studies should be reviewed cautiously.

A large-scale systematic study of AVT and TC is needed so that professionals and families can make educated decisions on the efficacy of these treatments for children with CIs. To complete this study, it would be necessary to have an adequate sample size and the availability of trained AVT therapists. These studies would provide professionals and families with important evidence-based research supporting effective language learning approaches for children with CIs.

CONCLUSION

As seen in this study, the outcomes of children with CIs for language regardless of communication mode are variable. Differences such as age at implantation, family involvement, and device variances have major impacts on outcome results. Each child is an individual with a different set of strengths and weakness; therefore, the treatment approach and plan must be individualized to suit the needs of the child and the family. It is important for professionals to remember decisions for cochlear implantation and intervention are difficult for parents as they are deciding how their child will communicate with others and how they will communicate with their child. Intervention is a valuable part of supporting the child and family and should be implemented systematically with speech, language, and auditory training incorporated for age-appropriate development of receptive and expressive language.

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APPENDIX

Reference: Phillips, B., Ball, C., Sackett, D., Badenoch, D., Straus, S., Haynes, B., & Dawes, M. (1998). Oxford Centre for Evidence-Based Medicine - Levels of Evidence http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/

Level	Therapy / Prevention, Aetiology / Harm	Prognosis	Diagnosis	Differential diagnosis / symptom prevalence study	Economic and decision analyses
1a	SR (with homogeneity*) of RCTs	SR (with homogeneity*) of inception cohort studies; CDR" validated in different populations	SR (with homogeneity*) of Level 1 diagnostic studies; CDR" with 1b studies from different clinical centres	SR (with homogeneity*) of prospective cohort studies	SR (with homogeneity*) of Level 1 economic studies
1b	Individual RCT (with narrow Confidence Interval"¡)	Individual inception cohort study with > 80% follow-up; CDR" validated in a single population	Validating** cohort study with good" " " reference standards; or CDR" tested within one clinical centre	Prospective cohort study with good follow-up****	Analysis based on clinically sensible costs or alternatives; systematic review(s) of the evidence; and including multi-way sensitivity analyses
1c	All or none§	All or none	Absolute SpPins and	All or none	Absolute

		case-series	SnNouts" "	case-series	better-value or worse-value analyses " " " "
2a	SR (with homogeneity*) of cohort studies	SR (with homogeneity*) of either retrospective cohort studies or untreated control groups in RCTs	SR (with homogeneity*) of Level >2 diagnostic studies	SR (with homogeneity*) of 2b and better studies	SR (with homogeneity*) of Level >2 economic studies
2b	Individual cohort study (including low quality RCT; e.g., <80% follow-up)	Retrospective cohort study or follow-up of untreated control patients in an RCT; Derivation of CDR" or validated on split-sample§§§ only	Exploratory** cohort study with good" " " reference standards; CDR" after derivation, or validated only on split-sample§§§ or databases	Retrospective cohort study, or poor follow-up	Analysis based on clinically sensible costs or alternatives; limited review(s) of the evidence, or single studies; and including multi-way sensitivity analyses
2c	"Outcomes" Research; Ecological studies	"Outcomes" Research		Ecological studies	Audit or outcomes research
3a	SR (with homogeneity*) of case-control studies		SR (with homogeneity*) of 3b and better studies	SR (with homogeneity*) of 3b and better studies	SR (with homogeneity*) of 3b and better studies

3b	Individual Case-Control Study		Non-consecutive study; or without consistently applied reference standards	Non-consecutive cohort study, or very limited population	Analysis based on limited alternatives or costs, poor quality estimates of data, but including sensitivity analyses incorporating clinically sensible variations.
4	Case-series (and poor quality cohort and case-control studies§§)	Case-series (and poor quality prognostic cohort studies***)	Case-control study, poor or non-independent reference standard	Case-series or superseded reference standards	Analysis with no sensitivity analysis
5	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles"	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles"	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles"	Expert opinion without explicit critical appraisal, or based on physiology, bench research or "first principles"	Expert opinion without explicit critical appraisal, or based on economic theory or "first principles"

Produced by Bob Phillips, Chris Ball, Dave Sackett, Doug Badenoch, Sharon Straus, Brian Haynes, Martin Dawes since November 1998. Updated by Jeremy Howick March 2009.

Notes

Users can add a minus-sign "-" to denote the level of that fails to provide a conclusive answer because:

EITHER a single result with a wide Confidence Interval

OR a Systematic Review with troublesome heterogeneity.

Such evidence is inconclusive, and therefore can only generate Grade D recommendations.

*	By homogeneity we mean a systematic review that is free of worrisome variations (heterogeneity) in the directions and degrees of results between individual studies. Not all systematic reviews with statistically significant heterogeneity need be worrisome, and not all worrisome heterogeneity need be statistically significant. As noted above, studies displaying worrisome heterogeneity should be tagged with a "-" at the end of their designated level.
"	Clinical Decision Rule. (These are algorithms or scoring systems that lead to a prognostic estimation or a diagnostic category.)
"¡	See note above for advice on how to understand, rate and use trials or other studies with wide confidence intervals.
§	Met when all patients died before the Rx became available, but some now survive on it; or when some patients died before the Rx became available, but none now die on it.
§§	By poor quality cohort study we mean one that failed to clearly define comparison groups and/or failed to measure exposures and outcomes in the same (preferably blinded), objective way in both exposed and non-exposed individuals and/or failed to identify or appropriately control known confounders and/or failed to carry out a sufficiently long and complete follow-up of patients. By poor quality case-control study we mean one that failed to clearly define comparison groups and/or failed to measure exposures and outcomes in the same (preferably blinded), objective way in both cases and controls and/or failed to identify or appropriately control known confounders.
§§§	Split-sample validation is achieved by collecting all the information in a single tranche, then artificially dividing this into "derivation" and "validation" samples.
" "	An "Absolute SpPin" is a diagnostic finding whose Specificity is so high that a Positive result rules-in the diagnosis. An "Absolute SnNout" is a diagnostic finding whose Sensitivity is so high that a Negative result rules-out the diagnosis.
"¡"¡	Good, better, bad and worse refer to the comparisons between treatments in terms of their clinical risks and benefits.

" " "	Good reference standards are independent of the test, and applied blindly or objectively to applied to all patients. Poor reference standards are haphazardly applied, but still independent of the test. Use of a non-independent reference standard (where the 'test' is included in the 'reference', or where the 'testing' affects the 'reference') implies a level 4 study.
" " " "	Better-value treatments are clearly as good but cheaper, or better at the same or reduced cost. Worse-value treatments are as good and more expensive, or worse and the equally or more expensive.
**	Validating studies test the quality of a specific diagnostic test, based on prior evidence. An exploratory study collects information and trawls the data (e.g. using a regression analysis) to find which factors are 'significant'.
***	By poor quality prognostic cohort study we mean one in which sampling was biased in favour of patients who already had the target outcome, or the measurement of outcomes was accomplished in <80% of study patients, or outcomes were determined in an unblinded, non-objective way, or there was no correction for confounding factors.
****	Good follow-up in a differential diagnosis study is >80%, with adequate time for alternative diagnoses to emerge (for example 1-6 months acute, 1 – 5 years chronic)

Grades of Recommendation

A	consistent level 1 studies
B	consistent level 2 or 3 studies ***or*** extrapolations from level 1 studies
C	level 4 studies ***or*** extrapolations from level 2 or 3 studies
D	level 5 evidence ***or*** troublingly inconsistent or inconclusive studies of any level