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Which Language-Learning Environment is the Most Advantageous for Deaf Children with Cochlear Implants?

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Abstract

The use of paediatric cochlear implants has increased significantly over the last decade. The outcomes of deaf children with cochlear implants tend to surpass the outcomes of non-implanted deaf peers; however, they remain highly variable, and may be influenced by a number of different factors. One factor is the language-learning environment children are exposed to post-implantation. The evidence into which environment is most advantageous for children's outcomes is mixed, with different studies recommending either spoken language-only, bimodal bilingual, or simultaneous communication models. In this essay, recent research comparing the outcomes of children from different language-learning environments is presented and discussed. There is strong evidence that bimodal bilingualism has a number of advantages for linguistic, cognitive, and social-emotional outcomes. However, there are significant barriers to its development in all children. This essay concludes that use of simultaneous communication in schools and at home is a viable alternative, but that further research within the UK context is needed. The wider implications of this approach are discussed.

An estimated 900,000 people in the United Kingdom (UK) have severe or profound hearing loss (Action on Hearing Loss, 2015), of which approximately 45,000 are children (National Deaf Children's Society, 2015). The World Health Organisation (WHO) classifies "severe impairment" as a hearing loss of 61-80 dB in the individual's better ear, while "profound impairment (including deafness)" is a loss of more than 81 dB. For children, any loss greater than 30 dB is considered "disabling" (WHO, 2018). Hearing impairment in childhood can be congenital (present from birth), progressive (manifests at birth and worsens over time), or late-onset (manifests after birth) (Fortnum, et al., 2001). In the UK, 1 in every 900 babies are born with some degree of hearing loss (Action on Hearing Loss, 2015). Children born deaf, or who experience hearing loss in early childhood, face significant challenges in their

development and may have poorer outcomes in terms of language acquisition (Svirsky, Robins, Kirk, Pisoni & Miyamoto, 2000), expressive and receptive language abilities (Moog & Geers, 1985), vocabulary acquisition (Luckner & Cooke, 2010), reading comprehension (Allen, 1986), and overall literacy (Kyle & Harris, 2011).

Early identification and intervention is crucial for improving these outcomes. Since 2006, universal neonatal hearing screening has improved the diagnosis, referral and treatment of hearing impairments (Action on Hearing Loss, 2015). In addition, technological advances mean that babies born deaf, but who still have a functioning and accessible auditory nerve, may be eligible for cochlear implants (CIs) (Leigh, Dettman & Dowell, 2016). CIs electrically stimulate the auditory nerve to produce hearing percepts (Svirsky et al., 2000). The external component receives incoming auditory input, processes it, and transfers the signal to a sub-cutaneous internal component. This decodes the transmitted signal and stimulates the cochlea, which in turn stimulates the auditory nerve. Over time, the age of implantation for CIs has fallen (Christiansen & Leigh, 2002), and many children now receive this implant before 24 months of age (Harris, 2015), and some before 12 months (Grant, 2008). Although CIs do not restore hearing completely, hearing levels post-implantation are typically on par with those of children with moderate hearing loss who use hearing aids (Dettman & Dowell, 2010), which enables many children with CIs to develop spoken language.

There is a wealth of research into the outcomes of pupils with CIs. In 2000, Svirsky and colleagues reported that the English language development of children with CIs exceeds the development rate of un-implanted children, and is comparable to that of their hearing peers; this is due to them "developing an oral linguistic system based largely on auditory input obtained from a cochlear implant." (pp. 157). However, language outcomes following CIs remain highly variable (Geers, Moog, Biedenstein, Brenner, & Hayes, 2009), and this has been attributed to a range of factors. One factor is the communicative model the child is exposed to post-implantation (Jiménez, Pino & Herruzo, 2009). A number of models exist for deaf learners, which are described in Table 1. In this essay, I will first explore the ethical implications of using paediatric CIs. I will present literature on the effect of different language-learning environments on children's language development, academic outcomes, and social-emotional development. I will then evaluate the research, and discuss the implications for practice, including areas of future involvement for Educational Psychologists.

Table 1. Communicative models for deaf learners with CIs

Language-learning environment	**Description**
Speech / Spoken Language-only	Use of a spoken language without use of any form of signing / sign language.
Bimodal Bilingualism	Concurrent learning of both a spoken language and a sign language.
Simultaneous / Total Communication	Use of signs alongside speech in the word order of the spoken language

Ethical Considerations

It is helpful to acknowledge the existing ethical debates around the use of paediatric CIs. These centre around three main issues: a) whether the use of paediatric CIs is itself ethical, b) whether deaf children who are deemed suitable for CIs should still be exposed to sign language pre-implantation, and c) whether sign-language use should continue post-implantation. As in existing literature, in this essay I use *deaf* with a "d" to refer to individuals' auditory status, and *Deaf* with a "D" to describe a collective community that primarily communicates through sign language (Humphries et al., 2012b; Lane, 2005).

Firstly, some members of the Deaf community oppose CIs for deaf children for a number of reasons, one of which is the issue of consent. As young deaf children cannot give consent, parents must decide for or against CIs on their child's behalf. Lane (2005) inferred that "most Deaf children would likely refuse that consent to surgery if they were old enough to decide" (pp. 300), which questions whether allowing parental choice is ethical practice. In addition, the use of CIs has implications for deaf children's cultural identity, and for the Deaf community as a whole. Most parents of deaf children are themselves hearing (Hassanzadeh, 2012), and see CIs as a means of facilitating spoken language development (Geers et al., 2017); there is an argument that this violates deaf children's fundamental human right to learn and become fluent in sign language (Ladd, 2007). The increasing use of CIs is even described as causing the "cultural genocide" of Deaf people (Crouch, 1997, pp. 20), and may render sign language obsolete (Ladd, 2007).

There is also debate over the use of sign language pre-implantation, which medical professionals have advised against in the past (Humphries et al, 2012a). Lack of language exposure during the critical period (first five years of development) leads to decreased grey matter (Penicaud et al., 2013), and a lack of neuro-linguistic structures necessary for understanding language concepts (Hall, 2017). This critical period applies to both spoken and sign language (Mayberry & Eichen, 1991). Preventing exposure to sign language pre-implantation could lead to language deprivation if the child is accessing no language at that point (Hall, 2017). This would be particularly troubling for children who do not develop good speech skills even with their CI, as they will require signing for future communication but may have missed the critical period for learning it (Humphries et al., 2012a). For children with CIs who do go on to speak, early exposure to any language, including sign language, helps facilitate language development and may in fact accelerate spoken language acquisition (Hassanzadeh, 2012; Jasinska, Langdon & Petitto, 2013). Potentially, the use of sign language pre-implantation is a necessity as well as a right.

Finally, there is a long-standing discussion over whether deaf or hearing-impaired children who receive CIs should be taught using a spoken language-only, or speech and sign language approach (Hall, 2017). Some parents are advised not to continue with sign language post-implantation (Humphries et al., 2012b), and in some cases, participation in intervention programmes is contingent on agreeing to this (Hyde & Punch, 2011). The implications of different language-learning environments for deaf children's academic and social-emotional

outcomes will be discussed in the remainder of the essay.

Speech / Spoken Language-Only

Several studies found that speech-only language-learning environments produce better outcomes for deaf pupils with CIs, particularly in terms of speech intelligibility and auditory reception (Geers, Spehar & Sedey, 2002; Tobey, Rekart, Buckley & Geers, 2004). However, the studies may no longer accurately reflect the current population of deaf children receiving CIs, as advancements in technology, and early screening and detection, mean that the profiles of pupils implanted over a decade ago are potentially vastly different from the profiles of pupils implanted now. In a recent study by Geers et al. (2017), information on the exposure to sign language of 97 children with CIs was provided by parents at baseline (just before CI surgery) and again 12, 24, and 36 months later. Level of signing post-implantation led to statistically significant differences in speech recognition, speech intelligibility, spoken language, and reading comprehension. No exposure was correlated with better performance across all measures, which supports previous research.

Similar findings have emerged in the educational context; the speech perception and language comprehension of pupils in mainstream, speech-only classrooms were significantly better at 36 and 60 months post-implantation compared to pupils taught using sign-supported speech or sign language only (Langereis & Vermeulen, 2015). Overall academic achievement was also better. From these findings, one might conclude that sign-language exposure following CIs has no advantages for children's academic achievement, and may in fact hinder it. However, many studies into CIs, including that of Geers et al. (2017), recruit only children from hearing parents; there is a lack of research with children from non-hearing families who would be fluent in sign language (Mitchiner, 2015). It is important to investigate whether outcomes would be different following exposure to sign language from proficient signers.

Bimodal Bilingualism

Learning spoken language and sign language simultaneously is considered a form of bilingualism due to the notably different linguistic features between the two languages (Blom & Marschark, 2015). The term "bimodal" indicates the use of two different modalities (Menéndez, 2010). Some Deaf parents recognise that learning spoken English would help their children succeed in a "Hearing World" and remove the barriers they themselves had faced, and so choose CIs for their deaf children in order to achieve this (Mitchiner, 2015). The number of bilingual deaf children may be increasing if more Deaf parents make this choice. Despite this, few studies have compared the outcomes of bimodal bilinguals to deaf children with CIs born to hearing parents (Mitchiner, 2015). Hassanzadeh (2012) found that bilingual children with CIs had better speech perception, speech production and overall language development than those from hearing families. However, the evidence is inconsistent; in a similar, comparative study by Jiménez and colleagues in 2009, bimodal bilinguals had better verbal and manual expression, but poorer speech intelligibility. For children who sign to achieve better expression using hand gestures, this is potentially unsurprising. However, they also achieved better comprehension of visual symbols and verbal fluency (they were able to evoke

a greater number of words using a picture stimulus).

Bimodal bilingualism may have other cognitive advantages too; it was found to enhance cognitive control in terms of attention switching (Kushalnagar, Hannay & Hernandez, 2010), mental flexibility, psychomotor speed and some aspects of working memory (MacNamara & Conway, 2014). Due to the use of distinct sensory-motor systems for spoken and sign language, there is also no processing cost for switching between languages (Emmorey, Giezen & Gollan, 2016). Therefore, bilingual children may have cognitive advantages over those taught spoken language only.

One of the other perceived benefits is participation and belonging in both the Hearing and Deaf communities. Young bimodal bilinguals who were interviewed about their experiences saw learning spoken English as advantageous in terms of gaining an education and future employment, and access to the Hearing World. (Ford & Kent, 2013). They also valued learning sign language as they could access the Deaf community and make friends with non-speaking Deaf individuals, with whom they could not otherwise communicate. Difficulties with social, emotional and mental health (SEMH) appear to be elevated for deaf students, including those with CIs (Huber & Kipman, 2011), but "deaf community identification, socialization with deaf peers, and early access to communication with family and peers" are protective factors (Hall, 2017, pp. 963). Thus, sign bilingualism may promote positive identity formation, and lead to better social-emotional and language outcomes.

Total / Simultaneous Communication

Total or simultaneous communication (TC / SC) uses signs alongside spoken language (Lederberg, Shick & Spencer, 2013). In SC, the word order of the spoken language is maintained, unlike in traditional sign languages which have different phonology and grammar (Blom & Marschark, 2015). SC has led to reading abilities above the national average for deaf students, sometimes on par with their hearing peers (Spencer, Barker & Tomblin, 2003; Spencer, Gants & Knutson, 2004). However, pupils in these studies were implanted relatively late, and recent research with children who received their CIs much younger is lacking. Other researchers suggest that it is the early development of good underlying language skills, rather than their communicative environment, which leads to successful literacy outcomes (Lederberg et al., 2013). Our understanding of literacy development in children with CIs is limited and more research is needed to inform what teaching approaches will lead to the greatest improvements.

In terms of other academic outcomes, the evidence is mixed. Past research has found that CI users in mainstream education who used SC had significantly higher receptive and expressive spoken vocabulary than children taught using speech-only (Connor, Hieber, Arts & Zwolan, 2000). In addition, SC may enhance children's language comprehension depending on the learning environment, and the material presented. Children with CIs have worse speech perception in noisy environments, or ones with poor acoustics (Eisenberg et al. 2017; Iglehart, 2016). In 2017, Blom, Marschark and Machmer found that when background babble was present, giving students spoken materials accompanied by signs led to significantly higher

comprehension scores than presenting materials without signs. In an earlier study of 40 college students, SC proved advantageous when difficult material was presented, but had no advantage over speech alone for material that was less difficult (Blom & Marschark, 2015). These findings may be particularly relevant to deaf children of secondary school age or older; the academic gains made by CI users in primary school do not always carry over into secondary education (Geers, Tobey, Moog & Brenner, 2008), and this may be due to the increasing complexity of the concepts being taught. Therefore, they may benefit more from SC than children in primary schools.

Discussion

In the last two decades, a few studies have investigated the outcomes of pupils with CIs taught in different communicative environments. The few which recommend spoken language-only tend to specifically address speech outcomes (Fitzpatrick et al., 2016), and conclude that reduced signing post-implantation leads to better spoken language (Geers et al., 2017). Parents who speak and sign may expose their children to slightly less aural input, which could lead to slower development of auditory perception skills and delayed spoken language as a result. However, these findings seem to be negated for children raised as bimodal bilinguals, who may even outperform their peers from hearing families (Hassanzadeh, 2012). As many hearing parents are not proficient signers, it may be that the quality of exposure to sign language, not the quantity, is the key factor. Hassanzadeh (2012) recruited only 14 children in this study, and so the generalisability of the findings is limited. Such comparative research has not been conducted to date in the UK, which is an area for possible future research. Bimodal bilingualism may also indirectly contribute towards academic outcomes by promoting better social-emotional wellbeing in terms of belonging, friendships, and identity formation (Ford & Kent, 2013; Mitchiner, 2015).

There are, however, barriers to the development of bilingualism in all deaf children with CIs. Hearing parents face significant challenges in learning enough sign language to communicate with their children (Hyde & Punch, 2011). Therefore, it is unlikely that the sign language input at home will be sufficient. Humphries et al. (2012a) argue that families should be better supported to learn sign language, and access to sign language courses improved, to enable parents to become more proficient. In addition, all deaf children should have frequent contact with signing individuals in the Deaf community, to provide good signing models. Such contact may also help them foster a Deaf identity, which has positive implications for their belonging.

The issue of inadequate signing input is further compounded by a lack of sign language exposure in school. Parents must choose either a predominantly signing or predominantly spoken language educational placement (Mitchiner, 2015). Children taught in mainstream, oral-language classrooms do not receive sign language input from school. If there is no input from school, and limited input from the home because of parents' abilities, then bilingualism will not develop. Even Deaf parents in Mitchiner's (2015) study expressed concerns about their children not receiving sufficient input to become fluent in both languages, and felt pressured to sign at home in order to compensate for this.

As some have argued that learning sign language is a fundamental human right for deaf children (Ladd, 2007), there is some support for the introduction of British Sign Language (BSL) in mainstream schools. This would increase sign language exposure for deaf children, and may enable hearing peers to communicate with them in multiple modalities. Deaf children and young people (CYP) reported feeling more comfortable with their dual identity when hearing people learn sign language, rather than them always being expected to adapt (Ford & Kent, 2013). They appreciated the effort made by hearing individuals who tried to use some signs, even if they were not proficient (Sutherland & Young, 2007). In addition, learning sign language has benefits for the hearing peers. In the Sign in Education pilot, hearing children taught in BSL for one afternoon a week showed increased levels of motivation, attention and concentration (Robinson, 1997). In America, kindergarten pupils who received American Sign Language instruction developed better receptive language (Daniels, 2004). Therefore, it appears that both parties would benefit from this approach. However, there may be difficulties with recruiting enough native BSL signers to deliver instruction in all schools. In addition, the UK Government does not currently recognise BSL as a foreign language, and lobbying by those in favour of BSL teaching has not yet produced a shift in Government policy. Therefore, it may be more beneficial to look at alternative teaching methods for deaf children with CIs.

One alternative is Sign Supported English (SSE), which is a form of SC. SC can be advantageous in certain situations, such as noisy environments, or when explaining novel, complex concepts (Blom et al., 2017; Blom & Marschark, 2015). However, as these studies were conducted with college students, it is unknown whether the findings would apply to younger learners, or children who had received their implants earlier. This would be important to determine using future longitudinal research. As SSE follows the grammatical structure of spoken English, it could be implemented by one trained member of staff, which makes it more practical than instruction in speech and BSL.

SSE may also be advantageous in the home environment. Some parents of deaf children reported becoming almost fluent in Signed English after struggling with Australian Sign Language (Hyde & Punch, 2011). If SSE is easier for hearing parents to learn, and is used within schools, this will ensure a more consistent approach. It would also enable parents to communicate with their children if the CI developed a fault and stopped working, which some parents have experienced and found challenging (Hyde & Punch, 2011). Some children with CIs who fully develop spoken language may still choose to sign later in life as a means of establishing a Deaf identity and signing with deaf peers (Wheeler, Archobold, Hardie & Watson, 2009). As SSE is based on signs from BSL, having some level of SC in schools could help facilitate this should children choose to become sign bilingual in the future.

SC may be one way of increasing sign exposure in school. However, there are limitations to its implementation. Although SSE is based on signs from a sign language, there is a clear distinction between the two in the minds of young Deaf bilinguals (Ford & Kent, 2013). There are implications in terms of communication with BSL users, as some level of adaptation needs to be made, and this may compromise the Deaf identity of CYP. Furthermore, SC is only

successful in supporting students' learning if delivered by skilled users (Marschark, Sapere, Convertino & Pelz, 2008). As Lederberg et al., (2013) write, "the production of sign systems by hearing adults varies considerably, and omissions and mis-signings are not infrequent" (pp. 17). Therefore, the benefits of SC could be compromised by improper delivery. The implication of this is that schools would need to be proactive in training or employing staff to deliver instruction in SSE as and when required.

Implications for Educational Psychologists (EPs)

Further research is needed to determine whether SC, or any model, has the potential for improving outcomes of deaf children with CIs in the UK (Fitzpatrick et al., 2016). EPs may play a part by contributing to the research in this field, in order to help inform policy and practice. The findings will have significant implications for allocation of resources within schools, and so any practices with deaf children must be evidence-based, and supported by robust research (Spooner, McKissick & Knight, 2017). According to Rhoades (2018, pp. 154), "this should not be trumped by either politics or ideology". At the heart of the EP role is advocating for the rights and best interests of the child, and so EPs could contribute valuable evidence that is free from any political agenda. If further research concludes that SC is a valuable mode of instruction, then EPs may have a role to play in bringing about organisational change by disseminating the findings from the research to schools, in order to encourage them to move towards this approach for learners with CIs.

In addition to considering organisational change, and nation-wide policy and practice, it is equally important to consider the views of individual learners. Some qualitative research has investigated the views of deaf CYP but it is limited, and focussed on social-emotional benefits of speaking and signing (Ford & Kent, 2013; Sutherland & Young, 2007). EPs involved in consultations with schools may aid in capturing the individual child's voice, and their views on the advantages and disadvantages of a SC approach for their learning and SEMH, through use of specific tools at their disposal. This could be expanded into wider, small-scale research at LA level to support the existing findings in the literature.

Conclusion

Children born deaf or hearing-impaired and fitted with CIs have better linguistic and academic outcomes than non-implanted peers; however, these outcomes are highly variable (Geers et al., 2009). One influencing factor is the child's language-learning environment (Jiménez et al., 2009). There is a lack of sufficient recent, empirical research properly comparing language outcomes of pupils in different environments (Fitzpatrick et al., 2016), and the research to date has yielded inconsistent findings, with different studies producing evidence in favour of spoken language-only, bilingual and SC models. Speech-only environments appear to produce better speech intelligibility and auditory perception in deaf children born to hearing parents (Geer et al., 2017). However, CI users born to Deaf, signing parents perform better, which suggests that being a bilingual speaker of both languages has advantages for children's development (Hassanzadeh, 2012). Bilingualism may also protect against SEMH difficulties, by enabling CYP to form a Deaf identity and participate in that community (Ford & Kent, 2013).

In addition, early sign language exposure may accelerate spoken language development (Jasinska et al, 2013).

As most deaf children are born to hearing parents, who may struggle to learn sign language (Mitchiner, 2015), there are barriers to bimodal bilingualism developing in all deaf children with CIs. Improving access to sign language courses, and integration into the Deaf community from the point of diagnosis, regardless of parents' intentions to implant, may increase exposure to sign language at home and in the community (Humpries et al., 2012a). Signing exposure in school could be increased through use of a TC / SC approach. However, as with other models, there is mixed evidence for SC, and Fitzpatrick et al.'s (2016) meta-analysis concluded that adding sign language to spoken language neither enhances nor interferes with language acquisition. This area requires further research within the UK context. Currently, only one comparative study into SC versus speech-only has been carried out in the UK (Connor et al., 2000); the rest were conducted in other countries, and there may be issues with generalising the findings from different languages and education systems to our own. Finally, in light of some studies which have found no effect of different communicative environments on outcomes, (Yanbay, Hickson, Scarinci, Constantinescu & Dettman, 2014) it is also important for future research to consider what other factors, in addition to the language-learning environment, might explain the variation.

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