

Main Article

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Abstract

Objectives. To evaluate the mental health of paediatric cochlear implant users and analyse the relationship between six dimensions (movements, cognitive ability, emotion and will, sociality, living habits and language) and hearing and speech rehabilitation.

Methods. Eighty-two cochlear implant users were assessed using the Mental Health Survey Questionnaire. Age at implantation, time of implant use and listening modes were investigated. Categories of Auditory Performance and the Speech Intelligibility Rating Scale were used to score hearing and speech abilities.

Results. More recipients scored lower in cognitive ability and language. Age at implantation was statistically significant ($p < 0.05$) for movements, cognitive ability, emotion and will, and language. The time of implant usage and listening mode indicated statistical significance ($p < 0.05$) in cognitive ability, sociality and language.

Conclusion. Timely attention should be paid to the mental health of paediatric cochlear implant users, and corresponding psychological interventions should be implemented to make personalised rehabilitation plans.

Introduction

Cochlear implantation is an effective surgical method for treating severe to extremely severe sensorineural deafness. According to public data from the China Disabled Persons' Federation, during 2018 and 2020 the total number of people receiving cochlear implant surgery and hearing aid adaptation in China was 1 109 842 (420 172, 365 933 and 323 737 people received cochlear implant surgery and hearing aid adaptation services in 2018, 2019 and 2020, respectively; the data comes from the public data of <https://www.cdpf.org.cn>).

It is believed that the disease itself and medical treatment usually have an impact on patients' psychology, and might change their behaviour, attitude and mood.¹ Mental health problems caused by sensorineural deafness and the impact of cochlear implant on the patients' psychological status after surgery have therefore received widespread attention. Compared to healthy children, deaf children have a higher prevalence of mental and behavioural disorders.² Paediatric cochlear implant users showed more emotional symptoms and companion problems, such as insufficient self-confidence, loneliness and timidity.³ Castellanos *et al.*⁴ found that deaf children were 2.6 times more likely to have psychological problems than normal children.

By evaluating the mental health of 82 paediatric cochlear implant users, this study analysed the relationship between six dimensions (movements, cognitive ability, emotion and will, sociality, living habits and language) and hearing and speech rehabilitation to provide a reference for making rehabilitation plans for paediatric cochlear implant users.

Materials and methods

Participants

After excluding children with white matter lesions, epilepsy, autism and other nervous system diseases, 82 cochlear implant users (3–6-year-old children) from a hospital in northwest China from June 2018 to June 2022 were investigated. The subjects were diagnosed with bilateral severe or extremely severe sensorineural deafness, and underwent hearing and speech rehabilitation training at formal rehabilitation institutions.

Measures

The participants were assessed using the Mental Health Survey Questionnaire for 3–6-year-old children (Appendix 1), which was adapted by the Guangzhou Xieneng Children Development Centre based on the Children's Development questionnaire compiled by American psychologist Levant. The questionnaire consists of groups of questions for three age ranges: 3–4 years old, 4–5 years old and 5–6 years old. Each group has 38–40

questions, covering the six dimensions of movements, cognitive ability, emotion and will, sociality, living habits and language, which basically reflect the whole picture of children’s mental development. There are two options for each question: Yes and No. Choosing Yes means scoring 1, whereas choosing No means scoring 0. Finally, the scores for each question in the six dimensions were summed. If the total scores in each dimension reached or exceeded the standard criteria, participants were considered to have reached the level of a normal child in the same month in this dimension, which is called the ‘qualified rate’ hereafter. And vice versa.

The participants’ hearing and speech abilities were scored using the Categories of Auditory Performance (Appendix 2) and the Speech Intelligibility Rating Scale (Appendix 3) proposed by Professor Nikolopoulos of Nottingham University. The Categories of Auditory Performance test uses an eight-point hierarchical rating scale to assess auditory perception. Scores range from the lowest level (0) of being unaware of environmental sounds to the highest level (7) of using the telephone with a known person. The Speech Intelligibility Rating Scale is used to show the degree of comprehensibility of the speaker’s speech, such that the listener can understand the speaker’s message. It consists of five hierarchical categories ranging from 1 (connected speech is unintelligible, pre-recognisable words in spoken language and the primary mode of communication may be manual) to 5 (connected speech is intelligible to all listeners and children understand it easily in everyday contexts).

Statistical analysis

Data were analysed using GraphPad Prism 9.0.0. Descriptive statistics are presented using mean ± standard deviation and proportions. The scores of implant time usage and listening modes were analysed using the Kruskal–Wallis test, and the scores of age at implantation were analysed using the independent *t*-test and the Wilcoxon rank-sum test. Using the Wilcoxon rank-sum test, the mean scores of the Categories of Auditory Performance and the Speech Intelligibility Rating Scale of those who met the standard criteria of the Mental Health Survey Questionnaire in every dimension were compared with the mean scores of those who did not.

Results and analysis

Scores of all dimensions and qualified rates

Participants were divided into three groups based on their age at the time of the investigation: 36–48, 49–60 and 61–72 months. As shown in Table 1, the qualified rate of the participants was higher for movements but lower for cognition,

emotion and will, sociality and language. The qualified rate of children aged 36–48 months (66.7 per cent) was higher than that of the other two groups.

Age at implantation

In terms of age at implantation, the participants were divided into two groups: less than or equal to 36 months and more than 36 months. The scores for movements were analysed using an independent *t*-test (as they were in accordance with the normal distribution) and the variance was even. The scores in the other five dimensions were analysed using the Wilcoxon rank-sum test (because they were not normally distributed).

Figure 1 shows that the scores in all dimensions of the less than or equal to 36 months group were higher than those of the more than 36 months group. Significant differences were observed in movements, cognitive ability, emotion and will, and language, but not in sociality and living habits.

Time of implant usage

In terms of the time of implant use, participants were divided into three groups: less than or equal to 12 months, 13–24 months and more than 24 months. The scores in the six dimensions of each group were analysed using the Kruskal–Wallis test (because they did not conform to the normal distribution). Figure 2 shows that the longer the duration of implant usage, the higher the scores on all dimensions. Compared with the less than or equal to 12 months group and the 13–24 months group, the more than 24 months group scored significantly higher in cognitive ability, sociality and language.

Listening modes

The participants were classified into three groups according to their listening mode: cochlear implant, cochlear implant + cochlear implant, cochlear implant + hearing aid. The scores in the six dimensions of each group were analysed using the Kruskal–Wallis test (because they did not conform to the normal distribution). From Figure 3, it can be seen that the scores of the children in the latter two groups were higher than those of children with unilateral cochlear implants in all dimensions, and statistical significance (*p* < 0.05) was observed in cognitive ability, sociality and language.

Categories of Auditory Performance and the Speech Intelligibility Rating Scale

Based on whether the participants met the standard criteria for each dimension of the Mental Health Survey Questionnaire, they were divided into two groups (Yes or No). The

Table 1. Scores for all dimensions of the paediatric cochlear implant users’ mental health questionnaire at different ages (scores, $\bar{x} \pm s$) and qualified rates (cases, *n* (%))

Age (months)	Cases (<i>n</i>)		Movements	Cognitive ability	Emotion and will	Sociality	Living habits	Language
36–48	21	Score	6.86 ± 1.31	5.10 ± 1.84	3.62 ± 1.60	3.62 ± 1.72	6.62 ± 1.66	3.05 ± 2.77
		Qualified rate	47.6 (10)	4.8 (1)	28.6 (6)	19.0 (4)	66.7 (14)	4.8 (1)
49–60	36	Score	8.50 ± 1.81	7.92 ± 4.93	4.97 ± 2.24	3.69 ± 3.13	1.50 ± 1.00	3.00 ± 2.85
		Qualified rate	36.1 (13)	25.0 (9)	22.2 (8)	19.4 (7)	25.0 (9)	2.8 (1)
61–72	25	Score	3.32 ± 1.80	3.88 ± 2.91	1.24 ± 0.52	4.60 ± 2.33	5.12 ± 1.54	3.80 ± 2.63
		Qualified rate	36.0 (9)	4.0 (1)	6.0 (15)	16.0 (4)	32.0 (8)	8.0 (2)

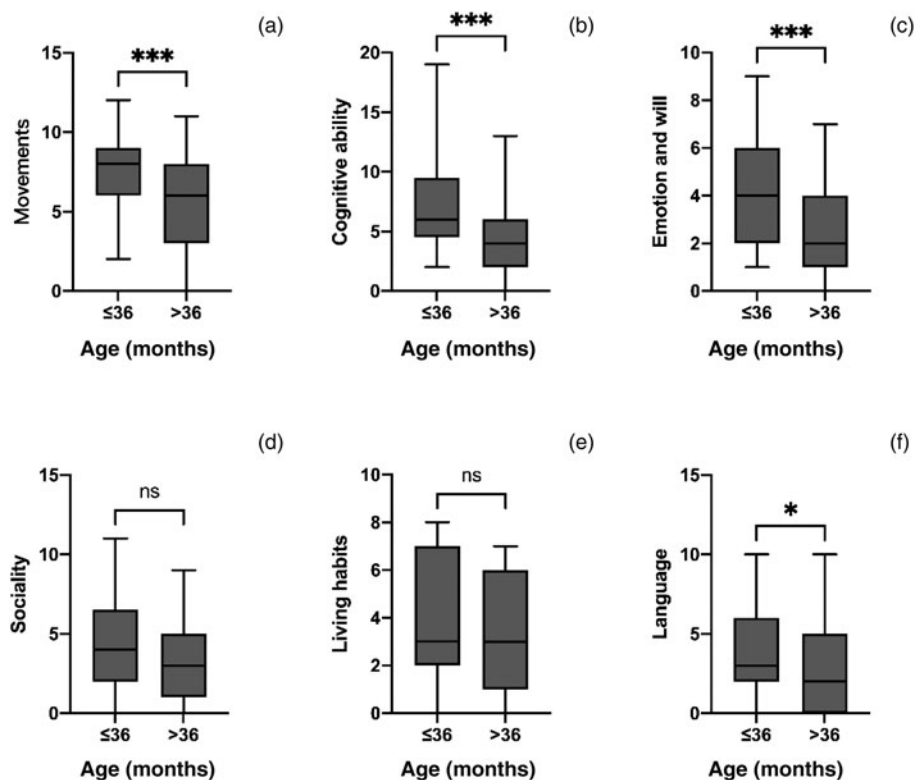


Figure 1. Comparison of scores for various dimensions of the mental health of children in terms of age at implantation: (a) movements, (b) cognitive ability, (c) emotion and will, (d) sociality, (e) living habits and (f) language. Centre lines indicate median values, boxes represent interquartile ranges and error bars show overall ranges. * $p < 0.05$; *** $p < 0.001$; ns = not significant

Categories of Auditory Performance and the Speech Intelligibility Rating Scale scores in each dimension were analysed using the Wilcoxon rank-sum test (because they were not normally distributed). Figures 4 and 5 show that the mean Categories of Auditory Performance and Speech Intelligibility Rating Scale scores of the Yes group in the five dimensions were higher than those of the No group, and there was statistical significance ($p < 0.05$) in cognitive ability.

Discussion

Deaf children and adolescents are at a high risk of mental and neurodevelopmental disorders, with a prevalence of 19–77

per cent. The risk of depression, anxiety and somatoform disorder in this group is higher than in hearing people.⁵ Children with hearing impairment are twice as aggressive as those with normal hearing.⁶ Hearing loss has a negative impact on the development of receptive and expressive language, and such children will have learning difficulties and decreased academic achievement,⁷ which will lead to a lack of self-confidence and psychological barriers such as anxiety and depression.

Cochlear implantation not only provides a safe and comfortable hearing range for hearing-impaired patients but also aims to promote mental health and improve their quality of life. It also has demonstrated a positive impact on improving anxiety and depression in deaf patients, and prolonged

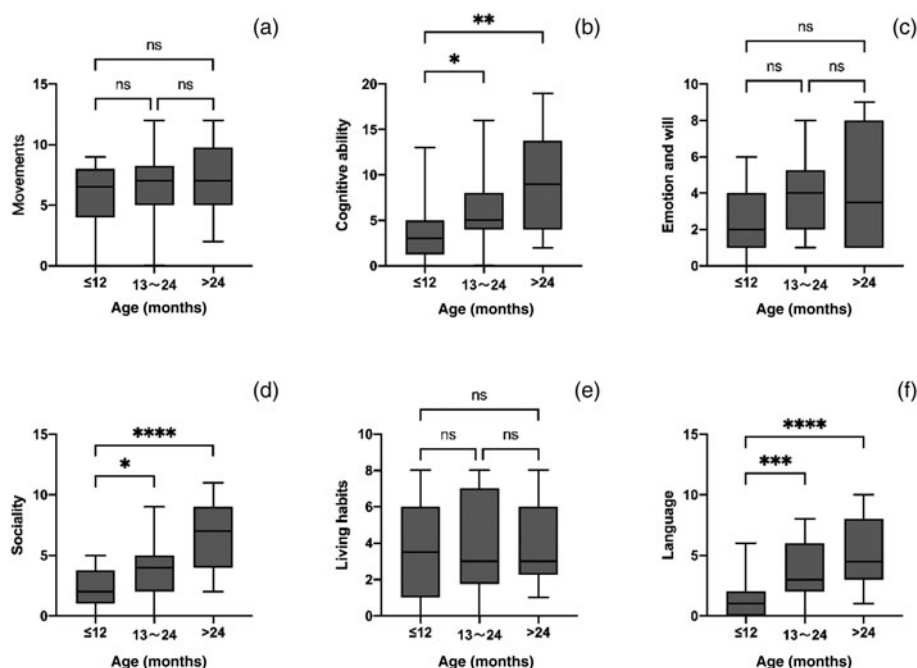


Figure 2. Comparison of scores for various dimensions of the mental health of children in terms of time of implant usage: (a) movements, (b) cognitive ability, (c) emotion and will, (d) sociality, (e) living habits and (f) language. Centre lines indicate median values, boxes represent interquartile ranges and error bars show overall ranges. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$; ns = not significant

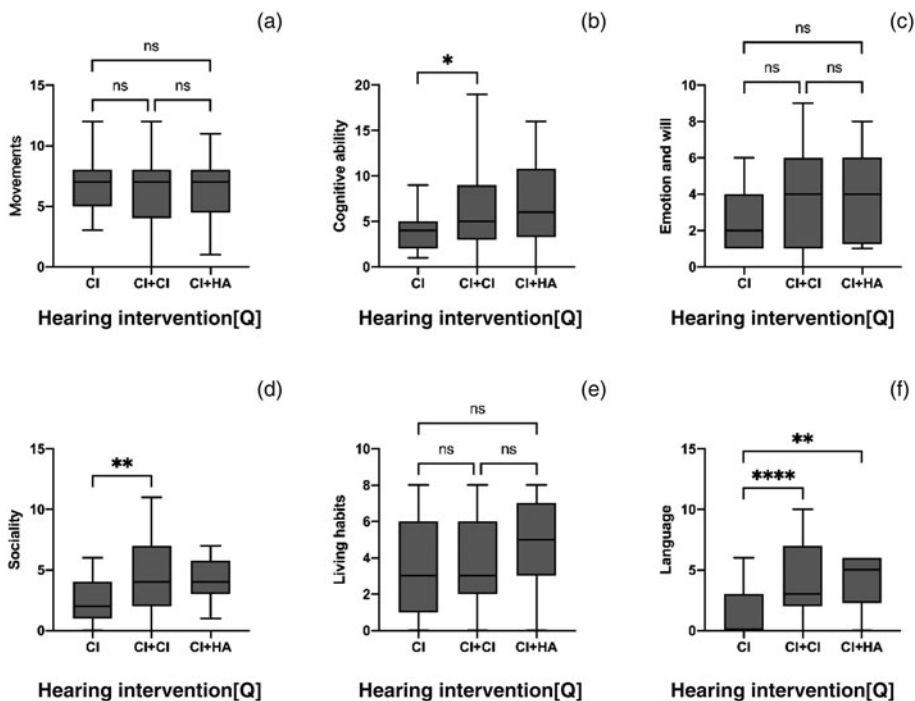


Figure 3. Comparison of scores for various dimensions of the mental health of children using unilateral, bilateral cochlear implant and binaural mode: (a) movements, (b) cognitive ability, (c) emotion and will, (d) sociality, (e) living habits and (f) language. Centre lines indicate median values, boxes represent interquartile ranges and error bars show overall ranges. * $p < 0.05$; ** $p < 0.01$; **** $p < 0.0001$; ns = not significant; CI = cochlear implant; HA = hearing aid

implant usage helps improve the mental health of patients.⁶ However, these patients experience a higher psychological burden than those with normal hearing.⁸

The results of this study show that cochlear implant users aged 3–6 years generally have lower scores and qualified rates in the six dimensions of the Mental Health Survey Questionnaire, especially cognitive ability and language. Previous studies have found that children with cochlear implants have many defects in cognitive ability, sociality, language and attention.^{9,10} Children with good cognitive ability, language and communication skills have better overall

psychosocial outcomes,¹¹ therefore clinical workers and guardians of children with cochlear implants should pay attention to their post-operative mental health when formulating individualised rehabilitation plans for them. Necessary intervention measures should also be implemented to promote the development of mental health, thus reducing the incidence of mental health disorders and guaranteeing better integration into mainstream society.

This study also shows that the younger the age at implantation, the higher the scores patients will achieve in all dimensions, especially in the four dimensions of movements,

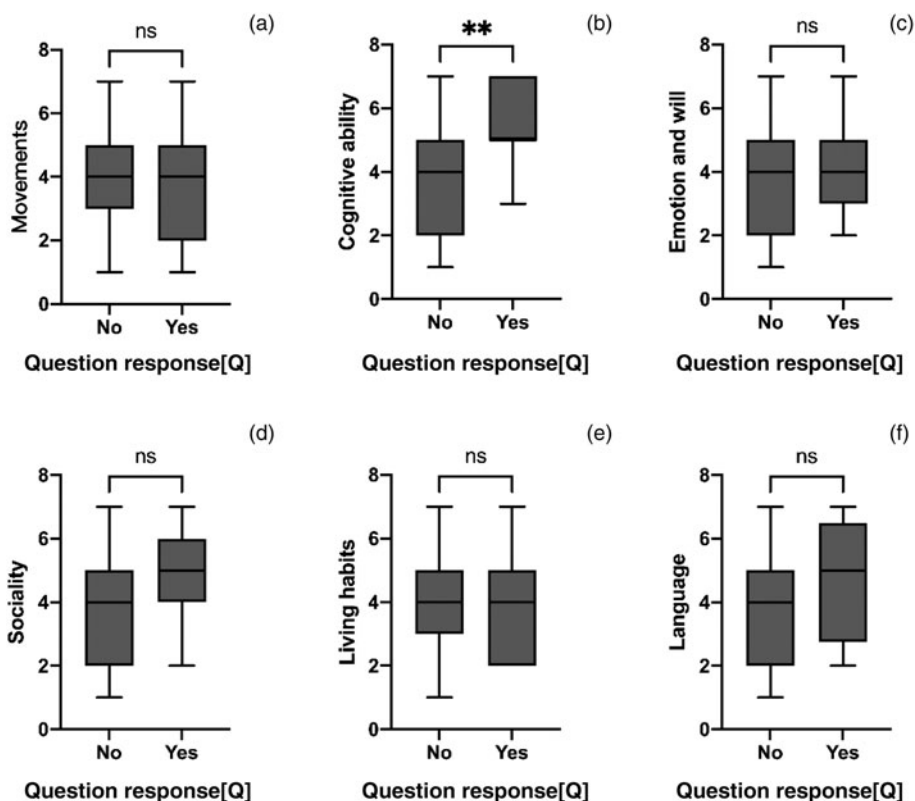


Figure 4. Comparison of Categories of Auditory Performance scores between participants reaching the standard criteria or not: (a) movements, (b) cognitive ability, (c) emotion and will, (d) sociality, (e) living habits and (f) language. Centre lines indicate median values, boxes represent interquartile ranges and error bars show overall ranges. ** $p < 0.01$; ns = not significant

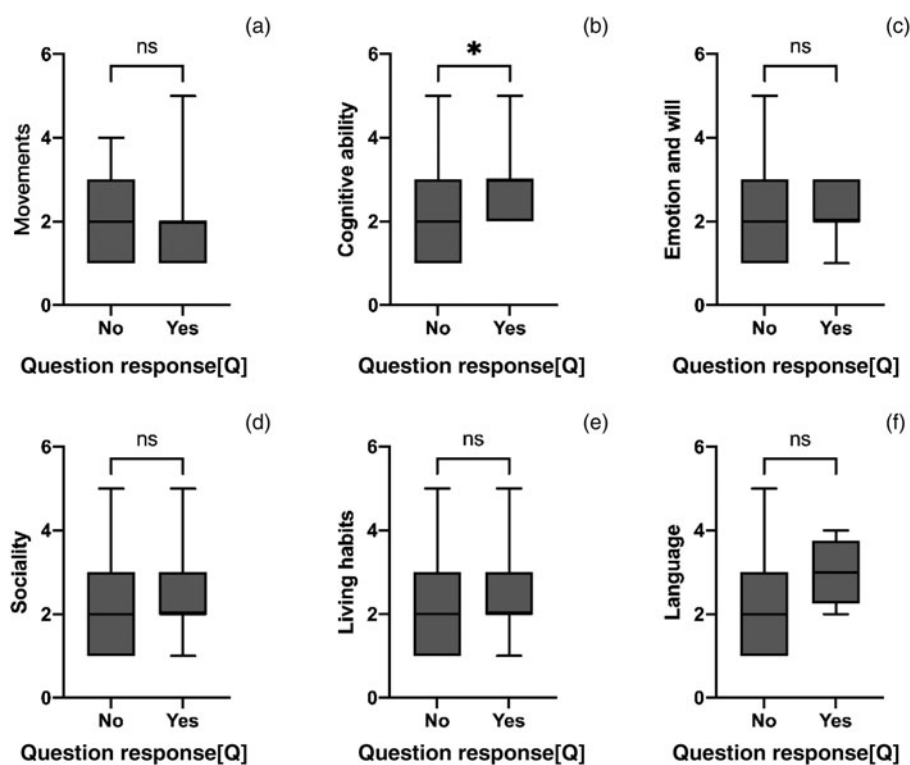


Figure 5. Comparison of Speech Intelligibility Rating Scale scores between participants reaching the standard criteria or not: (a) movements, (b) cognitive ability, (c) emotion and will, (d) sociality, (e) living habits and (f) language. Centre lines indicate median values, boxes represent interquartile ranges and error bars show overall ranges. * $p < 0.05$; ns = not significant

cognitive ability, emotion and will, and language. The development of hearing and speech functions is inseparable from that of the brain. Studies have shown that children’s brains develop most quickly before the age of 3,¹² therefore the younger the age at implantation, the better the children’s cognitive ability and language expression.¹³ Earlier surgery may lead to richer vocabulary, better oral ability and better speech intelligibility.¹⁴

With increasing age of children with cochlear implants, those with better hearing and speech function show a relatively extroverted personality, and they will also perform better in emotion and will, and sociality. However, for children younger than 12 months, there are higher risks of surgery, anaesthesia and post-operative complications because of their underdeveloped mastoid.¹⁵ This study indicates that the earlier deaf children received cochlear implants, the better they performed in all mental health dimensions. Cochlear implant surgery is recommended as soon as possible for deaf children older than 12 months, as this is conducive to the development of their mental health.

It was found that the longer the duration of implant usage, the higher the scores in all dimensions, especially in the three dimensions of cognitive ability, sociality and language. Previous literature^{12,16} reported that the hearing and speech functions of children with cochlear implants gradually improved with increased implant usage. Children’s hearing and speech functions developed most quickly within one year after the operation, especially in the first six months. The current study suggests that the longer the duration of implant usage, the better the children’s hearing and speech performance.

The children’s social scores also gradually increased after communicating with people with normal hearing during regular rehabilitation training. This indicates that their psychological status gradually recovers with the increasing time of implant usage. It can therefore be considered that the longer the time of implant usage, the less likely it is that children will have psychological problems, thus long-term cochlear implantation is strongly recommended. Guardians should

encourage children to actively communicate with others and improve their language understanding and communication skills to enable them to complete the identity conversion from rehabilitation to ordinary school students.

The scores of the cochlear implant and cochlear implant, and cochlear implant and hearing aid groups were higher than those of the cochlear implant group in all dimensions, especially cognitive ability, sociality and language. Guerzoni *et al.*¹⁷ found that unilateral cochlear implant group children were inferior in reading comprehension to cochlear implant and cochlear implant, and cochlear implant and hearing aid groups. Xu *et al.*¹⁸ showed that the vocabulary growth rate in the cochlear implant and cochlear implant group was better than that in the cochlear implant and hearing aid group. Sharma *et al.*¹⁹ pointed out that the cochlear implant and cochlear implant group had stronger speech noise perception and sound source localisation ability than the cochlear implant group.

This study showed that binaural-bimodal fitting or bilateral cochlear implantation is beneficial to the mental health of paediatric cochlear implant users, therefore it is recommended that children with unilateral cochlear implants use binaural-bimodal fitting after operation or that bilateral cochlear implantation is performed if conditions permit it.

The mean Categories of Auditory Performance and Speech Intelligibility Rating Scale scores of participants meeting the standard criteria in the five dimensions (cognitive ability, emotion and will, sociality, living habits, and language) of the Mental Health Survey Questionnaire were higher than those of participants who did not meet the standard criteria, and there was a statistically significant difference in cognitive ability. The cognitive ability of children with hearing impairments is an important factor in predicting speech perception after surgery. Children with better cognitive ability have higher scores in auditory speech.²⁰

It was found that the mental health of children is not only related to their age at implantation and time of implant usage, but also to their hearing ability and speech intelligibility.

Children scoring higher on the Categories of Auditory Performance and Speech Intelligibility Rating Scale spontaneously communicated more with those with normal hearing. From the collection of questionnaire data, it was clear that most children with better post-operative hearing and speech function were more extroverted, more willing to communicate with others and their sociality developed better. This indicates that the development of good language and functional communication is extremely important for the development of good social psychology.

The limitations of the present study include the fact that a cross-sectional study may not have determined the changes in the mental health of children with cochlear implants. A longitudinal study should be included in future research. Respondents' different understandings of the questions in the Mental Health Survey Questionnaire might have caused subjective results. The Categories of Auditory Performance and Speech Intelligibility Rating Scale scores seemed to reach a ceiling effect a few years after implant usage, making an exact subsequent assessment impossible.

Conclusion

During the post-operative follow up of cochlear implant users, attention should be paid to hearing, speech rehabilitation and mental health. In China, the majority of cochlear implant users are children. Childhood is a critical period for personal physical and psychological development, therefore importance should be attached to post-operative psychological changes, carrying out corresponding psychological interventions in cases of abnormalities and formulating personalised rehabilitation plans. The occurrence of bad emotions may thus be reduced and children with cochlear implants may live like hearing children of the same age, with the aim of returning to society and reducing the burden on families and society.

- Factors affecting mental health were analysed using the Mental Health Survey Questionnaire and the scores were compared with the Categories of Auditory Performance and Speech Intelligibility Rating Scale scores
- Children with cochlear implants who were younger at implantation and had longer implant usage had higher Mental Health Survey Questionnaire scores, indicating better rehabilitation after surgery
- The development of good language and functional communication is extremely important for good mental health development

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Competing interests. None declared

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Appendix 1

Mental Health Questionnaire for Children Aged 3~4

- (1) Can you ride a stroller? ① Yes ② No
- (2) Can you climb stairs alternately with both feet? ① Yes ② No
- (3) Can you build things like houses and cars with building blocks? ① Yes ② No
- (4) Do you often draw pictures like faces with crayons? ① Yes ② No
- (5) Can you say your name? ① Yes ② No
- (6) Can you distinguish between male and female partners, and know your gender? ① Yes ② No
- (7) Do you seldom drop food during meals? ① Yes ② No
- (8) Do you have to wear a diaper to sleep at night? ① Yes ② No
- (9) Can you unbutton your pants when you go to the toilet? ① Yes ② No
- (10) Do you often say “good”, “bad”, “like” and “dislike” to express your own thoughts? ① Yes ② No
- (11) Do you like some of the characters in some storybooks or cartoon dramas? ① Yes ② No
- (12) Can you swing or sit on a seesaw? ① Yes ② No
- (13) Can you jump off 2~3 steps? ① Yes ② No
- (14) Can you eat with chopsticks? ① Yes ② No
- (15) Can you brush your teeth with a toothbrush? ① Yes ② No
- (16) Can you cut paper with scissors? ① Yes ② No
- (17) Do you often quarrel with friends and complain to your parents? ① Yes ② No
- (18) Do you always like to ask “why”? ① Yes ② No
- (19) Do you often add your own name when speaking? ① Yes ② No
- (20) Can you basically speak in everyday life? ① Yes ② No
- (21) Do you know what “beautiful” and “interesting” mean? ① Yes ② No
- (22) Do you deliberately say the opposite and play language games? ① Yes ② No
- (23) Do you often play different roles when playing games? ① Yes ② No
- (24) Do you often play with your companions for more than half an hour? ① Yes ② No
- (25) Do you often run out with a “Yah!” to frighten people when they are not noticing? ① Yes ② No
- (26) Do you like to listen to certain songs or stories repeatedly and memorise them carefully? ① Yes ② No
- (27) Do you often imitate the singing of singers? ① Yes ② No
- (28) Do you like to play a good role in games? ① Yes ② No (29) You never urinate at will while playing. ① Yes ② No
- (30) Do you often count when handling things? ① Yes ② No
- (31) You do not cry when washing your hair, bathing or changing clothes in cold weather. ① Yes ② No
- (32) Will you help clean up the dishes after eating? ① Yes ② No
- (33) Will you go to the designated place? ① Yes ② No
- (34) Can you distinguish between “above”, “in the middle” and “below”? ① Yes ② No
- (35) Do you often urge your partner to do something? ① Yes ② No
- (36) When speaking, do you often use some conjunctions to connect the words? ① Yes ② No
- (37) Do you ask adults for help when you encounter something you cannot do? ① Yes ② No
- (38) When you need to use something, do you say “please lend me...”? ① Yes ② No
- (39) When playing hide-and-seek, do you often hide in places where others cannot find you? ① Yes ② No
- (40) Do you understand the meaning of words expressing time such as “today”, “yesterday”, “forever”, etc.? ① Yes ② No

Standard criteria for each dimension of psychological development for children aged 3~4

Dimensions	Movement	Cognitive ability	Emotion and will	Sociality	Living habits	Language
Number of items	1, 2, 12, 13, 14, 15, 16, 25, 33	3, 4, 6, 11, 16, 18, 22, 25, 26, 27, 30, 34, 36, 37, 39, 40	10, 11 19, 21, 26, 27, 28, 31, 33	5, 17, 20, 22, 23, 24, 28, 35, 37, 38	7, 8, 9, 14, 15, 29, 31, 32	5, 6, 10, 17, 18, 19, 20, 21, 22, 30, 34, 35, 36, 38, 40
Age (months)						
40	3 scores	6 scores	3 scores	3 scores	3 scores	6 scores
44	6 scores	12 scores	5 scores	6 scores	5 scores	10 scores
48	9 scores	16 scores	9 scores	10 scores	8 scores	15 scores

Mental Health Questionnaire for Children Aged 4~5

- (1) Can you jump long distance with both feet? ① Yes ② No
- (2) Can you do somersaults? ① Yes ② No
- (3) Can you throw a ball with another person at close range with both hands? ① Yes ② No
- (4) Can you squeeze something out of plasticine or clay? What is the shape of the item? ① Yes ② No
- (5) When speaking, do you use “I” to represent yourself? ① Yes ② No
- (6) When reading picture books with a partner, do you discuss with each other? ① Yes ② No
- (7) Do you often tell your mother or other caregivers what you see or hear? ① Yes ② No
- (8) Do you often exchange toys or other objects with your partner? ① Yes ② No
- (9) Can you cut paper with scissors and cut out some shapes? ① Yes ② No
- (10) Do you know how to apply paste on paper and paste it? ① Yes ② No

- (11) Can you jump with one foot? ① Yes ② No
- (12) Can you hold the bar with your hands and hang your body up and down? ① Yes ② No
- (13) Can you shoot the small ball correctly? ① Yes ② No
- (14) Do you often quote other people's words when speaking? ① Yes ② No
- (15) When you want to do something, do you often discuss with your peers? ① Yes ② No
- (16) Do you often say "let us do it..." before doing something? ① Yes ② No
- (17) Do you look sad when you see pictures of poor people in picture books or on TV? ① Yes ② No
- (18) Can you learn the guessing game of "hammer, scissors, cloth"? ① Yes ② No
- (19) If an adult praises something you have done, will you tell all the details of it? ① Yes ② No
- (20) Do you look sad if you fail in games? ① Yes ② No
- (21) Do you often pay attention to the health of your mother or caregiver and say "someone is sick!?" ① Yes ② No
- (22) When there is pain somewhere on the body, can you tell the exact location of the pain? ① Yes ② No
- (23) Do you sometimes compare what you do with what others do? ① Yes ② No
- (24) Do you often take a bath by yourself? ① Yes ② No
- (25) Do you often know how to wipe your nose? ① Yes ② No
- (26) Do you often wash your face and dry yourself? ① Yes ② No
- (27) Do you often tell your teachers and peers what you have experienced the day before? ① Yes ② No
- (28) Do you often brag to your peers? ① Yes ② No
- (29) Can you say things like "today is..." and "there are... days"? ① Yes ② No
- (30) When writing or drawing wrongly, do you use an eraser to correct them, or redo them? ① Yes ② No
- (31) When reading picture books or watching TV, do you often add your own imagination to understand? ① Yes ② No
- (32) Do you know how to wring out the towel after washing your face? ① Yes ② No
- (33) Can you draw more regular squares or other figures? ① Yes ② No
- (34) Can you help people convey information roughly and accurately? ① Yes ② No
- (35) Do you like to help with housework? ① Yes ② No
- (36) Can you count from 1 to 10? ① Yes ② No
- (37) When you see your companions have good toys, you will ask your parents to buy them too, but never take other people's toys as your own? ① Yes ② No
- (38) When you want to play with friends, do you often say "I want to play too"? ① Yes ② No
- (39) When you fall, if your parents tell you to be strong, will you stop crying? ① Yes ② No

Standard criteria for each dimension of psychological development for children aged 4~5

Dimensions	Movements	Cognitive ability	Emotion and will	Sociality	Living habits	Language
Number of items	1, 2, 3, 4, 9, 10, 11, 12, 13, 18, 24, 25, 32	3, 4, 6, 9, 10, 15, 16, 18, 20, 21, 22, 23, 27, 29, 30, 31, 33, 34, 36	5, 17, 20, 21, 23, 28, 30, 37, 38, 39	7, 8, 14, 15, 16, 19, 27, 28, 34, 37, 38	22, 26, 35	5, 6, 7, 14, 19, 27, 29, 31, 34, 36
Age (months)						
52	6 scores	6 scores	3 scores	3 scores	2 scores	5 scores
56	12 scores	16 scores	9 scores	9 scores	3 scores	9 scores
60	13 scores	19 scores	10 scores	11 scores	3 scores	10 scores

Mental Health Questionnaire for Children Aged 5~6

- (1) Can you raise both arms horizontally and turn around with eyes closed? ① Yes ② No
- (2) Can you jump on rubber bands or ropes? ① Yes ② No
- (3) Can you shoot a ball while walking? ① Yes ② No
- (4) Can you find materials to make simple toys? ① Yes ② No
- (5) Can you draw a simple plot based on the content of the story? ① Yes ② No
- (6) When someone does not agree to your request, will you try to persuade the others? ① Yes ② No
- (7) When telling a story, do you often make up plots based on your imagination? ① Yes ② No
- (8) When you are told that something cannot be done, do you pay attention to other people's compliance? ① Yes ② No
- (9) Do you often take the initiative to invite your peers to play games? ① Yes ② No
- (10) When eating, you never litter the rubbish, and can pack up after meals. ① Yes ② No
- (11) Do you use paper to clean your butt after defecation? ① Yes ② No
- (12) Can you jump over a height of 30~40 cm with your knees? ① Yes ② No
- (13) When playing games, do you often compete in groups of peers? ① Yes ② No
- (14) Can you jump vertically and touch objects on the spot? ① Yes ② No
- (15) Can you easily draw different postures of people? ① Yes ② No
- (16) Can you count objects within 10 and give the total number? ① Yes ② No
- (17) When you want to go to a friend's house, do you often ask your parents for permission first? ① Yes ② No
- (18) Do you like to ask about the meaning of some words in picture books? ① Yes ② No
- (19) Can you write your own name? ① Yes ② No
- (20) Can you read the time on the clock? ① Yes ② No
- (21) Do you often use the words spoken by adults in different contexts? ① Yes ② No
- (22) Do you often debate with others? ① Yes ② No

- (23) Can you stand on one foot for 5~10 seconds with arms raised? ① Yes ② No
- (24) Do you show concern when you see your partners in difficulty, and do your best to help them? ① Yes ② No
- (25) Can you turn left (right)? ① Yes ② No
- (26) Can you fetch things as instructed, or buy things from the store? ① Yes ② No
- (27) Can you make your own bed? ① Yes ② No
- (28) Will you greet guests? ① Yes ② No
- (29) Can you build complex simulations with building blocks or sand with your partners? ① Yes ② No
- (30) Do you know the difference between horizontal and vertical? ① Yes ② No
- (31) Can you sleep alone? ① Yes ② No
- (32) Can you tie your shoelaces? ① Yes ② No
- (33) Do you dry yourself after taking a shower? ① Yes ② No
- (34) Can you give the address of your home? ① Yes ② No
- (35) Can you describe the content of pictures coherently? ① Yes ② No
- (36) Can you tell what day of the week yesterday was, today is and tomorrow will be? ① Yes ② No
- (37) When someone younger than you is making trouble for no reason, can you bear it? ① Yes ② No
- (38) Can you play the Word Solitaire Game? ① Yes ② No

Standard criteria for each dimension of psychological development for children aged 5~6

Dimensions	Movements	Cognitive ability	Emotion and will	Sociality	Living habits	Language
Number of items	1, 2, 3, 12, 14, 23	4, 5, 15, 16, 25, 30, 36, 7, 9, 13, 18, 21, 29, 39	24, 37	28, 9, 13, 6, 22, 8, 29, 24, 37, 17, 34	10, 11, 17, 26, 27, 31, 32, 33, 34	19, 20, 35, 7, 18, 21, 25, 30, 36, 38, 6, 22, 8, 29, 26
Age (months)						
64	4 scores	6 scores	1 scores	5 scores	4 scores	5 scores
68	5 scores	14 scores	2 scores	10 scores	8 scores	12 scores
72	6 scores	15 scores	2 scores	11 scores	9 scores	15 scores

Appendix 2

Categories of auditory performance (CAP)

Score	Criteria
0	No awareness of environmental sounds
1	Awareness of environmental sounds
2	Response to speech sounds
3	Recognition of environmental sounds
4	Discrimination of some speech sounds without lip-reading
5	Understanding of common phrases without lip-reading
6	Understanding of conversation without lip-reading
7	Use of telephone with a known listener

Appendix 3

Speech intelligibility rating (SIR)

Score	Scoring criteria
1	Connected speech is unintelligible. Pre-recognisable words in spoken language, primary mode of communication may be manual.
2	Connected speech is unintelligible. Intelligible speech is developing in single words, when context and lip-reading clues are available.
3	Connected speech is intelligible to a listener who concentrates and lip-reads within a known context.
4	Connected speech is intelligible to a listener who has a little experience of a deaf person's speech; the listener does not need to concentrate unduly.
5	Connected speech is intelligible to all listeners. Child is understood easily in everyday contexts.