Cognitive ability and speech discrimination in adults with a unilateral cochlear implant

Version 2

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Abstract

**Introduction:** Each year an increasing number of Swedish adults receive cochlear implants (CI), mostly to improve spoken communication. Speech discrimination following CI insertion is affected by the patient’s cognition, i.e. working memory, phonological representation and lexical access, all pre-operatively evaluated by sub-tests in the clinical test battery KIPS.

**Aim:** To investigate the relationship between KIPS and post-operative speech discrimination after insertion of a unilateral CI in Swedish adults, and the possible prognostic value of KIPS in selection of CI candidates in the future.

**Material and Methods:** A retrospective chart review of 24 patients was performed, of which 19 were selected for the final analysis. The absolute change between pre-operative and 6 months post-operative speech discrimination results were plotted against the results of each KIPS sub-test in scatter diagrams.

**Results:** 17 patients improved their speech discrimination. Greater improvement was seen in patients over 65 years and those hearing impaired as adults, compared to patients younger than 65 years and those hearing impaired in childhood. No correlation between the results on KIPS and post-operative speech discrimination improvement was found.

**Conclusion:** This study showed no relationship between KIPS and the change in speech discrimination. Most, but not all, previous work on speech discrimination and cognition was confirmed in regard to age and duration of deafness despite a small study population. More research on the overall result on KIPS and improved speech discrimination is necessary to establish its prognostic value.

**Keywords:**
Cochlear implant
Cognition
KIPS
Lexical access
Phonological representation
Speech discrimination
Working memory
### List of Abbreviations

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<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>CI</td>
<td>cochlear implant</td>
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<tr>
<td>dB</td>
<td>decibel</td>
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<td>PB-list</td>
<td>phonetically balanced list</td>
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<td>BMI</td>
<td>body mass index</td>
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<td>TIPS</td>
<td>text information processing system</td>
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1. Introduction

1.1 Unilateral cochlear implant
A cochlear implant (CI) is a hearing device used to improve communication and hearing in patients with hearing loss. The CI consists of an external speech processor, placed behind the ear over the temporal bone, which transmits sound signals through the skin to a surgically implanted internal receiver. The sound signals stimulate the auditory nerve fibers by transmission through the internal receiver to an electrode inserted into the cochlea, enabling the individual to perceive sound as the auditory nerve relays the signal to the brain. A unilateral CI consists of one device implanted in one ear, but many patients receive bilateral CIs and have one device implanted in each ear [1,2]. Following insertion of a CI the recipient must exercise the neural circuits regularly, with the help of a professional CI team in auditory rehabilitation, in order to help the brain learn and re-learn how to interpret sounds and to eventually improve hearing [3].

![Diagram of cochlear implant](image)

**Figure 1. Hearing with a cochlear implant.** (After permission from Cochlear®).

1. Microphones on the sound processor pick up sounds and the processor converts them into digital information.
2. This information is transferred through the coil to the implant just under the skin.
3. The implant sends electrical signals down the electrode into the cochlea.
4. The hearing nerve fibers in the cochlea pick up the signals and send them to the brain, giving the sensation of sound.

1.2 Speech audiometry – reception threshold and discrimination
Speech audiometry tests are a way of determining comprehension of speech, as opposed to pure tone audiometry that only establishes hearing sensitivity with pure tones presented at different frequencies and intensity levels. In the first test of speech audiometry the patient is asked to repeat two-syllable words that are presented with equal accentuation on each syllable
at different intensities, that is they are presented at different decibels (dB). The result determines the speech reception threshold, measured as the intensity at which the patient is able to repeat at least 50% of the words in a correct manner, as this is the minimum number of words an individual must understand in order to comprehend regular conversation [4]. The speech reception threshold sets the lower limit for the second test, the speech discrimination test, in which recognition, or discrimination, of words above the threshold is determined. The words used in speech discrimination tests are phonetically balanced, meaning that they are presented at a frequency consistent with regular conversation [2]. Words presented can be multi- or monosyllabic; the latter are used for the purpose of quantitative measurement to establish the number of words the patient is able to repeat from a standardized phonetically balanced list (PB-list), usually comprised of 50 monosyllabic words [4]. The percentage of words correctly repeated represents the level of communication that the patient is at. The normal hearing individual has a 100% comprehension level at 65dB, but testing usually starts at the intensity where the patient can hear the words comfortably above the speech reception threshold. An intensity level around 50-60 dB represents normal conversation, but increasing the level does not affect the result, and since it is only interesting to establish the individual patient’s ability to discriminate between words, the test leader must present the words at an intensity that the patient is able to hear. Depending on the nature of the patient’s hearing loss, tests are performed with or without masking with noise on the opposite ear, which is known to increase the validity and sensitivity of the test [5].

1.3 Unilateral cochlear implant surgery - indications, prevalence and benefits

The Swedish National Board of Health and Welfare’s list of conditions when a patient should be offered unilateral CI surgery are the national guidelines for candidate selection. Certain conditions are dependent on the caregiver and the CI team surrounding the patient, including psychosocial and pedagogical staff as well as audiological and surgical staff. The remaining conditions are related directly to the patient:

1. The best ear has a pure tone average in pure tone audiometry louder than 70dB hearing level, as well as a result less than 50% in speech audiometry with phonetically balanced monosyllable words.

2. Using optimally suited hearing aids; pure tone audiometry at 4 kilohertz is equal to or less than 50dB, or the result of speech audiometry with phonetically balanced monosyllable words is less than 50%.
The patient does not suffer from a disease or condition that interferes with the procedure [3].

However, not every patient meeting the conditions is offered an implant. A study of CI prevalence from Göteborg, Sweden showed that only 11.8 per 100,000 residents were offered assessment for CI surgery although as many as 18.6 per 100,000 residents fulfilled the audiometric criteria. The study reasoned that the discrepancy between the prevalence of patients with a CI and the prevalence of patients qualified for, but not receiving, a CI could be due to patients being offered and then rejecting a CI, severe illness (although these patients may in fact have the greatest need of a CI) and physicians unable to identify patients that meet the criteria [6]. Although the patients receiving a CI are fewer than those meeting the criteria for one, the number of CI surgeries among Swedish adults 20 years and older is steadily rising [Figure 2]. Considering health economy it has been determined that a unilateral CI in a Swedish adult is cost effective, although the evidence is weak. Also, older patients as well as patients with a long duration of deafness have been established as less cost effective [3]. Still, only a small number of patients that could benefit from a CI actually receive one, and if all patients who fulfill the audiometric criteria were assessed for surgery a significantly higher number of individuals would likely become implanted [6].

![Figure 2](http://www.socialstyrelsen.se/statistik/statistikdatabas/operationerislutenvard)
Improved spoken communication is the desired benefit in most CI candidates. It is important to note that the constantly updating criteria for CI candidacy have changed to include a wider group of individuals that are not primarily selected for improved speech recognition. Studies of tinnitus and unilateral deafness in the same ear reveal that unilateral CI can be used as a successful treatment for this condition [7,8]. Some patients benefit from a CI with the aim of improved communication even though they do not fulfill the audiometric criteria. That is, their hearing impairment is not severe enough to qualify for surgery but after receiving a CI their communication level is still significantly enhanced. Patients unable to communicate through speech in everyday situations without written interpretation can also benefit from a CI, as well as patients with progressive vision impairment [3]. In addition, certain individuals with different types of syndromes, such as the CHARGE syndrome, do not develop a spoken language but are increasingly becoming implanted with the aim of improving quality of life and connecting with the people surrounding them [9].

1.4 Factors affecting speech discrimination
Factors affecting post-operative speech discrimination in CI candidates in a study of 114 post-lingually deafened individuals, i.e. individuals deafened after development of spoken language, were related to the anatomical position of the CI as well as cognition, age at implantation and duration of hearing loss [10]. Studies of age at implantation and CI outcome have reached different conclusions on whether speech discrimination is affected negatively post-operatively by age, or rather is an effect of duration of deafness [11]. As the implant position does not relate directly to the hearing impaired individual’s cognitive ability, age or duration of impairment, it will not be considered in this study.

Cognitive ability, or cognition, includes the processes of problem solving, memory and language. It is developed through explicit experiences that enable the expansion of neural circuits [12]. Cognition has been associated with a number of factors, such as smoking habits [13], level of education, age [14] and Body Mass Index (BMI) [15]. Specific cognitive skills that are associated with speech understanding are phonological processing skills, working memory and lexical access [16]. All cognitive activities include use of the phonological processing system, more specifically so in activities related to language processing (either written or spoken). Phonological representation is the mental representation of sounds made by the brain, i.e. the sound as it is presented in the brain when read or listened
to [17]. A study comparing cognitive skills and speech understanding in CI candidates with a control group of hearing individuals showed that cognitive tests requiring explicit use of phonological representation gave significantly lower results in the CI group. However, cognitive tests that do not require explicit use of phonological representation, such as working memory and lexical speed, showed no difference to the control group. Among the hearing impaired, a pre-operative level of phonological representation equal to the hearing individuals resulted in higher scoring on post-operative speech understanding tests than the individuals with a lower level of pre-operative phonological representation [18]. The phonological processing skills in adults with acquired hearing loss have been shown to deteriorate, which correlates to the duration of deafness [19].

Working memory and lexical access do not correlate to duration of hearing loss, but are instead affected by age; especially these skills deteriorate over the age of 65 years [10,20]. Lexical access is the ability to process sound information into comprehensive language. The speed at which this information can be retrieved from long-term memory is called lexical speed or verbal inference speed and is important for speech understanding following CI surgery. If a patient performs poorly on lexical speed tests it will affect all other types of cognitive processing skills [21,22].

It has been established that working memory is also related to speech discrimination [20], and that individuals with CI’s who also have a less extensive working memory seem to perform well on speech discrimination tests as long as their phonological representation is intact. Similarly cochlear implanted individuals with less intact phonological representation but a well functioning working memory also receive high results on speech discrimination tests and are capable of understanding and conversing with a person out of sight or over the telephone. Thus, the ability to fill in the missing auditory stimulation in a hearing impaired individual is dependent on phonological representation as well as working memory, but deterioration in one of the two does not necessarily result in poorer speech recognition [18].
1.5 KIPS

The K in KIPS stands for *klinik* (clinic), as KIPS is a clinical test battery used to assess a patient’s cognitive abilities, specifically abilities important for perception of sound in the hearing impaired. It is used in the process of selecting CI candidates in some parts in Sweden.

It has been developed from the more comprehensive Text-Information-Processing-System test called TIPS, which takes almost 1 hour to complete, but has been shortened to 20-40 minutes to better suit a clinical context. KIPS consists of different sub-tests each giving a separate score that can be united in an overall evaluation [23]. The three distinct cognitive skills included in the test battery are working memory, phonological representation and lexical access. The test battery has been described in greater detail in previous research [24]. A brief explanation of the tests follows.

Working memory is tested using a reading span test in which the patient is shown three-letter sentences that are either normal as in *Prästen läste bibeln* (The priest read the Bible) or meaningless/absurd as in *Senapen sov skönt* (The mustard slept well). The patient is asked to press yes on a keyboard if the sentence makes sense, and no if the sentence is absurd. After a set of three, four or five sentences the patient is asked to orally repeat the first or last word in each sentence. The test leader counts the number of correctly repeated words from each set.

Phonological representation is tested in the rhyme test. The patient is presented two words at a time and is asked to press the yes-button if they rhyme, and the no-button if they do not. The patient is instructed to answer as fast as possible. The test results are presented as the number of correctly given answers, and the average speed at which they were given.

Lexical access is tested in two different sub-tests. In the first, the physical match test, the patient is presented two letters at a time and asked to press the yes-button if they are identical, as in *AA*, and the no-button if they are different, as in *Aa*. The patient is instructed to answer correctly and as fast as possible, and the results are given as number of correct answers, and the average speed at which the answers were given. The second test is the lexical text test. The patient is presented one word at a time and asked to press the yes-button if the word makes sense, and the no-button if it is a nonsense-word, and is instructed to answer as fast as possible. The results of the lexical text test are also given as the number of accurate answers and the average speed it took for the patient to answer [23].
1.6 Aim

Prior work has studied the relationship between hearing impaired or cochlear implanted individuals and their cognitive abilities, respectively. There are also studies on the relationship between pre-operative cognition and the subsequent outcome of cochlear implantation that is measured as speech discrimination, most of them in noise [3]. The rising numbers of patients fulfilling the criteria for or receiving a CI in Sweden will likely result in a future need to select the individuals with a higher probability of greater post-operative results, especially as the evidence of cost effectiveness is weak and some patient groups are already known to be less cost effective.

The aim of this study is to investigate the relationship between the cognitive abilities measured by the KIPS test battery, and the change in speech discrimination after insertion of a unilateral cochlear implant in Swedish adults. Does a better result on any of the sub-tests in KIPS lead to greater change in speech discrimination after implantation with a unilateral CI, and can the sub-tests of KIPS be used as prognostic predictors in selecting candidates that may benefit more of a CI than others in the future?

2. Material and Methods

2.1 Study design

The study was performed as quality assessment work in the form of a retrospective chart review at the Ear-, Nose-, Throat Clinic and the Audiology Clinic at the Örebro University Hospital, Sweden. The same person reviewed the patient charts after the inclusion criteria were established, and extracted the data to an external computer.

2.2 Patients

All patients who had received their first CI in Örebro up until March 2015 and whose test results of KIPS were available were originally included in the patient chart review. 24 patients were identified and their charts were assessed. Information was gathered on the patient’s age, gender, BMI, smoking habits, occupation, level of education, other diseases, duration of hearing impairment, language, test results on KIPS. Pre-operative speech discrimination data was collected as the last test available before surgery, and post-operative data as all available
tests after surgery. Post-operative test results varied in time from four days to 36 months after surgery, with test results from 6 months after surgery available for the highest number of patients. The patients who had been tested at 6 months post-operatively were therefore selected for the statistical analysis of the study and a more extensive chart review. Of the original 24 patients five patients were excluded; two due to neuropsychiatric disorders that could affect the result of KIPS, and three had not been tested at 6 months after surgery. 19 patients were ultimately included in the final analysis of the study.

Among the 19 patients there was an even distribution in gender and age groups (over and under 65 years). There were slightly more patients with a hearing impairment acquired in adult life compared to the patients who had been hearing impaired from childhood. All patients hearing impaired as children were under the age of 65 at surgery, but only three patients who became hearing impaired as adults were also in the younger age group. All patients were able to communicate in spoken language, and six patients were also able to use sign language in addition to spoken language [Table 1].

**Table 1. Basic characteristics of patients included for statistical analysis.**

<table>
<thead>
<tr>
<th></th>
<th>Number of patients n</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At surgery mean ± SD (range)</td>
<td>58 ± 17 (21-80)</td>
<td></td>
</tr>
<tr>
<td>At surgery n &gt; 65 years (%)</td>
<td>9 (47)</td>
<td></td>
</tr>
<tr>
<td>At surgery n &lt; 65 years (%)</td>
<td>10 (53)</td>
<td></td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women n (%)</td>
<td>10 (53)</td>
<td></td>
</tr>
<tr>
<td>Men n (%)</td>
<td>9 (47)</td>
<td></td>
</tr>
<tr>
<td><strong>Duration of hearing impairment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>From childhood n (%)</td>
<td>7 (37)</td>
<td></td>
</tr>
<tr>
<td>Age n &gt; 65 years (%)</td>
<td>0 (0)</td>
<td></td>
</tr>
<tr>
<td>Age n &lt; 65 years (%)</td>
<td>7 (100)</td>
<td></td>
</tr>
<tr>
<td>From adulthood n (%)</td>
<td>12 (63)</td>
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</tr>
<tr>
<td>Age n &gt; 65 years (%)</td>
<td>9 (75)</td>
<td></td>
</tr>
<tr>
<td>Age n &lt; 65 years (%)</td>
<td>3 (25)</td>
<td></td>
</tr>
<tr>
<td><strong>Language</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spoken only n (%)</td>
<td>13 (68)</td>
<td></td>
</tr>
<tr>
<td>Spoken and sign language n (%)</td>
<td>6 (32)</td>
<td></td>
</tr>
</tbody>
</table>
2.3 Statistics

Descriptive statistics in the form of scatter and bar diagrams, mean values and standard deviation was used to evaluate the relationship between each sub-test on KIPS and the change on PB-list, which was calculated as the absolute change between pre- and post-operative results. Each scatter diagram was visually inspected for positive or negative correlation between the two parameters. All numbers were set at two significant digits.

2.4 Ethical considerations

Reviewing patient charts is always an intrusion on a person’s privacy, but to follow up and ensure the quality of healthcare it is sometimes necessary to analyze the procedures and care that has been given and to evaluate the outcome. This study was performed as a quality assessment at two different clinics, and written permission was given by the clinical department head at each clinic to access and assess the patient charts. The data extracted from the charts was specified beforehand and extracted to non-confidential files on a private computer. Each patient received a code number in the extracted files to ensure no one would be able to link the results to a specific individual, and no names or personal identity numbers were extracted.
3. Results

All patients except two improved their speech discrimination results 6 months after surgery, compared to pre-operative results. The two patients that displayed a negative absolute change were hearing impaired as children and younger than 65 years. Six patients had a pre-operative result on PB-list that was described as not measurable, which automatically put them at 0%. Figure 3 illustrates the speech discrimination data for all patients.

![Speech discrimination data per patient measured pre- and post-operatively as percentage on phonetically balanced list (PB-list). Change in speech discrimination displayed as absolute change between pre-operative and post-operative PB-lists.](image)

The average pre-operative result on PB-list was 11% (SD±12%) and the average post-operative result on PB-list was 43% (SD±23%), with a mean absolute change of 32 (SD±27). The patients in the age group 65 and above displayed a mean absolute change of 42 (SD±21), and lower age group a mean absolute change of 21 (SD±28). Those who had been hearing impaired from childhood had a mean absolute change of 6 (SD±18) and the patients hearing impaired as adults had a mean absolute change of 45 (SD±19).
The patients scored an average of 54% (SD±19%) on the reading span test. There was no correlation between high scores on the reading span test and greater absolute change on PB-list. The patients in the age group above 65 years generally scored lower, averaging 42% (SD±18%), while the younger age group scored an average of 64% (SD±13%) [Figure 4].

![Figure 4](image)

**Figure 4.** Relationship between result on reading span test and absolute change on phonetically balanced list according to age group. ¹) One patient marked × (>65 years) is not visible in the figure at (10, 63%)

Rhyme accuracy and rhyme speed results revealed an average of 81% (SD±13%) and 1819ms (SD±612ms), respectively. No correlation between results on rhyme accuracy or speed and absolute change on PB-list were visible. There were also no differences on rhyme tests between the patients who had been hearing impaired as children and the patients who had become hearing impaired later in life.

Physical match accuracy was high in the younger age group, with a mean of 98% (SD±4%), and lower in patients over 65 years, who displayed a mean of 77% (SD±23%). The younger patients also had a faster response time in physical match speed, averaging 868ms (SD±187ms), compared to an average of 1112ms (SD±256ms) for patients aged above 65 years. The patients who had a high absolute change on PB-list did not respond faster on the
physical match speed test than the rest of the study group, nor were they more accurate on the physical match accuracy test. All patients received high scores on the test for lexical accuracy, with a mean of 95% (SD±6%), with no difference between age groups. The patients under 65 years were slightly faster in the lexical speed test compared to the older patients. The former had a mean response time of 910ms (SD±194ms) and the latter 1171ms (SD±714ms). In the age group above 65 years one patient had a significantly longer response time at 3046ms, and taking this patient out of account, the same age group had a mean response time of 938ms (SD±137ms). There was no correlation between lexical speed or rhyme tests and absolute change on PB-list.

BMI, smoking habits, other illnesses and level of education were poorly noted in the patient charts, and or not available for all patients, and thus these factors were excluded from the statistical analysis.

4. Discussion

4.1 General discussion

As expected most of the patients in the study performed better on post-operative speech discrimination tests, improving their communication skills in spoken language, as this is usually the main purpose of cochlear implantation. The patients with a negative outcome, who were hearing impaired in childhood, may have undergone CI surgery for other reasons than improved communication via speech, for example to hear traffic sounds or for better spatial awareness. Progression of hearing impairment in adult life is more commonly due to age and noise-exposure during life [25] and it is less plausible that patients with an acquired hearing loss in adulthood were offered a CI for other reasons than improved speech discrimination. This might possibly also explain the negative results for those hearing impaired in childhood.

The markedly lower mean absolute change in the younger patients, who were also the patients hearing impaired in childhood, might be explained by the same reasons as mentioned above, since most of the patients under 65 years were also hearing impaired in childhood. One of the patients hearing impaired as a child suffered from tinnitus, and one of the younger aged patients, although hearing impaired as an adult, suffered from sudden deafness on the
opposite ear, supporting the notion that these patients did not necessarily receive a CI due to desired speech discrimination improvement. Tinnitus in itself can also cause lower speech discrimination results [2]. As the charts did not specify the reason that lead the CI team to decide that the patient would benefit from CI surgery it remains unknown if the poor results on PB-list could represent a different desired benefit than improved spoken communication.

None of the sub-tests on KIPS showed any correlation to the change in speech discrimination post-operatively, negative or positive. The following part of the discussion deals with the results confirming or rejecting previous research in this area.

The older patients had poorer reading span than the younger, which is consistent with other studies [10,20]. However, both age groups had a positive mean absolute change on PB-lists but varying results on the reading span test, and a better score on the former did not match a better score on the latter. In fact the patients aged above 65 years had a higher mean absolute change on PB-list than the younger patients despite their generally lower results on the reading span test. This suggests that a higher score on reading span tests cannot be used to predict a greater improvement in speech discrimination after CI surgery.

Prior work showing that duration of deafness affects phonological representation [19], tested by rhyme accuracy and speed in KIPS, could not be supported by this study. Our results might be explained by the previous studies stating that a poor phonological representation can be compensated by a well functioning working memory. It is however noteworthy that no correlation between rhyme tests and absolute change on PB-list was found, as it does not concur with previous work, which established that phonological representation is of greatest importance for post-operative speech understanding in CI recipients [18]. Still, the importance of phonological representation in speech discrimination cannot be confirmed nor rejected by the results of this analysis without evaluating and cross matching individual sub-tests, such as reading span, for each patient.

Physical match accuracy and speed results coincided with the study in which younger individuals performed faster and more accurately [10]. The older age group had a slower average lexical speed, but after excluding one patient with a significantly slower speed the result of the older group was close to the younger age group, which suggests that age might
influence lexical test results as previously shown [10], but that it might also be depending on the individuals tested. Poor performance on lexical tests is known to have a negative effect on overall cognition[21,22], which raises the question of what effect this has on the overall result on KIPS in the patients with lower scores on lexical tests and if this affected the outcome of the original analysis between the different sub-tests and post-operative speech discrimination.

4.2 Limitations
The results in this small group of patients cannot be assumed to represent a larger population. Not knowing the reason why they became CI candidates is an issue as the aim of this study is to evaluate speech discrimination and there may have been patients included that did not receive a CI for the purpose of improved spoken communication. It is also difficult to evaluate issues concerning duration of hearing impairment, as the patients were only known to have become hearing impaired in child- or adulthood, which depending on the individual could mean all between 2 and 50 years of hearing impairment and says nothing of the degree and progression of hearing loss from when it was first discovered. An important limitation is that it is unknown what effect the sub-tests on KIPS have on each other, and how this affected the end result. The other factors associated with cognition and that might have had some effect on the KIPS sub-tests, such as smoking and BMI, could not be analyzed in this study as they were poorly noted in the patient charts. Lastly, the anatomical position of the implant may also have had a great influence on the result, since it is known that the position affects speech discrimination in CI patients.

5. Conclusion
The overall improved speech discrimination for the patients included in this study was an expected result. The extent of improvement that differed according to age group and duration of deafness could possibly depend on differences in desired outcome as not every patient is selected for CI surgery with only the aim to improve spoken communication. Previous work regarding the factors affecting each sub-test was largely confirmed by this study. The diverging results in lexical speed as well as phonological representation may be explained by individual variations and that the studied cognitive abilities may affect one another. It should be recalled that age and duration of deafness, which are two of the factors affecting speech
discrimination in the hearing impaired, are known to affect the third factor, cognition. It is unknown which of the cognitive abilities tested in KIPS and analyzed in this study, or any of the two other factors, could be of greatest importance regarding post-operative speech discrimination improvement. None of the sub-tests on KIPS showed any correlation to the absolute change on PB-list, positive or negative. Using the sub-tests on KIPS as possible prognostic predictors for improved post-operative speech discrimination is therefore not supported by our study. In fact, the question rises whether KIPS is a useful clinical routine test in the preoperative investigation of CI candidates. Our study suggests KIPS has an uncertain predictive value and considering it consumes both time and effort from the patient and the caregiver, perhaps it should still be looked upon as a research field, rather than as part of the preoperative assessment of possible CI candidates.

6. Further research

This study has raised a series of questions that should be addressed in the future. The most important is how a combined overall result on KIPS affects post-operative speech discrimination. In order to further evaluate if KIPS could be used as a prognostic predictor for improved speech discrimination, studies exclusively on patients with the main purpose to improve spoken communication are needed. It is also of interest to know to what extent the sub-tests of KIPS influence and affect each other, and if it would be possible to adjust post-operative auditory rehabilitation according to the results on KIPS sub-tests. For example, can a better phonological representation be used to develop an individual training program that takes advantage of that specific cognitive ability in the patient?

7. Acknowledgements

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8. References


