Phonological capacities in deafened adults and individuals with a severe hearing-loss: Some functional consequences

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Phonological representation in deafened adults: functional consequences

In the present paper we will give an overview of a number of studies where the purpose has been to examine deafened adults´ phonological representation of sounds and possible functional consequences of an imperfect phonological representation. Deafened adults´ performance on cognitive tasks that require phonological processing has been compared with that of normal hearing individuals. The results indicate that the phonological representation in deafened adults deteriorates as a function of absence of external auditory stimulation. The magnitude of the deterioration is further correlated with duration of deafness, where long duration leads to poorer performance. The quality of the deafened adults´ phonological representation is related to performance in communicative tasks such as visual speechreading, tactile supported speechreading and speech understanding with cochlear implants. The results will be discussed with respect to (a) what factors that cause the deterioration in the phonological representation and (b) what kind of role a phonological representation serves in speech understanding for this group of individuals.

Représentions phonologiques chez les adultes devenus sourds : conséquences fonctionnelles

Dans cette contribution, nous allons donner un aperçu général des études ayant pour but d'examiner la représentation phonologique des sons chez les adultes devenus sourds et les conséquences fonctionnelles possibles d'une représentation phonologique imparfaite. Les performances des tâches cognitives qui nécessitent un traitement des données phonologiques ont été comparées à celles de personnes normalement entendantes. Le résultat indique que la représentation phonologique chez les adultes devenus sourds se détériore en fonction de l'absence de stimulation auditive. L'importance de la détérioration est en outre corrélée avec la durée de la surdité où les durées longues correspondent à des performances moindres.
La qualité de la représentation phonologique des adultes devenues sourds est reliée à la performance dans les tâches de communication comme la lecture visuelle de parole, la lecture de la parole assistée par des moyens tactiles et la compréhension de la parole avec les implants cochléaires.
Le résultat sera débattu en considérant (a) quels sont les facteurs qui causent la détérioration dans la représentation phonologique et (b) quel rôle joue la représentation phonologique dans la compréhension de la parole pour ce groupe de personnes.

PHONOLOGICAL CAPACITIES IN DEAFENED ADULTS AND INDIVIDUALS WITH A SEVERE HEARING-LOSS: SOME FUNCTIONAL CONSEQUENCES

The importance of phonological processing in various kinds of cognitive tasks is well established in the literature [1]. Phonological processing is critical for tasks such as reading [2] and short-term memory-performance [1]. However, less is known about what kind of role phonological processing skills serves in audio-visual and visual speech understanding for individuals with a post-lingually acquired deafness and for individuals with a severe hearing loss.

The purpose of this paper is to review some results from studies conducted in our laboratory where the main focus has been to examine phonological capabilities in deafened adults and individuals with a severe, bilateral hearing-impairment, and to relate their phonological processing skills and whether to visual speechreading performance and to audio-visual speech understanding with cochlear implants.

Several studies have examined the question whether congenitally deaf individuals have developed phonological processing skills and whether they can use them in cognitive tasks that particularity require such processing (e.g., reading, remembering, rhyming; [3-10]. The combined empirical picture from these studies suggest that congenitally deaf do develop such functions, but that these functions are less precise and less accurate compared to a population of normal hearing individuals. Deafened adults and individuals with a severe hearing-impairment differ from populations of congenitally deaf in at least one fundamental aspect : as they should have had the opportunity to developed a phonological representation of sounds similar to normal hearing individuals based on their auditory experience. The question is what happens to their phonological processing skills when they are (completely or almost completely) deprived from external auditory sensations ? To examine this question, we employed a cognitive test-battery including tests (i.e., tests of working memory, rhyme-judgement and verbal information-processing speed) that varied in terms of demands on phonological processing.

METHOD

Participants

The individuals that have participated in our studies were either bilaterally, hearing-impaired of deafened adults. Common to all individuals in these two groups is that they, prior to the onset of their hearing-impairment or deafness, had a hearing capability, with or without a hearing-aid. The normal hearing individuals that served as controls were matched for age, verbal ability and years of formal schooling. For the hearing-impaired individuals, the audiograms showed an average hearing loss of 75 dB for the « best ear » according to the most recent available medical records. All individuals in this group were able to follow a conversation when they had their hearing-aids turned on. The deafened adults had no functional residual hearing capability (aided or unaided).

Materials and Procedure

All cognitive tests, used in the studies, were presented by means of a computer where the subjects had to respond by pressing pre-defined buttons (i.e., the reaction-time tests) or by means of oral responses (i.e. the memory tests).

Tests

Name matching : The subjects' task was to match as fast as possible two letters as having the same or different names [12]
Lexical decision-making : The subjects' task was to decide whether a string of letters constituted a real word or not [13]
Semantic decision-making : The subjects' task was to decide as fast as possible whether a presented word belonged to a pre-defined category of words or not [14]
Rhyme-judgement : The subjects' task was to decide as fast as possible whether two simultaneously presented words or non-words rhymed, whether a word and non-word rhymed [15]
Picture-word rhyme judgement task
The subjects' task was determine whether a presented picture and word rhymed.
Phonological lexical access: The subjects' task was to decide whether a string of letters (a non-word) sounded like real word or not
Orthographical lexical access : The subjects' task is to decide whether a word is correctly spelled or not
Reading span test : The subjects' task was to comprehend sentences and to recall either the first or the final words of a presented sequence of sentences in correct serial order [13]
Letter and word Span: The subjects' task was to recall in correct serial order a string of letters or words, presented one at a time on the computer screen. The letters and the words were either phonological similar or dissimilar to each other.

RESULTS

Phonological processing skills

At a group level, the results demonstrate that deafened adults and severe hearing-impaired typically perform at a significantly lower level compared to normal hearing control groups on cognitive tasks that explicitly requires phonological processing. That is, various kinds of the rhyme-judgement tasks. On the other hand, there are no differences between the groups on cognitive tasks where phonological processing is indeed a task demand, but less central than compared to rhyme-judgement tasks. The implication of this outcome is that the phonological skills in the groups of deafened adults and hearing-impaired deteriorates as a function of the impairment. Here, it is interesting to note that both groups of impaired individuals displays a similar empirical pattern, despite the fact the hearing-impairment individuals can follow a spoken conversation (although with some effort) with their hearing aids turned on. Thus, the cause of phonological deterioration is not the absence of hearing sensations as such, rather it seems that an impoverished auditory experience is sufficient to initiate a process of phonological deterioration.
If we inspect the results at an individual level, two observations deserves attention. First we find for both groups of impaired individuals, a significant negative correlation (typically in the range of r = .50 -.55 for groups including 15 to 25 individuals) between the duration of the impairment and performance on the rhyme-judgement and short-term memory tasks. That is, the longer they have been deaf or had a severe hearing-impairment the poorer their performance becomes. Thus, suggesting that the deterioration is progressive in nature. However, this correlation is far from perfect; some individuals manage to keep their phonological representations relatively intact despite the fact that they have been deaf for a substantial number of years. Further research have to specify more precisely the factors that make it possible for some

individuals to maintain their phonological processing skills relatively intact, whereas this ability deteriorates (sometimes dramatically) for others.

A second observation suggests a possible relationship between the impaired individual's speech intelligibility and performance on phonological tasks, such that the participants with a relatively intact overt speech were those with the highest level of performance on the phonological tasks. Leybaert, Alegria, Hage and Charlier [10]have recently reported results indicating that there is no relationship between speech intelligibility and performance on rhyme tasks. The population in this study was prelingually, profoundly hearing-impaired or deaf children that were exposed to training in cued speech. The results from our studies and from studies by Leybaert and colleagues thus implies that there is no relation between the quality of the overt speech and phonological processing skills when the phonological skills are developing (as for children), whereas there is a relationship when the phonological processing skills are deteriorating.

Visual speechreading and phonological processing skills

For deafened adults and the hearing-impaired groups performance on cognitive tasks explicitly requiring phonological processing is significantly related to performance a on various kinds of speechreading tests. That is, better scores on the phonological tests is associated with better speechreading performance. For the group of deafened adults there is also a negative correlation between duration of deafness and speechreading scores (c.f. [16 for a similar association between « years since last used hearing aid » and speechreading scores).

The relation between phonological skills and speechreading is not a new or a sensational finding, rather the involvement of phonological processing in visual speechreading has been demonstrated a number of times and in a variety of ways previously[4,11,17]. However, what is interesting from our set of results is that they perform very poorly on all tasks requiring phonological processing. Common to these individuals is that they became deaf early in life (i.e., when they were 5 to 8 years old) and that their major form for communication is oral. A possible implication of this outcome is that an early impairment may selectively push the development of visual speech-relevant skills forward, which in turn opens up for the possibility of an early neural reorganisation [18].

Speech understanding with cochlear implants and phonological processing skills

In a longitudinal study, we have followed 20 deafened adults who had received a cochlear implant with a purpose to find possible pre-operative, cognitive predictors of outcome in terms of speech understanding with the implant. In this study, we have tested the individuals one month before the operation and at six months intervals after the operation up to four years post-operatively. When we examined the individuals level of speech understanding with the implant, the individuals have been classified in « hearing » and to being able to follow a telephone conversation.

Participants

Twenty cochlear implant candidates (mean age 49,8 years) participated in the study and were given the cognitive tests at the time when they were candidates for implantation and visited the clinics for medical examination. None of the implant candidates had any functional residual hearing according to their most

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