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Acoustic environments that support equally accessible oral higher education as a human right

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Abstract

Purpose: People have the right to freedom of opinion and expression, as defined in Article 19 of the Universal Declaration of Human Rights. Higher education plays a major role in helping students to develop and express their own opinions and, therefore, should be equally accessible to all. This article focuses on how students judge the accessibility to oral instruction in higher education listening contexts.

Method: We collected data from 191 students in higher education by means of a questionnaire, addressing understanding speech in different types of classrooms and various educational settings.

Result: In lecture halls, understanding speech was judged to be significantly worse than in smaller classrooms. Two important negative factors were identified: background noise in classrooms and lecture halls and the non-use of a microphone.

Conclusions: In lecture halls students achieve good or excellent speech perception only when lecturers are using a microphone. Nevertheless, this is not a standard practice. To achieve genuine inclusion in tertiary education programs, it is essential to remove acoustic barriers to understanding speech as much as possible. This study is a first step to identify communication facilitators to oral higher education instruction, for students with hearing loss or communication impairment.

Keywords: *Article 19*; *Universal Declaration of Human Rights*; *United Nations*; *higher education*; *tertiary education*; *acoustics*; *acoustic environment*; *speech perception*; *hearing disabilities*; *participation*

Introduction

Education as a human right

The right to education is a human right for all. This article focuses on how to create an effective learning environment for students with and without hearing disabilities with a view to achieving equal access to oral higher education. Human rights are the basis of freedom, justice and peace. These rights are universal, meaning that they apply to every human being in the world. Celebrating the 70th anniversary of the Universal Declaration of Human Rights makes it an occasion for celebration for approximately 7.6 billion people. In agreement with Article 19, all people have "the right to freedom of opinion and expression; this right includes freedom to hold opinions without interference and to seek, receive and impart information and ideas through any media and regardless of frontiers" (United Nations, 1948). By means of interaction between individuals and the world around them, it is possible to form an opinion and to shape ideas. The educational context is pre-eminently suited to seek, receive and impart information and ideas. As well as the right to freedom of opinion and expression, education is a human right for all, throughout life and a prerequisite for development. Article 26 of the Universal Declaration of Human Rights (United Nations, 1948) prescribes the human rights related to education. Among other things, it states that:

> Everyone has the right to education. Education shall be free, at least in the elementary and fundamental stages. Elementary education shall be compulsory. Technical and professional education shall be made generally available and higher education shall be equally accessible to all on the basis of merit (Article 26.1).

Despite the fact that equally accessible education is a clear and indisputable human right, many people still have to fight for it, as witnessed by the 17 sustainable development goals adopted by the UN General Assembly in 2015. Sustainable development

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goal number four states: “Ensure inclusive and quality education for all and promote lifelong learning” (United Nations, 2015). To achieve this goal it is important to: build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all (United Nations, 2015). The fact that there is a need to explicitly incorporate equally accessible education into the international reference of sustainable development goals shows that there is still a long way to go before mainstream higher education is indeed accessible to all on the basis of merit as envisaged by Article 26.1.

Higher education

The main aim of this study is to identify the communicative needs of students with hearing disabilities in higher educational contexts, in order to fully participate in mainstream oral education programs. In Europe, approximately a third of the population are graduates from higher education (Eurostat, 2009). Along with cognitive and social capacities, reduced hearing performance is part of the physiology and psychology and the body structure of people (International Classification of Functioning, Disability and Health (ICF), World Health Organization, 2001). Nevertheless, technological interventions such as hearing aids or a cochlear implant (as environmental factors) may be applied to facilitate activity and participation. A hearing aid is frequently used by people with mild to moderate hearing loss. It amplifies the sounds and directs the amplified sound into the outer ear. Hair cells detect larger vibrations and convert them into neural signals that are passed along to the brain. Over the past decades, cochlear implantation has become a standard intervention in most Western countries for people with profound hearing loss. The cochlear implant stimulates the auditory nerve electrically through electrodes placed in the cochlea.

For children with severe and profound hearing loss, the use of cochlear implantation has clearly enhanced oral communication. Compared to classical hearing aids, it gives children better opportunities to develop age-appropriate oral language skills (e.g. Hammer & Coene, 2016; Svirsky, Robbins, Kirk, Pisoni, & Miyamoto, 2000; Tomblin & Moeller, 2015). Research on spoken language development of children with a cochlear implant has shown that, together with an early age of implantation, access to spoken communication is one of the contributing factors in the language proficiency that will be achieved (Coene, Schauwers, Gillis, Rooryck, & Govaerts, 2011; Kirk et al., 2002; Nicholas & Geers, 2007). Thanks to the early detection of hearing loss in combination with early intervention, children obtain good overall results with their hearing interventions such as hearing aids or cochlear implants (Yoshinaga-Itano, Sedey, Coulter, & Mehl, 1998).

As a consequence, it is more likely that these children enter mainstream education programs at the same age as their normal hearing peers. Damen, Van den Oever-Goltstein, Langereis, Chute, & Mylanus (2006) compared the classroom performance of school-aged children with a cochlear implant to the performance of their normal-hearing peers in mainstream education programs. They concluded that students with a cochlear implant seem to perform well in mainstream education measured by the assessment of mainstream performance (AMP) and the Screening Instrument for Targeting Educational Risk (SIFTER) were filled in by teachers. Nevertheless, extra attention should be given to children who received their cochlear implant relatively late in childhood when entering mainstream education (Damen et al., 2006).

Furthermore, mainstream higher education programs have become an attainable goal for students with hearing disabilities. Although the use of signing or written supported language is not a common practice in mainstream education programs, the improved technological advancements associated with improved auditory access have made the genuine inclusion of many students, who are deaf or hard-of-hearing, into a feasible option. For others, special education may be a more suitable solution for success. The educational context lays the foundation of education facilities that are disability sensitive and provide inclusive and effective learning environments for all (United Nations, 2015). It plays a role in how and if students with hearing disabilities can participate and study successfully in mainstream higher education.

Learning environment

There is little research on the specific facilities that students with hearing disabilities may need in order to achieve a genuine form of inclusion in mainstream higher education. As classroom acoustics have been shown to influence speech understanding in the early school age (Nelson & Soli, 2000), in this study we will specifically focus on the role that external acoustic factors may play in tertiary higher education settings. In the literature, more detailed analyses have shown that the distance between speaker and listener, background noise, reverberation time, the room size, its shape and the properties of the materials used to construct it are all important factors that can disturb the audibility of speech (Mikulski & Radosz, 2012; Smaldino & Flexer, 2012). The youngest children in the school system are the most susceptible to the effects of background noise (Boothroyd, 2004; Jamieson, Kranjc, Yu, & Hodgetts, 2004; Klatte, Hellbruck, Seidel, & Leistner, 2010). The particular learning environment also plays an important role in the context of higher education. Contrary to primary or secondary education, lecture halls are commonly part of the teaching infrastructure. Lecture halls are mostly used to transfer information from lecturer to (often large groups of) students. Although the interaction between lecturer and student is often limited, the environment itself may still cause an important acoustic barrier to students. Compared to small classrooms, big lecture halls present a more challenging acoustical environment (Eggenschwiler, 2005). They are typically characterised by a higher degree of background noise, and a longer reverberation time. In combination with an insufficient sound system these features can negatively influence speech perception. Yet, in smaller classrooms, computer rooms or skills labs, other acoustic barriers put a burden on speech perception. Skills labs and computer rooms often represent a student's future working environment. Each type comes with a unique set of acoustic barriers affecting the transmission of a lecturer's oral instructions. Educational programs for future nurses, for instance, often have mock hospital rooms with corresponding medical devices and equipment. In a similar vein, skills labs for future engineers are equipped with a different set of devices and tools which enable the students to practice the relevant skills. As some equipment may increase existing background noise, oral instructions provided in this particular type of classroom might give rise to misunderstandings potentially resulting in inadequate and undesired outcomes.

Aims of this research

This study is an important first step to create a future, effective learning environment for students with hearing disabilities. It consists of evaluating the accessibility to oral instruction in higher education listening contexts for a reference group of hearing students. The operational objective of this study is to identify which factors act as potential facilitators and barriers for students to access spoken communication in tertiary learning environments. The outcomes of the data gathered about students with normal hearing in this study will indicate which individual education settings are most pertinent to follow up in further studies, targeting students with hearing disabilities.

Method

Participants

Data were collected from 191 students with (self-reported) normal hearing (89 males; 102 females). All participants took part in a higher education program in the Netherlands, either at the Rotterdam University of Applied Sciences or at the VU University Amsterdam. As the case in many Western European countries, in the Netherlands universities focus on academic education and research whereas universities of applied sciences emphasise vocational or applied training. These differences can be reflected in educational contexts and classroom type.

The Rotterdam University of Applied Sciences has ±35 000 students. The subgroup ($n = 91$) recruited from this university contained 49 male and 42 female students, who were in the first (43%), second (21%), third (18%) or fourth or fourth plus (19%) year of their study program. They were studying in 46 different education programs in 11 different departments. The VU University Amsterdam has ±22 000 students. In the subgroup ($n = 100$) from this university there were 40 male and 60 female students. Forty-seven percent were first-year students, 26% were in the second year, 13% in the third year and 14% in the fourth or fourth plus year of their study program. Participants in this study followed 38 different programs from nine different departments.

Procedure

Participants were randomly recruited in central areas of the faculties after college hours. It is important to obtain representative sampling of the student body on campus. Therefore, data were collected from a variety of different central areas at both participating higher education institutes. Participation was entirely voluntary, anonymous and there was no reward or financial compensation afterwards. Prior to filling in the questionnaire, students were asked about their hearing abilities. They were excluded from the study in advance if the students reported any hearing difficulties. After a brief instruction, the participants were asked to fill in an online questionnaire.

To investigate how students judge speech perception and listening effort in higher education listening contexts, a modified version of the questionnaire Listening Inventories for Education – student version (LIFE) (Anderson & Smaldino, 1998), was developed. The Dutch version of the questionnaire (LIFE-NL, Neijenhuis, 2005a, 2005b) focuses on children in primary education and was not suitable for the higher education context. Therefore, adjustments had to be made, taking into account different types of classrooms such as lecture halls, classrooms, skills labs and computer rooms and various listening conditions, such as microphone use and the presence of background noise. The first part of the questionnaire contained questions about how the participants would define the different types of classrooms according to their educational context. This was done by asking about each room where students attended classes and how many students it could accommodate. Also, students were asked whether the lecturer made use of a microphone while teaching. Whether students had experience with smaller classrooms, skills or practice labs or big lecture halls was of course dependent upon their individual study program and the total number of students enrolled in this program. Some education programs made use of lecture halls with a capacity up to 400 students, while programs with smaller groups of students will never need classrooms that accommodate more than 50 students.

In the second part of the questionnaire the participants were asked to judge their ability to understand speech in well-defined listening contexts. All participants first received a short explanation of a hypothetical teaching situation and were then asked how well they felt they could understand the lecturer or student. The questions included reference to microphone use and the absence or presence of background noise in those particular situations based on their own experience. For example: "The teacher gives a lecture in a quiet lecture hall. How well can you understand the words the lecturer is saying?" The responses were measured on a Likert-type scale, ranging from one *excellent* to five *very poor*. The entire set of questions was subdivided in four sections, concerning lecture halls, smaller classrooms, skills labs and computer rooms. All students were required to answer the questions concerning the smaller classroom section. The other sections were optional, depending on whether or not a particular type of classroom was a relevant teaching environment for the individual student.

Data analysis

The first part of the questionnaire was used for descriptive statistics. In order to obtain information about the variability among the responses to each question, an exploratory principal component analysis was conducted on the 25 items of the second part of the questionnaire with direct oblimin rotation, to investigate the internal structure of the survey (Field, 2000). The purpose of the analysis was to explore possible underlying factors in the dataset and to find the smallest number of interpretable factors that can adequately explain the correlations among the items (Conway & Huffcutt, 2003). The analysis was exploratory in the sense that it only specified the number of components. A possible interpretation of the potential underlying joint features of these components will be made in the discussion. Only the scores of the sections concerning the lecture hall and classroom contexts (second part of the questionnaire) were used in this analysis. A factor analysis of the data with respect to the skills lab and computer room could not been made because of the high number of students who did not attend classes in such classroom types.

To select the number of factors, we first used the Kaiser's criteria according to which the eigenvalue of a factor should be greater than one. With the use of Cattell's scree test (1966), the pattern of eigenvalues was examined for breaks or discontinuities. Criteria for retaining components were the following: items were required to have a factor loading of at least 0.40 and items load only on one component. The presence of cross loaded items indicated that these were not pure measures of one component. Cronbach's α was used to assess the internal consistency of the retained components. Scores on the resulting components were calculated by using the average score on the items in the component. For all statistical analyses the Statistical Program for the Social Sciences (SPSS) version 23.0 (IBM Corp., 2015; IBM, New York City, NY) was used.

Results

The first part of the questionnaire contained questions about how the participants defined the different types of classrooms according to their educational context. At the Rotterdam University of Applied Sciences 78% of the students reported having classes in lecture halls; at VU University Amsterdam all students (100%) had classes in lecture halls. Computer rooms and skills labs were reported to be more commonly used for educational purposes at the Rotterdam University of Applied Sciences (55 and 35%, respectively) than at VU University Amsterdam (42 and 18%, respectively).

Seventy-five percent of the participants defined a lecture hall as a hall with a capacity between 50 and 150 students. A regular classroom was defined as a smaller room offering space to 20–30 students, as reported by 61% of the participants. In lecture halls, 41% of the participants reported that a microphone was not always used by lectures. In smaller classrooms the use of microphones was exceptional. According to 99% of the students lecturers never used any microphone in these smaller classroom settings.

In the second part of the questionnaire the participants were asked to judge the accessibility to oral instruction in higher education listening contexts. Questions were formulated as follows: "The teacher gives a lecture in a quiet lecture hall. He/she uses a microphone. How well can you understand the words the teacher is saying?" Or in the section classroom: "There is lot of noise in the hallway during the class. The teacher is not using a microphone. How well can you understand the words the teacher is saying?" There was a large amount of variation among the responses to all questions, indicating a large amount of inter-subject difference. Participants judged speech understanding to be *very poor* more frequently in the context of lecture halls

($n = 262$), than in the context of classrooms ($n = 37$).

Exploratory factor analyses

Within the exploratory analysis of underlying factors the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.75, above the recommended value of 0.6 and Bartlett's test of sphericity was significant (χ^2 (300) = 1794.04, $p < 0.05$) and, therefore, exploratory principal component analysis was appropriate.

Seven factors with eigenvalues greater than one explained 71% of the variance. The eigenvalues showed that the first factor explained 30% of the variance, the second factor 12% of the variance, a third factor 8% and a fourth factor explained 6% of the variance. The fifth, sixth and seventh factors had eigenvalues of just over one, each factor explaining around 5%. Following Cattell's scree test (1966), visual inspection of the scree plot suggested the existence of four factors (eigenvalues of 7.44, 2.96, 2.11 and 1.52), and the percentage of variance accounted for by a four-factor solution is about 56%. Based on these outcomes four-factors were selected for rotation. Finally, we verified if items had a factor loading of at least 0.40 and if they did not load one more than one component. Six items loaded on more than one component (Q3, Q13, Q15, Q16, Q18 and Q21) and were, therefore, rejected. With the exception of item Q17, all remaining items had factor loadings of at least 0.40. Cronbach's α was used to assess the internal consistency of the retained components. Component 1 (Cronbach's $\alpha = 0.80$), component 2 (Cronbach's $\alpha = 0.83$) and component 3 (Cronbach's $\alpha = 0.70$) had good reliability. The reliability of component 4 (Cronbach's $\alpha = 0.51$) was low (Kline, 1999). Table I shows the factor loadings after rotation and which items clustered on the same components.

The boxplots in Figure 1 show the spread and central tendency of the dataset. Looking at the average judgement on the items in the component, the lowest scores were given to the questions related to component 2 ($M = 3.40$, $SD = 0.73$) and the highest judgements were given to component 4 ($M = 1.69$, $SD = 0.62$). Considering the fact that the responses were given on a Likert-type scale, low scores correspond with a good speech perception in the educational listening context.

Discussion

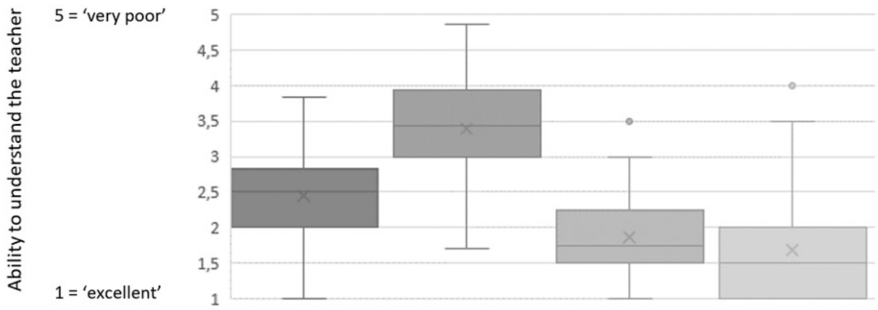
Interpretation of the exploratory factor analyses

The exploratory factor analysis shows the possible underlying factors in the dataset and the number of interpretable factors that can adequately explain the correlations among the items. Four factors are identified by factor analysis. Cronbach's α for components 1, 2 and 3 are high enough for further interpretation.

An interpretation of the components is made by analysing the overlapping aspects of the questions in each component. All the questions loading on component 1 represent listening conditions in regular classrooms. With the exception of question 23, in all conditions there is a combination of speech and background noise. The average judgement on this component is 2.45, which can be interpreted as *good* to *neutral*. We interpret this as representing daily regular classroom conditions with background noise. For the average students with normal hearing it is

Table I. Identification of four components relating to how well the teacher is understood after exploratory principal component analysis with oblimin rotation.

Item		Factor loading
Component 1, Chronbach's $\alpha = 0$ .80		
Q24	Classroom–murmur (4)	0.797
Q22	Classroom–murmur - no lip reading (2)	0.752
Q20	Classroom–murmur (3)	0.725
Q19	Classroom–murmur - one talking student	0.648
Q25	Classroom–murmur (5)	0.490
Q23	Classroom–quiet (2)	0.442
Component 2, Chronbach's $\alpha = 0.83$		
Q6	Lecture hall–quiet–without microphone - no lip reading	0.818
Q10	Lecture hall–murmur–without microphone (2)	0.762
Q2	Lecture hall–quiet–without microphone	0.730
Q4	Lecture hall–murmur–without microphone (1)	0.652
Q8	Lecture hall–murmur–without microphone - no lip reading	0.640
Q12	Lecture hall–murmur–one talking student	0.584
Q11	Lecture hall–quiet–one talking student	0.491
Component 3, Chronbach's $\alpha = 0.70$		
Q5	Lecture hall–quiet–with microphone - no lip reading	0.828
Q9	Lecture hall–murmur–with microphone (2)	0.729
Q1	Lecture hall–quiet–with microphone	0.573
Q7	Lecture hall–murmur–with microphone–no lip reading	0.562
Component 4, Chronbach's $\alpha = 0.51$		
Q13	Classroom–quiet (1)	0.577
Q15	Classroom–quiet– no lip reading (1)	0.497



	Component 1	Component 2	Component 3	Component 4
	n = 191	*n* = 149	*n* = 136	*n* = 191
Mean (SD)	2.45 (.59)	3.40 (.73)	1.87 (.54)	1.69 (.62)

Figure 1. Mean scores and deviation per component on the five-point Likert scale. Component 1: regular classroom with background noise, Component 2: lecture hall with no microphone, Component 3: lecture hall with microphone, Component 4: regular classroom-quiet.

possible to achieve good speech perception in this setting. Component 2 represents the listening conditions in lecture halls. In all the questions of this component the lecturer did not use a microphone, and sometimes there was additional background noise. The average judgement on component 2 is 3.40, which was between *neutral* and *poor*. So we may conclude that it is not possible to achieve good speech perception in this context for the average student with normal hearing. Component 3 represents listening conditions in lecture halls, but in this component the lecturer was said to use a microphone, sometimes in combination with additional background noise. The average judgement on component 3 is 1.87, which can be interpreted as *good* or *excellent*. The results of this component might indicate that when a microphone is used by the lecturer it is possible to achieve a good or excellent speech perception. When summarising, the underlying factors that occur in the different components of the dataset, they can be identified as background noise in regular classrooms and lecture halls and the non-use of a microphone.

This study sample represented Dutch university students. The distribution of participating students in the sample can be considered as representative. Although, the questionnaire developed in this study is not validated, which can be considered as a limitation, it deals with many higher education listening contexts and can be used as an exploratory instrument. This results support the claim that different types of classrooms lead to different acoustic barriers in higher education (Mikulski & Radosz, 2012; Smaldino & Flexer, 2012) and that the use of a sound system can influence the speech perception (Eggenschwiler, 2005). The data in this study show that students with normal hearing find understanding speech in lecture halls to be more difficult than in classrooms. All students at the University and 78% of the students at the University of Applied Sciences have classes in lecture halls. Therefore, it is important for both universities to pay attention to these results. Furthermore, this data show that in lecture halls accommodating between 50 and 150 students, the use of a microphone is not always standard practice. When a lecturer chooses not to use a microphone, this can present a challenging educational situation for students. This point must be considered when studying the needs of students with hearing disabilities. These findings are a first step towards a more detailed examination of different acoustic barriers in higher education, especially in lecture halls. Future research could also investigate why microphone use is not a standard practice for lecturers.

Conclusion

Within the context of higher education, it is difficult to achieve good speech acoustics in a lecture hall as compared to regular classrooms or small lecture halls. The component analysis of the questionnaire responses provides a good insight into the specific aspects of educational settings that influence speech understanding. In lecture halls students only achieve good or excellent speech perception when a microphone is used by the lecturer. Yet, rather surprisingly microphones were used by fewer than 60% of lecturers in lecture halls. The outcome of this study could be used to make lecturers aware of the fact that their speech transmission is significantly reduced when they are not using a microphone in such big lecture halls.

In agreement with Article 19, all people have "the right to freedom of opinion and expression" (United Nations, 1948). It is important to facilitate this right in all possible ways. Given that the non-use of a microphone impacts on hearing students' ability to understand the teacher, these effects are expected to be more pronounced for students with hearing difficulties. These findings should also be taken into consideration when creating an effective learning environment for students with special needs. The newly developed questionnaire in this study can be used for identifying acoustic barriers in higher education contexts. Our data show how students with normal hearing judge the accessibility to oral instruction in higher education and it can be taken as a baseline against which it is possible to find out if similar barriers apply to students with hearing difficulties.

Declaration of Interest

There are no real or potential conflicts of interest related to the manuscript.

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