Listening environment in classrooms – the effects on reading fluency

Do boys benefit more than girls from an improved listening environment in the classroom?

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Abstract

Background:

Norway is one of the countries with the highest gender gap in performance level of reading. Previous studies have emphasised the importance of ensuring that educational facilities have proper acoustic management, to provide children with an optimal listening and learning environment. However, classrooms settings have changed in the last couple of years and challenges with disturbing noise in teaching activities are rising. Implementing assistive listening devices in teaching for children with typical hearing, is a way of improving the audibility and listening environment during teaching activities. The objective of the current research was to examine if using a sound amplification system in teaching would have a positive effect on reading fluency, and if it would benefit boys more than girls.

Methods

The sample consisted of two groups of children aged 9 to 10 years old, with typical hearing (n=46). The treatment group (n=24) received intervention, using a sound amplification system in teaching for a period of eight weeks, while the control group (n=22) continued with ordinary teaching without amplified sound. All the children were assessed in reading fluency, general working memory, non-verbal intelligence, hearing thresholds and executive function.

Analysis

An independent t-test and paired samples t-test were used to analyse the data, and to compare the mean difference in total between the two test occasions. Effect size was measured by Cohen’s d, to get an indication of the potential size difference between the groups, including potential differences between boys and girls.

Results

The results showed a significance difference in reading fluency with the treatment group, compared to the control group. In addition, did the results indicate that the boys benefitted more than the girls from an improved listening environment in their classroom.

Conclusion

Sound amplification system had a positive effect on reading fluency, especially for the boys. Further research is needed in order to get a better understanding for what is causing the gender gap in performance level and how to reduce it in the future.

Sammendrag

Bakgrunn:

Norge har gjentatt ganger blitt rangert som et av landene med størst kjønnsforskjeller i skolen. Tidligere studier har påpekt hvor avgjørende det er med gode akustiske forhold i undervisningsrom for å fremme et godt lytte- og læringsmiljø. Mange skoler har de siste årene endret struktur og fått en mer åpen løsning. Dette har ført til økende utfordringer med støy og forstyrrende aktiviteter, ettersom klasserom med åpen løsning oppfordrer til mer aktiv deltakelse fra barna. Et alternativ for å forbedre lyttemiljøet for barn med typisk hørsel kan være lydutjevningsanlegg, som fremhever og tydeliggjør tale. Formålet med denne studien var å undersøke om bruken av lydutjevningsanlegg i undervisning hadde en positiv effekt på leseflyt, og om et forbedret lyttemiljø hadde en bedre innvirkning på guttenes utvikling, i forhold til jentene.

Metode

Utvalget i studien utgjorde to grupper med barn i alder 9 til 10 år, alle med typisk hørsel (n=46). Intervensjonsgruppen (n=24) brukte lydutjevningsanlegg i undervisning i åtte uker, mens kontrollgruppen (n=22) fortsatte med ordinær undervisning uten forsterket lyd. Alle barna ble testet i leseflyt, generelt arbeidsminnet, non-verbal intelligens, hørselsscreening og eksekutive funksjoner før og etter intervensjonsperioden for å kunne undersøke endringer.

Analyser

Det ble gjennomført t-tester for å analysere datamaterialet og sammenligne forskjellene mellom de to testtidspunktene. Effektstørrelsen ble målt ved bruk av Cohen's d, for å få en indikasjon på størrelsen på den potensielle forskjellen mellom gruppene.

Resultater

Resultatene indikerte en signifikant forskjell på leseflyt hos intervensjonsgruppen, i forhold til kontrollgruppen. I tillegg viste resultatene at det forbedrede lyttemiljøet hadde en bedre innvirkning på utviklingen hos guttene enn jentene i intervensjonsgruppen.

Konklusjon

Lydutjevningsanlegg hadde en positiv innvirkning på leseflyt, og spesielt blant guttene. Det trengs mer forskning på temaet for å få en bedre forståelse for hvorfor slike kjønnsforskjeller oppstår og hvordan det kan reduseres.

Preface

The last two and half years of studying at the university of Oslo has been challenging, but educational and exciting. I am thankful for the opportunity I have had to be a part of the research project *Listening environment in classrooms* and writing this thesis. It has been a long and challenging process, but I have had excellent company and help along the way.

I would like to express my gratitude to my supervisor, Associate Professor Ulrika Löfkvist for all your kind help and support throughout the whole process of this project and thesis. I would like to thank Professor Gary Rance at the University of Melbourne for initiating this project and assisting during this process, from across the world.

I would like to express my gratitude to all teachers and the children who participated in this study. A big thank you to Andreas Tegeman and Nina Lu for assisting in the installation of sound amplification system, and measurements of the acoustics in the classrooms.

A special thank you to my "master partner" Andréa Chanell Jønsberg, for all your help, support and organisational skills. This process would not have been same without our common appreciation for systematic organisation of paperwork and yellow ring binders. Thank you to my fellow students, audiogjengen, who have been so patient and supportive throughout all my questions, frustration and the need for socialisation with food and snacks.

Last, but not least a huge thank you to my family and friends for being forever patient, encouraging and helpful throughout the last two and half years. I am especially thankful for my group of proof-readers, your knowledge and eye for details in finding all my "skriveleifs" have been invaluable, and now your watch has ended.

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Charlotte Bruåsdal Larsen

Table of contents

1 Introduction

This thesis is part of a research program called *Listening environment in classrooms*, which is a collaboration between the Department of Special Needs Education at the University of Oslo and the Department of Audiology and Speech Pathology at the University of Melbourne.

The overall purpose of the research program is to examine how listening environment in ordinary classrooms might affect academic development. The first part of the project focused on listening environment in classrooms with a closed layout, and what effect the use of sound amplification system in teaching would have on academic development in children aged 9 to 10 years old with typical hearing. The sound amplification system consisted of microphones to the teacher and the children to improve speech, and a speaker at the front of the class. The second part of the project, which will commence later, is going to be conducted in a larger scale and have a slightly different design than the first part. It will, according to plan, include classrooms with both closed and open-plan layouts and examine how the different listening environments affect children's academic development. In addition, the second part will include children with typical hearing, hearing impairment or auditory processing disorder in the sample.

1.1 Background and inspiration for this thesis

The Norwegian educational system is considered well-functioned and provide children with high quality education and safe learning environments (NJ MED, 2019). Every three-year Norway participate in the Programme for International Student Assessment (PISA), which is run by the Organisation for Economic Co-operation and Development (OECD). PISA evaluate the functionality of educational systems in the participating countries by testing fifteen-year-olds' academic performances in key subjects in school (UDIR, 2016). The purpose is to examine how prepared they are to encounter real life situations based on their ability to master the key subjects of reading, mathematics and science (OECD, 2018).

In 2018, PISA was conducted in 80 countries worldwide and more than half a million fifteen-year-olds participated (OECD, 2018). However, the analyses of those results will however not be available until the end of 2019, so the information regarding PISA are therefore based on the results from 2015. Out of the 72 countries who participated in 2015, Norway was one of the countries with the highest gender gap in regard to academic performances. The boys outnumbered the girls in number of dropouts and performed, more often than the girls, in the lower levels in reading, mathematics and science(The Ministry of Education and Research [Kunnskapsdepartementet] 2018a). Only 65% of the boys graduated from upper secondary education within the normal schedule, compared to 72% of the girls. The results are interesting and concerning, especially as reading was the subject where the girls surpassed the boys significantly. In reading, the boys were outperformed by the girls with 40 score points, compared to an average of 24 score points in the other countries (Borgonovi, Ferrara, & Maghnouj, 2018; OECD, 2018).

Considering that most platforms for learning and social interactions are based on written and oral interaction, the development of linguistic and communication skills is an essential part of early childhood (Cole & Flexer, 2011; Tomblin, Oleson, Ambrose, Walker, & Moeller, 2014). An extensive number of research imply that hearing is the most efficient modality in the linguistic development, and that actions to increase this development have a long-term effect on quality of life (Cole & Flexer, 2011; Sloutsky & Napolitano, 2003; Tomblin et al., 2014; Werker, 2006). Thus, are good listening skills essential in the development of sufficient language and speech to participate in social interactions. Cole and Flexer (2011) also imply that adequate listening and linguistic skills are a precondition for the development of reading, writing and other cognitive functions. It is therefore important that kindergartens and schools promote good listening environments, in order to support the linguistic development.

In 2014 the Norwegian Directorate of Health (Helsedirektoratet [NDH]) issued an updated version of guidelines and recommendations on how to ensure environmental health care in kindergartens and schools in Norway. Amongst the recommended preventative measures, sound insulating partition and sound amplification system were mentioned (Helsedirektoratet, 2014). Several international studies have examined what effect amplified sound or the use of sound amplification system in teaching may have on academic skills in children with typical hearing and different degree of hearing loss. A recent study conducted by Duarte da Cruz et al. (2016) examined what impact a sound amplification system had on the overall noise level in the classroom, the teacher's voice and the children's academic performance. After three months use of the sound amplification system, the noise level in the class was reduced, which helped ease the teacher's vocal strain and it had a positive effect on the children's performance in reading.

A somewhat similar study was conducted in Australia by Zanin and Rance (2016), except they assessed how different combinations of amplified sound used in teaching affected academic performance in children with mild-to-profound hearing loss. They implied that the most beneficial way to affect academic development in children with hearing impairment, was to use a combination of sound amplification system and remote microphone (Zanin & Rance, 2016). The remote microphone would send the sound directly from the teacher's microphone to the child's hearing aids or cochlea implants, while the sound amplification system would benefit the other children as well. For some of the children, the use of remote microphone increased the attention to their hearing impairment, and thus negative stigma. Thus, they chose to not continue to use any ALDs, despite better audibility and speech intelligibility (Zanin & Rance, 2016). Although, several studies support the statement from Zanin and Rance (2016) that the use of sound amplification system benefits all children, which could be emphasised in order to remove some of the negative stigma of using this system in teaching.

Part of the incentive for this thesis was in light of the guidelines from NDH and the previous studies conducted by Duarte da Cruz et al. (2016) and Zanin and Rance (2016). There has not been conducted any similar research in Norway, at the time this thesis was completed. Thus, the current research had an incentive to examine how the use of sound amplification system might affect academic development in Norwegian children. In addition, to explore the issue of significant gender difference in performance level in reading, emphasised in the 2015 PISA results.

1.2 Research question

The focus in this thesis was limited to include only children with typical hearing and classrooms with a closed layout. This was as a result of the time constraint to conduct the research within the schedule of the school year. The aim was to examine if the use of sound amplification system in teaching affected the children's development in reading fluency, and if the improved listening environment benefitted the boys more than the girls.

In the process of developing a structured research question a PICO-layout was used. which is the first step in the process of an evidence-based practice. According to Wong and Hickson (2012) is this the first step in the process of an evidence-based practice. Needleman (2003) developed the PICO-layout as a tool to construct well defined clinical research questions. See **Table 1** for a description of the format and how it was used to develop the research question for this thesis.

Table 1. Format for developing a structured research question using the PICO-layout[1]

P	Population / problem	What is a concise description of the particular patient/client or problem?	Children aged 9 to 10 years of age with typical hearing/reading fluency
I	Intervention	Which main intervention am I considering?	Sound amplification system in teaching
C	Comparison	Am I comparing the treatment against the best alternative or no treatment?	No treatment, it will be compared to normal teaching without the use of sound amplification system
O	Outcome	What is (are) the main outcomes(s) that are of interest to my client and me?	Improved listening and learning environment in classroom, and thus increased reading fluency
Final clinical question		For children with typical hearing, 9 to 10 years of age, do the use of sound amplification system in teaching have a more positive effect on reading fluency compared to teaching without use of sound amplification system?	

Notes:[1]Format developed by Needleman (2003) as presented in Wong and Hickson (2012)

This process resulted in the following two research questions:

(1) *Does the use of sound amplification system in teaching have a positive effect on reading fluency in children with typical hearing?*

(2) *Do boys benefit more than girls from an improved listening environment in the classroom?*

The first (1) research question was based on the hypothesis that the use of sound amplification system in teaching would improve the listening environment in the classroom, and thus have a positive effect on reading fluency in all the children participating. The second (2) research question was in response to the 2015 PISA results and how Norway was one of the countries with the greatest gender gap in school performance (Kunnskapsdepartementet, 2018b; OECD, 2018). The hypothesis for the second (2) research question was based upon that the boys would benefit more than the girls from an improved listening environment.

1.3 The structure of the thesis

This master thesis is an article-based thesis and consisting of two parts. The first part of the thesis is a summary of the research project and consist mostly of theoretical and empirical background, together with methodological and ethical considerations. It will hereby be referred to as the *summary*. The second part is an article manuscript that will be sent to the international peer-reviewed *Journal of Research in Reading* with the intention of being published, hereby referred to as the *article*. The article consists of the research *Listening environment in classrooms – the effect of sound amplification system*. There might be some overlapping parts that is mentioned in both the summary and the article. The article follows the author guidelines and requirements retrieved from the journal (see appendix 1. (p. 77)).

Chapter one in the summary provides the background, theme and purpose of the thesis, which led to the current research questions and hypothesis used in the study. Chapter two provides a presentation of theoretical and empirical background, and some of it will be used in the article. Chapter three describes the methodological considerations and the research design, in addition to ethical implications, recruitment process, the sample and choice of statistical analysis. Chapter four consist of a short conclusion, limitations and future perspective

The collecting, organizing and interpreting of data was completed in cooperation with another master student at the University of Oslo, Andréa Chanell Jønsberg. The preparations and work of collecting data was performed in teamwork but the aim for the thesis' were different. The intention for this thesis was to examine how reading fluency would be affected by the use of sound amplification system and gender differences, while Jønsberg focused on executive functions.

1.4 List of abbreviations

ALD	Assistive Listening Device
BRIEF-2	Behaviour Rating Inventory of Executive Functioning
CIs	Confidence Interval
HFPTA	High-Frequency Pure Tone Average
HI	Hearing Impairment
NDH	The Norwegian Directorate of Health (Norwegian; Helsedirektoratet)
OECD	Organisation for Economic Co-operation and Development
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
RTs	Reverberation Times
SIPS	Sound Information Processing System
STAS	Standardised Test for Decoding and Spelling (Norwegian; Standardisert Test for Avkoding og Staving)

2 Theoretical and empirical background

In this chapter the main theoretical and empirical background for listening and linguistic development will be accounted for, in addition to listening environment in the classroom.

2.1 Listening and linguistic development

Cole and Flexer (2011) highlights the importance of how hearing is the most efficient modality in the development of language, reading and other cognitive skills. The process of hearing starts before a child is born, as the inner ear is fully developed already in week 20 of pregnancy. The infant is therefore able to receive low-frequency sounds like heartbeats and the mother's voice while it continues to develop in the womb (Cole & Flexer, 2011). The first couple of years of life is considered the most crucial period for developing adequate listening, and thus also language skills (Gordon & Harrison, 2005; Werker, 2006; Winegert & Brant, 2005). There is although a difference between the concept of listening and hearing, which is important to know in order to understand its connection to learning. "Hearing is the perception of sound" (Stach, 2010, p. 42), which means that it is acoustic input that reach the brain. On the other hand, listening is intentionally or incidentally having attention to acoustic input. According to Cole and Flexer (2011, p. 12) is hearing a prerequisite for learning how to listen. The hearing paths lead acoustic input to the brain and is matured by receiving auditory input. This process of maturing or change, is referred to as neuroplasticity (Tye-Murray, 2015). A normal maturing of the hearing paths is considered essential for a child to achieve an adequate linguistic development (Cole & Flexer, 2011), and the sensitivity period for neuroplasticity according to Tye-Murray (2015) is during the three first years of life.

2.1.1 Hearing impairment

If something is preventing the brain from receiving acoustic input during the sensitivity period, such as a hearing impairment (HI), the linguistic development is at risk of being interrupted or delayed (Sharma & Campbell, 2011). Stach (2010) describe a HI as "sounds that do not reach the brain" and is caused by something in either the outer, middle or inner ear that prevents the sound from reaching the brain. A HI is categorised based on the degree (from mild to profound), type (conductive, sensorineural or mixed) and aetiology (genetic or acquired) (Stach, 2010). Early exposure to auditory input plays an essential role in the linguistic development, and for a child with HI the exposure to acoustic input would be drastically reduced. The consequences could possibly be a delayed language development, and later literacy delay (Tye-Murray, 2015).

2.1.2 Linguistic development

A high amount of auditive stimuli will increase the opportunity for a child to make a stronger connection between the phonological form of a word and the meaning of that word. During the first year, a child starts to tune their phonetic perceptions to become more sensitive to phonetic distinctions used in their own native language (Löfkvist, 2014; Nation & Snowling, 2004; Tomblin et al., 2014; Wass, Anmyr, et al., 2019; Wass, Löfkvist, et al., 2019; Werker & Fennell, 2009). Through interactions the phonetic distinctions that are considered more important will be strengthen, while the more uncommon ones will be weakened (Werker, 2006). The phonetic distinctions are used to create phonetic categories, which function as a mental dictionary for the child and are used to learn, produce and understand new words.

2.1.3 Reading fluency

The linguistic development in early childhood is part of the foundation in the ability to learn how to read and write (Cole & Flexer, 2011). Prior to this development, it is essential that the child can recognise strings of speech sounds and start to attach meaning to the sounds (Löfkvist, 2014, p. 7; Nation & Snowling, 2004). This lexical knowledge and the phonetic categories that are established during early childhood, later affects the child's vocabulary. A large vocabulary and a lexicon of orthographic representation is a prerequisite for learning how to read fluently (Calet, Defior, & Gutiérrez-Palma, 2015; Sloutsky & Napolitano, 2003; Wass, Löfkvist, et al., 2019). Orthographic skills refer to the ability to memorise new words, while phonological skills refer to the knowledge of separate phonemes in the pronunciation of words (Calet et al., 2015; Nation & Snowling, 2004; Wass, Löfkvist, et al., 2019). These are both essential skills to master in order to read fluently, but studies claim they are used at different points in the learning process. Calet et al. (2015) divide the process of learning into two phases; in the first phase focus is towards learning how to read, while in the second phase focus is shifted towards reading to learn. In the first phase phonological decoding is used to understand the words, while in the second phase orthographic skills are used to understand the meaning of the words by recognising the words (Calet et al., 2015; Wass, Löfkvist, et al., 2019). Reading fluency is defined as a combination of speed and accuracy, and is considered as an appropriate indicator for reading competence Calet et al. (2015).

2.2 Listening and learning environment

The ability to receive, process and understand acoustic input, in addition to separate informative sounds from noise, is referred to as auditive processing skills. These processes occur in the auditory cortex in the brain (Cole & Flexer, 2011; Stach, 2010). The auditory processing skills might be reduced because of HI, which can cause challenges in terms of linguistic development and cognitive abilities. The difficulties with processing acoustic input may cause trouble to localise and remembering sounds, understanding dialects, following multiple instructions and separating speech from background noise (Stach, 2010; Zanin & Rance, 2016). However, some of these challenges are not only relatable for children with HI. Zanin and Rance (2016) suggested that children, independent of HI or typical hearing, could experience the same difficulties at school if the noise and activity level in the classroom increased. As children's brain is still maturing, it does not perform cognitive tasks in the same way as an adult brain (Duarte da Cruz et al., 2016). Children needs quieter learning environments, as noise reduce the learning trajectories, in addition to more audibility and intelligible speech (Duarte da Cruz et al., 2016; Zanin & Rance, 2016). The importance of proper acoustic management in classrooms are therefore emphasised.

2.2.1 Classroom environment

The traditional closed layout classroom and teaching have in the last couple of years, to a certain degree, been replaced by open-plan classrooms that encourage a more active participation from the children. As a result, the classrooms in primary schools have changed to be able to cover more various functionalities at the same time, than earlier. This have affected the overall noise level and created a more challenging learning environment for children, especially those with special needs, but also typically developed children, because of increased level of noise during teaching activities. This can be a disturbing aspect for some, but it could potentially also be a contributor to stress and other health issues (Helsedirektoratet, 2014). School classes in Norway usually consist of 30 children and often does the noise level increase in relation to the number of children in the same room. A classroom with a high activity level amongst the children and poor acoustic management may create a poor listening, and learning environment, that also influence on social communication.

2.2.2 Acoustic management

Acoustic management of a classroom refers to the listening and learning environment in a classroom. Often there can be a sub-optimal listening environment because of high levels of background noise or longer reverberation times (Duarte da Cruz et al., 2016; Walker et al., 2015; Zanin & Rance, 2016). Despite the recommendations from NDH (Helsedirektoratet, 2014), on how to ensure environmental health care in schools, sometimes it is not possible to change the layout or construction of the classrooms to reduce background noise or reverberation times. Alternative methods are therefore available in some cases, such as assisting listening devices (ALD) which refers to any device that enhance acoustic sound (Zanin & Rance, 2016). Sound amplification system is a form of ALD, that consists of a speaker, a microphone for the teacher to wear around the neck and microphones for the children to use at their desks. The purpose with the system is to enhance the speaker's voice and is normally used when teaching someone with a hearing impairment or learning disability that would benefit from increased audibility or intelligible speech. However, most children may benefit from an improved listening environment and hearing the teacher's voice more clearly.

3 Method

In this chapter the participants, research design, ethical and methodological considerations will be accounted for. As this thesis was part of a pilot project for a larger research project, a longitudinal study, a description of the whole project will be described first before the details in this current research is explained.

3.1 Participants

The sample in this study consisted of 46 individuals from the same primary school in Oslo, divided in two different classes in 4th grade, group 1 (N=24) and group 2 (N=22). The sample was not randomly selected and most likely not a representative sample for the whole population of 4th graders in Norway. Although, all participants had non-verbal intelligence scores within the average range, as measured by Ravens Matrices (Raven, Raven, & Court, 2008), and the classrooms was considered as typical classrooms for Norwegian primary schools. Thus, some results from the research might be applicable to other children around the country in the same age group, with similar characteristics or learning environments.

3.1.1 Recruitment process

The recruitment process started in the middle of December 2018. An email with information about the project, who was in charge and contact information, was sent out to every primary school in Oslo that met the requirements set for the project (N=61). Requirements specified that the school could not have an open-plan layout for their classrooms and had a minimum of two classes in 4th. grade, with at least 20 children in each class. Out of the 61 primary schools that was invited to participate, 12 schools replied. Included in those numbers, was the school who accepted our request and chose to participate in the project. While the other 11 schools declined the request to participate, they responded with positive comments and feedback about the project. They encouraged research on the topic of classroom environment and its effect on learning and wanted to be on a mailing list to receive information about the results. All necessary preparations were arranged late in December 2018 and early January 2019. The first meeting with the principal and teachers was in the third week of January.

3.2 Research design

In this current part of the research two groups participated, and both groups received the same intervention, but at different time during the research period. As both groups were considered as the treatment group and the control group they were been coded as group 1 (n=24), who received intervention in the first eight weeks, and group 2 (n=22), who received intervention the last eight weeks of the project (see *Figure 1*). Each participant was assessed at three different time points, test time 1 at the beginning of the project, test time 2 after the first intervention finished and test time 3 at the end of the project after the second intervention period had finished. At each test times abilities in reading fluency, general working memory, non-verbal intelligence, hearing threshold and behaviour in different social settings were assessed.

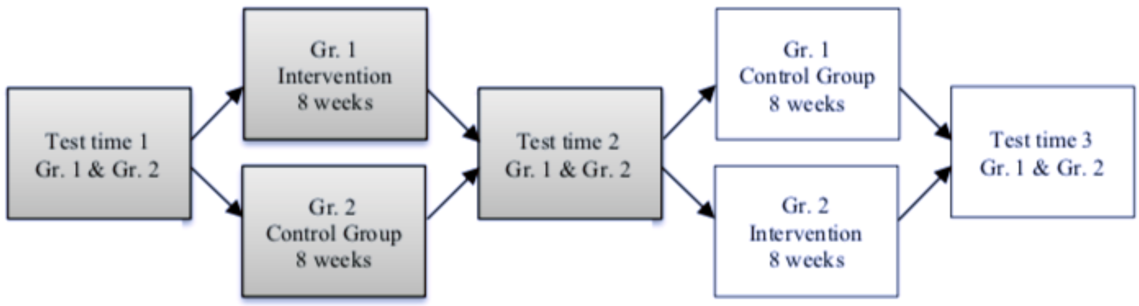

Figure 1. Research design for the whole research period where the relevant period for the current research is highlighted in grey

As a result of limited time, restrictions and guidelines regarding the extent of this thesis, only data from test time 1 and test time 2 was included. The aim was to examine how the use of a sound amplification system might affect reading fluency, and if the boys benefitted more than the girls from an improved listening environment. All the data from test time 1 was included to assess the background characteristics of the children and explore the differences and similarities between the groups. The mean scores from the reading fluency assessment from test time 1 and test time 2 was included as the quantitative data analysed with the purpose of answering the research questions. Hereafter when it is referred to either the research design, test times or collected data, it is with subject to these restrictions. Applying these restrictions may limit the research in some ways. It does, however, not change the importance of exploring each part of the data in a complex research project. The rest of the data that was collected but not used for the purpose of the current research, are available for further research later.

The research design was a quasi-experimental pretest-posttest design, as it included two groups but only one of them received intervention. In addition, was the dependent variable was measured before and after the treatment was implemented to examine the effect of the intervention (Lund, 2002a). In this case the dependent variable was reading fluency and the intervention was the use of sound amplification system in teaching. The two groups consisted of 46 children in total in 4^{th} grade from the same primary school, group 1 (n=24) and group 2 (n=22). They were not randomly assigned, as they were already divided into their classes, and group 1 (n=24) was chosen in agreement with the teachers to receive intervention for eight weeks. The other class, group 2 (n=22) was considered the control group and did not receive any form of intervention during this time period. Both groups had the same time schedule, but at opposite times because they had the same teachers in all their classes. The classrooms they used were similar to each other in terms of layout, background noise and reverberation.

Prior to the study, a test pilot was conducted with two participants aged 23 and 25 years old. The participants' age was not in accordance with the age group that was of interest for this research, but it was a way to get to know the tests, practice and evaluate all the procedures before starting to administrate the research project.

3.3 Ethical implications

It is essential to follow a variety of values and norms of research ethics set by the Norwegian National Research Ethics Committees (NESH) when a research is conducted. These research ethics values and norms are guidelines established to regulate scientific activities in a way that prevents burden or liability for the researcher or for any individuals participating (NESH, 2016). Research is used for presenting valid knowledge and it is essential to carefully reflect on all aspects of the research process from the choice of research question, to the methodological and analytical approach (NESH, 2016). It is the researcher and the institution's responsibility to ensure that research projects are conducted in a responsible and reliable way, in order to create possibilities of valuable insight to new knowledge.

3.3.1 Careful and satisfactory recruitment and sampling

Participation in any research is voluntary and the informants recruited should not feel obligated or pressured to participate (NESH, 2016). The participants in this study was not contacted directly. Information about the study, its purpose and the researchers, was sent to all primary schools in the chosen area which did not have an open-plan based school layout (see appendix 2. p. 83). Only the ones who replied with a request for more information or was interested in participating was contacted further by email correspondence or phone calls. All communication up until the first meeting at the school with the principal and the teachers, was through email with the principal. It was decided that the teachers would first inform the children in their class, and then inform the parents through their weekly newsletter with a short note on the project and that more information would be sent home with the children in the coming week. Thus, increasing the chances of the parents looking for the information letter and increasing the interest for participating. If further communication with the parents was necessary, letters in sealed envelopes was given to the children during class for them to bring home. If any of the participants had any questions or wanted more information, they could contact the teachers, the researchers or the data protection officer, who was in charge of the participants privacy, at any time during the research period. All necessary contact information was printed on every single letter of information distributed.

3.3.2 Handling of personal data

Personal information and data about the participants that was collected through the project, was necessary for the research to be conducted. According to the guidelines from NESH (2016) such data needs to be handled with care, encoded and anonymized, so it is impossible to be traced back to the participants. All data must to be securely stored, out of reach for anyone else other than the authorized personnel agreed upon beforehand and deleted as soon as it is no longer necessary to keep. Participants have a right to know what information about them is collected, how it will be used, stored and when it will be deleted (NESH, 2016). This information was given before participation commenced. In accordance with the guidelines all data was encoded, first with a primary code and then a secondary code, anonymized and kept in a fireproof cabinet, separated from any forms or documents where the participants identity appeared (see appendix 3. p. 84).

This research needed to collect personal information about the participants, in terms of their names, birthday and what school they attended. A letter for approval was therefore sent to the Norwegian Centre for Research Data ([Norsk senter for Forskningsdata] NSD), who approved the project in early January 2019. At the date agreed upon, in the letter of approval from the NSD, all data will be terminated. Results from the research may be used or presented in other masters- or doctoral thesis, scientific research papers or articles, but all personal data are anonymized. The participants were informed about this and approved to it when they agreed to participate.

3.3.3 Informed consent

It is necessary to obtain an informed consent from all who participates in a research project. An informed consent should give the participant adequate information about the research, what information will be obtained and what it means for them to participate (NESH, 2016). The group of interest for this research was children 9 to 10 years of age, and because children under the age of 15 are considered minors and a vulnerable group, it was necessary to obtain an informed consent from their parents as well. According to the guidelines from NESH (2016) should children from the age of seven, or younger if they are able to form their own opinions on a matter, be allowed to receive information and express their opinions about participation. From the age of 12 years the children should, in addition to parental consent, be able to accept or decline participation in research themselves.

An information letter that contained information about the project, what the participation entailed and what personal information would be collected was handed out to the children to bring home to their parents. The letter included one informed consent for the parents to sign on behalf of their child (see appendix 4. p. 87), and one for the children to sign for themselves (see appendix 5. p. 90). There was also a description on how their personal information would be stored. The information in the letter for the children to sign, was adjusted to be more age appropriate and understandable for them, in addition did they receive the same information orally at the beginning of the project period. Before test time 1 started, each child was informed that their participation was voluntary and were asked, again, if they wanted to participate. It was essential to highlight the importance of their participation being voluntary and that even though their parents had approved, they could choose for themselves to participate or not. All the children with parental consent agreed to participate. At both test times the children were reminded that their participation was voluntary, and they could leave at any time if they wanted to without there being any consequences, as in accordance with the guidelines from NESH (2016). If they, at any time, wanted to end their participation and withdraw their consent, their personal information would be terminated.

3.3.4 Vulnerable groups in research

In research involving vulnerable groups it can sometimes be difficult to obtain freely given and informed consent to participate, this may concern for example children, individuals who are mentally ill or persons with intellectual disabilities. In some cases, a parent or legal guardian may consent on their behalf, but it is crucial for the researcher to take responsibility to protect the integrity of the individuals participating (NESH, 2016). Research involving vulnerable groups are considered valuable and important, but the responsibility to follow the ethical guidelines are even more vital. It is thus essential to conduct the research in a satisfactory and ethical manner to avoid any severe burden or liability for the participants (NESH, 2016). The children who participated in the current research was taken care of bey receiving all information in an age appropriate way both written and orally. They were repeatedly informed about their right to withdraw their consent at any time, without any consequences.

3.4 Instruments

The children were assessed in different abilities such as reading fluency, general working memory, non-verbal intelligence and hearing threshold. In addition to that, did the teachers fill out a questionnaire about the participants' executive functions. The test instruments used in this research project are listed in **Table 2.** In order to examine the listening environment in the classrooms and establish if the preconditions were similar for both groups, measurements of the acoustic environment were performed by an authorised acoustician.

Table 2. Test instruments and backgrounds statistics from test time 1 (n=46)

Ability	Test	Standardised	Test time 1		
			M	*(SD)*	Range
Reading fluency	STAS (Klingenberg & Skaar, 2003)	YES, Norway	161.17	(53.14)	242
General working memory	SIPS (Wass, 2009)	YES, Sweden	13.80	(1.98)	8
Non-verbal intelligence	Ravens matrises (Raven et al., 2008)	YES, UK	61.33	(25.27)	79
Hearing threshold	Audiometry, HFPTA (0.5, 1, 2 & 4 kHz)	----------------	L[1]:9.25 R[2]:10.75	(3.96) (6.58)	20 44
Executive functioning	BRIEF-teacher screening questionnaire (Gioia, Isquith, Guy, & Kenworthy, 2015)	YES, USA	58.45	(26.93)	79.9

Notes: [1]Left ear, [2]Right ear

3.4.1 Reading fluency

Reading fluency was assessed with a Norwegian test called *Standardisert Test i Avkoding og Staving* (STAS), which translate to Standardised Test in Decoding and Spelling and will hereafter be referred to as STAS. The main purpose of STAS is to acquire information about a child's ability to decode and spell words, in addition to indicate the cause of challenges with reading (Klingenberg & Skaar, 2001, p. 5). In other words, to identify who that needs extra support with their reading development, what the struggle is and how to support the individual in order to encourage and continue the reading development. STAS was standardised by a sample of 1000 Norwegian children, distributed by 100 children in each grade from 2nd to 10th grade (Klingenberg & Skaar, 2001). The process of collecting data for standardisation was carried out during October and November, quite at the beginning of a new school year.

STAS consists of two parts, the first part can be conducted in a group setting, while the second part is used for individual assessment. Within the two different parts, there are several subtests. For the purpose of this project only the individual assessment was used, and six out of the eight individually subtests were administered. Each of the subtests consisted of a continuous list with either non-words or regular words with meaning of increasingly difficulty. The purpose was to read out loud as many words as possible, with correct pronunciation, in 40 seconds (Klingenberg & Skaar, 2001, 2003). Any mispronunciation, errors or if the child skipped a word was marked in the test administers notes, in addition to underline the last word that was read within the time limit. For each correctly pronounced word, one point was given. The total test score was calculated by subtracting the number of errors from the total number of words read within the time limit of 40 seconds.

The reliability of STAS is in regard to if it measures a child's ability to decode and spell. Based on the sample size used for making the standardised norms the reliability has been considered to be high (Klingenberg & Skaar, 2003; Tempolex, 2017).

3.4.2 General working memory

The general working memory was tested with the *Sound Information Processing System (SIPS),* which was designed as a computer-based test battery containing nine subtests for examining cognitive functions (Wass, 2009). For the purpose of the current research only the subtest *sentence completion and recall* test was used, in paper version. The original language for the test was Swedish, but it has been translated into Norwegian.

The aim of SIPS was to examine general working memory. It was administered by presenting a series of uncompleted sentences where one word was missing. The child was asked to fill in the missing words and repeat them at the end of each series, which consisted of either two, three or four incomplete sentences (Wass, 2009; Wass et al., 2010). See appendix 6 (p. 93) for more information about the test, and how it is administered. If a child had difficulties remembering a word, help could be given by repeating the first phoneme in that word. For the purpose of scoring the results, it was essential to write down the word for each sentence, make a note if help was given or if any words were forgotten or replaced. Each correct remembered word was scored one point, and half a point if any help with the phoneme was given, with a maximum score of 18. SIPS has been standardised in Swedish, but is considered relevant to use for comparison with Norwegian children (Wass, 2009; Wass, Anmyr, et al., 2019; Wass et al., 2010).

3.4.3 Non-verbal cognitive ability

Non-verbal cognitive ability, or intelligence, was assessed using the Raven's Matrices, which consist of two parts; the *Coloured Progressive Matrices (CPM)* and the *Crichton Vocabulary Scales (CVS)*. CPM is a non-verbal measurement of cognitive ability, where the main purpose is to figure out the system underlying the figures that are presented (Facon, Magis, Nuchadee, & Boeck, 2011; Helland-Riise & Martinussen, 2017). The CVS is a verbal measurement of general ability and contains a list of 80 words to be defined (Raven et al., 2008). In both versions, the tasks are ordered by increasing difficulty. The aim was to get a perception of the children's non-verbal intelligence, and thus only CPM was used. The child was presented with 36 geometrical figures with coloured pattern where one piece was missing, and it was divided into three sets of 12 task. The assignment was to choose the correct piece to complete the pattern, from the alternatives that were given (Facon et al., 2011). One point was given for each correct answer. The results from all three sets were summed to a total score that was converted to percentiles based on the standardised scores included in the manual (Raven et al., 2008).

Raven's CPM is intended for children up to 11 years of age and should be administered in a one-to-one test situation, without any time restrictions (Raven et al., 2008). The standardised norms available is based on samples from the United Kingdom. Helland-Riise and Martinussen (2017) claimed the lack of testing amongst Scandinavian children might influence the relevance for using them in a Norwegian context. However, the test is based on non-verbal abilities, which makes it quite free of cultural influence and, in that case, would make it an appropriate test to use worldwide to get a reasonable measure for non-verbal intelligence (Helland-Riise & Martinussen, 2017).

3.4.4 Hearing threshold

A pure-tone audiometry was conducted to assess the children's hearing threshold, which refers to the capacity to detect stimuli (Stach, 2010). In the pure-tone audiometry signals were presented first to the right ear and then to the left ear. They were presented at different frequencies or threshold, and the child was asked to respond to the signals that were audible (Stach, 2010). The thresholds tested was 1000, 2000, 4000, 6000, 8000 and 500 Hz respectively, and a high-frequency pure tone average (HFPTA) based on the threshold average of 500, 1000, 2000, 4000 Hz was calculated (Smith, Bennett, & Wilson, 2008). As

HFPTA emphasise the higher frequencies, it is considered as an adequate indicator for hearing function and the understanding of speech as it covers the spectrum of sounds used in speech (Smith et al., 2008). All the children had HFPTA within the average range, 0-20dB, of typical hearing threshold.

3.4.5 Executive functioning

A questionnaire from the *Behaviour Rating Inventory of Executive Functioning (BRIEF-2)* was used to get an insight in executive functioning of the children. There are two versions of the questionnaire, a full version and a screening version. The full version contains 63 questions, while the screening version contains 12 questions. BRIEF-2 is a questionnaire intended for teachers, parents and children to measure everyday behaviour associated with executive functions in and reaction to, different social settings at home and in school (Gioia et al., 2015; Hysing & Sørensen, 2016). The data from BRIEF-2 was not used in relation to the research question in this study.

In the current research the screening version was distributed to the teachers to answer for each of the children in their class. For each question there was a three-point scale, (1) never, (2) sometimes and (3) often, alternative to reply to, which was scored respectively. The points were then transferred and computed into raw scores and percentiles that was used in comparison with the standardised norms in the manual (Gioia, Isquith, Guy, & Kenworthy, 2000). BRIEF-2 has been standardised by parents of 1419 American children within the age of 5 to 18 years old. The American standardised norms are considered applicable to use in Norwegian context (Hysing & Sørensen, 2016).

3.4.6 Acoustical diagnose of the classrooms

The acoustical environment in the classrooms were examined before the sound amplification system was installed, to make sure the preconditions were similar for both classrooms. The background noise level and reverberation time was measured when the classrooms were unoccupied, and then during a class where the children were working individually and quiet without much instruction from the teacher. The measured values of background noise level and reverberation times in both classrooms, unoccupied and with children present, are listed in **Table 3**. High levels of background noise and long reverberation times can have a deleterious effect on children's ability to discriminate speech from noise and thus understand the speech (Duarte da Cruz et al., 2016; Zanin & Rance, 2016). Zanin and Rance (2016) claim that the degradation of speech intelligibility occurs when reverberation times is greater than 0.4-0.5 seconds. However, studies have shown that improved audibility through the use of sound amplification systems and remote microphones contribute to reduce the negative effects of high levels of background noise and longer reverberation times (Duarte da Cruz et al., 2016; Tomblin et al., 2014; Zanin & Rance, 2016).

Table 3 Acoustic Measurements of classrooms

Classroom	**Reverberation times**[1]		**Background noise level**[2]		**Background noise level extra**[2]	
	Unoccupied	Occupied	Unoccupied	Occupied	Unoccupied	Occupied
Group 1	0.56	0.40	33	40[3]	41[5]	50[6]
Group 2	0.50	0.48	34	51[4]	40[5]	59[7]

Notes: [1]Measured in seconds, [2]Measured in dB, [3]Children were instructed to be quiet during measurement, [4]Children were not instructed to be quiet, [5]Technological devices, radiators and projector for smartboard, in the classrooms were switched on as they would be during class, [6]Children were working individually, [7]Children were having lunch and eating by their desks.

3.4.7 Sound amplification system

A sound amplification system is used to enhance the signal-to-noise ratio by strengthening the speakers voice, which makes it more clear and easier to hear and understand (Stach, 2010; Statped, 2016). The system used in this project consisted of a speaker, a portable microphone for the teacher to wear and table microphones used by the children at their desks. A sound amplification system is typically used when teaching someone with a HI or some form of disability that would benefit from an improved listening environment. However, amplified speech makes it easier to distinguish important sounds from background noise, and might benefit all, independent of HI or typical hearing.

3.5 Methodological considerations

There are different types of validity and reliability that can affect the process and outcome in a research. It is therefore important to be cautious and attentive to possible limitations that may potentially be a threat to the validity and reliability of the research. The terms of validity and reliability are not the same, but sometimes they overlap in considering results as valid, the measurements need to be reliable as well (Cohen, Manion, & Morrison, 2011). This means that the results are verifiable. Cohen et al. (2011) claims it is impossible for a research to be 100% valid, but that it is possible to improve the validity through careful sampling, appropriate use of instruments and statistical analysis of data. There are many forms for validity, but only a few are highlighted for the purpose of this research.

3.5.1 Validity in quantitative research

Validity is an important aspect in research and means being true to the assumptions supporting the statistics used, because a research project that is considered invalid is worthless according to Cohen et al. (2011). Therefore are the principles of, amongst other, controllability, replicability, predictability and observability emphasised as important to strive to follow (Cohen et al., 2011). A validation system was developed by Cook and Campbell (1979) for use in causal research, such as the current research, and consisted of four elements that should be considered in conducting a quantitative research; internal validity, external validity, statistical conclusion validity and construct validity.

3.5.2 Internal validity

If the connection examined is causal, meaning that the independent variable affects the dependent variable, the preconditions for internal validity is met (Cook & Campbell, 1979; Lund, 2002b). In this case the internal validity would be strong if the results implied that the use of sound amplification did indeed affect reading fluency. There are numerous threats to internal validity, some of them such as selection, maturation, history and instrumentation were relevant for the current research. Selection as a threat is based on systematic differences between the groups participating in the research (Lund, 2002b). In this case the selection threat would refer to the different level of reading fluency amongst the children in the two groups, before the research started. Maturation refers to how a change in the dependent variable might be caused by biological or environmental circumstances, instead of the independent variable (Lund, 2002b). The natural development and improvement in reading fluency would potentially make a threat to the internal validity, because it is considered normal for children in that age to have continuous progress in reading. However, the maturation would possibly apply to all the participants and therefore not affect the group difference in the same way as history could do. As history refer to a single event or experience that would happen during a research period, and could according to Lund (2002b) affect the dependent variable. There could have been events happening outside of school during the research period with some of the children that could affect their performance in reading fluency. Precautious measures were made in to make the school setting and preconditions as similar as possible, so any personal events would have a less remarkable effect on the results. The threat concerning the instruments used for assessments, was reduced as all the instruments had previously been standardised on an appropriate sample, so the results were comparable. In addition, were the instructions on how to administer the instruments thoroughly discussed and studied prior to the first test time to reduce any wrongdoings of the measurements.

3.5.3 External validity

If the results from a research can be generalised to the population that the sample represent, the external validity is considered to be strong (Cook & Campbell, 1979; Lund, 2002b). One of the most common threats to external validity is sample size, and to generalise from a small sample to a broad population (Cohen et al., 2011; Field, 2014). Although a big sample is preferred to reduce the threat against external validity, tendencies examined in small samples may still be applicable to the broad population. The sampling procedure is a crucial element in reducing this threat, and by random sampling the chance of a representative sample of the population increase (Field, 2014). A convenience sampling method was used for the current research, meaning information about the research was sent out to primary schools in Oslo and the first to accept the request for participation was included in the research. Based on the extent of this current research, the sample was large, but in order to generalise to the rest of the population a larger sample would be preferable. The results may, however the sample size was, be used as an indication for how sound amplification system might affect reading fluency with children in similar learning environments.

3.5.4 Statistical conclusion validity

If the correlation or tendency that is examined is statistically significant or there is a reasonable strong connection, the precondition for statistical conclusion validity is met (Cook & Campbell, 1979; Lund, 2002b). A reasonable strong connection is, according to (Lund, 2002b), determined by the field of expertise. In this research the field of expertise was educational audiology, which is a part of educational research, and the significance level is measured by a p-value that is set to 0.05. This means that if the p-value was greater than 0.05, there would be a 5% chance that the effect that was measured was due to chance, and that the effect could be seen in the sample but not necessarily in the population (Lund, 2002b).

Type I and type II errors are common threats to the statistical conclusion validity, and refers to the challenges of rejecting a true null-hypothesis or accepting a false null-hypothesis (Field, 2013; Lund, 2002b). These threats can be reduced with a larger sample, a lower significance level, reduced variance in the population and greater difference in effect size (Lund, 2002b).

Cohen's d can be used to measure the effect size in the sample. Based on the means of different groups, it indicate if there is a difference between the groups (Field, 2013). An effect size that is measured to 0.02 is considered small, 0.04 medium and 0.08 is considered large as defined by Cohen's d (Field, 2013; Hulme & Snowling, 2009). The results from this research indicated a significant difference between the groups in reading fluency. However, the effect size was measured by Cohen's d using the mean difference in total from test time 1 to test time 2 in the two groups. The measurements indicated that the difference from test time 1 to test time 2 for group 1 (n=24, 1.10 SD units) was larger than the difference for group 2 (n=24, 1.02 SD units). As the difference between the groups was 0.08, the effect size can be considered as large, as defined by Cohen's d (Field, 2013).

3.5.5 Construct validity

Construct validity refers to how well an instrument measure the variable it is supposed to measure (Cohen et al., 2011; Cook & Campbell, 1979; Lund, 2002b), which in this research the instrument used was STAS and the variable measured was reading fluency. The construct validity for STAS is considered strong by Klingenberg and Skaar (2001), because it has been validated and standardised on a large sample of Norwegian children in 2^{nd} to 10^{th} grade. It has also been included in several studies where the aim was to examine if different tools and tests commonly used in Norway correlated in the ability to determine reading difficulties (Klingenberg & Skaar, 2001; Tempolex, 2017). The variable measured in this research was reading fluency, which can be defined as a combination of speed and accuracy (Calet et al., 2015), and is considered an appropriate indicator for reading competence (Klingenberg & Skaar, 2001; Tempolex, 2017).

There are two aspects of threats against construct validity, the first is random errors of measurement and the second is systematic errors of measurement. Random errors do not occur randomly, they "behave" random, but do not make an impact in the long run or if the sample size is large (Kleven, 2002). Systematic errors, on the other hand, refers to the instrument, how it is measured and human error in terms of reading the measurements wrong (Lund, 2002b).

3.6 Reliability

Reliability refers to the dependability, consistency and replicability of research, in addition to the amount of errors in the data (Cohen et al., 2011; Kleven, 2002). Reliability is considered strong if it is possible to recreate the research in a similar context and obtain similar results (Cohen et al., 2011). There are several ways to increase reliability in research and limit the probability of errors in the measurements. Some of these consist of testing something twice, having two test times within a short time interval or to perform a test-retest. The common feature for all of these are that they examine the correlation between results at different test times, and a higher the correlation indicates a higher reliability (Cohen et al., 2011; Kleven, 2002). The research design for the current research was inspired by previous studies, which could possibly increase the chance of replicability as similar settings and results were achieved (Duarte da Cruz et al., 2016; Zanin & Rance, 2016).

3.7 Statistical analyses

An independent t-test and a paired samples t-test was used to compare the means of reading fluency from test time 1 and test time 2, across the groups and across gender in each of the groups. A simple bar plot was created to examine the mean difference from test time 1 and test time 2 across the groups. A clustered bar plot displayed the mean difference in total for the boys and girls across the groups. The simple and clustered bar plot was created with a confidence interval of 95% and was used to examine if there was a significant difference.

4 Concluding comment

The current research project had some limitations in terms of sample size, time restrictions and lack of qualitative data. It would have been preferable to include more groups of children and different kinds of classrooms, such as both closed layout and open-plan layout to examine the difference between the two kinds of classrooms. As a result of the restrictions and extent of this thesis, the intervention period was only eight weeks long. For future research it would be beneficial to extend the intervention period or do a longitudinal research to examine the long-term effects of the use of sound amplification system in teaching. To see change and effect from the sound amplification system, more than eight weeks would be recommended. All measurements in the research were quantitative data, meaning there was not any qualitative data collected from the participants in regard to their experiences or reflections from the intervention period. It could be interesting to examine if there was a difference between the children and the teachers in how they experienced an improved listening environment.

The results from the current research imply that using a sound amplification system had a positive effect on reading fluency, and that the boys benefitted more than the girls. Although there was a significance difference between the groups, more research is recommended to evaluate and examine the correlation between use of sound amplification system and academic development.

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6 Article manuscript

Listening environment in classrooms – the effect on reading fluency: boys benefit more than girls from an improved listening environment in the classroom

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Listening environment in classrooms – the effect on reading fluency: boys benefit more than girls from an improved listening environment in the classroom

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Abstract

Background: The objective was to examine if the use of sound amplification system in teaching would have a positive effect on reading fluency and if boys benefitted more than girls from an improved listening environment. Norway participate in international academic performance tests every three years and is one of the countries with the largest gender gap in performance. The boys are outperformed by the girls, especially in reading.

Methods: Quasi-experimental, pre- and post-test research, with a sample (n=46) of Norwegian children aged 9 to 10 years old, who were divided into two groups. One group received intervention in form of using a sound amplification system in teaching, and the other was the control group. All participants were assessed individually in reading fluency at two test times, before and after the intervention.

Results: The results indicated that the use of sound amplification system in teaching has a statistically significant effect on development in reading fluency (p=.001). The boys who received intervention had a significant better score on the reading fluency test post-test compared to the boys in the control group (p=.001).

Conclusion: Sound amplification system may have a positive effect on reading fluency, especially for boys. However, further research is needed in order to get a better understanding of what might cause the gender gap in reading fluency, and how to reduce the gender gap.

Keywords: reading fluency, gender gap, sound amplification system, listening environment

Introduction

The linguistic development in early childhood makes the foundation for the ability to read, write and develop other cognitive functions (Cole & Flexer, 2011). Multiple studies have emphasised how children during their first year in life tune their phonetic perceptions to become more sensitive to phonetic distinctions that is used in their own surrounding, native language. In that way they create phonetic categories that is used for learning new words and later in literacy (Nation & Snowling, 2004; Tomblin et al., 2014; Wass, Anmyr, et al., 2019; Wass, Löfkvist, et al., 2019; Werker & Fennell, 2009). However, in order to do so, there have to be acoustic input, which means that if something prevent the brain from receiving acoustic input, such as a hearing impairment, the linguistic development is at risk of being interrupted or delayed. A child's brain does not perform cognitive task in the same way as an adult's brain, and therefore need more audibility and intelligible speech signal compared to adults (Duarte da Cruz et al., 2016; Shield & Dockrell, 2008; Tomblin et al., 2014; Zanin & Rance, 2016). Furthermore, is the importance of proper acoustic management in learning facilities, like classrooms, to ensure optimal listening and learning environments for the children.

Despite access to acoustic standards for construction and design of educational facilities (Zanin & Rance, 2016), previous studies show that the regulations are not followed. Thus, may alternative methods be necessary to consider in order to ensure optimal learning environment in schools. An example of this might be to use assistive listening devices (ALD) such as a sound amplification system that consist of a speaker, microphone for the teacher to wear and microphone for the children to use at their desks. The system enhance the signal-to-noise ratio by strengthening the speaker's voice, and reduce the general noise level in the class as the microphones can only be used by one at a time (Stach, 2010; Statped, 2016; Zanin & Rance, 2016). Several previous studies have implied that the use of ALD in teaching improve the listening environment in the classroom (Duarte da Cruz et al., 2016; Zanin & Rance, 2016). Duarte da Cruz et al. (2016) examined how three months use of sound amplification system affected the overall noise level in ordinary classrooms, the teacher's voice and academic development in children with typical hearing. Their results showed that the academic performance in reading improved, speech intelligibility increased, and the teacher's vocal strain was reduced. Zanin and Rance (2016) explored how different combinations of ALD, thus amplified sound, affected learning in children with hearing impairment. They found that using a remote microphone, which send sound directly to the hearing aids or cochlear implants, in combination with a sound amplification system was most beneficial way to improve academic development. However, some of the children found the remote microphone attracted more attention to their hearing impairment and would rather not use it, despite the academic benefits from increased audibility and speech intelligibility.

The Norwegian educational system is considered to provide high quality education for all children, and is in general viewed as a well-functioned educational system (NJ MED, 2019). However, the results from the triennial Programme for International Student Assessment (PISA), indicate that there might be some flaws in the system. The results from the PISA conducted in 2015 revealed that Norway was one of the countries with the highest gender gap (Kunnskapsdepartementet, 2018b; OECD, 2018). The boys outnumbered the girls in dropouts from upper secondary education, with only 65% of the boys who graduated within the scheduled time period, compared to 72% of the girls (Borgonovi et al., 2018; OECD, 2018). In addition, did boys perform more often than the girls, in the lower levels in reading, mathematics and science. In reading, the girls outperformed the boys with 40 score points, which is higher than the average 24 score points of difference in the other countries who participated (Borgonovi et al., 2018; OECD, 2018). Norway participate in the Progress in

International Reading Literacy Study (PIRLS) every five year, which measure children's learning in reading. The results from the PIRLS in 2016 indicated an overall improvement in the performance level in reading, with boys and girls. However, Borgonovi et al. (2018) emphasise that despite the increased performance level in reading, the gender gap remained unchanged because the girls still outperformed the boys. It is interesting, but a bit concerning that the boys continue to be outperformed by the girls in academic performance. Further research on what might cause this gender gap and how to reduce it, is highly recommended.

Aim of this study

The main purpose of the current research was to examine if the use of sound amplification system in teaching would have an effect on reading fluency in children with typically hearing. In addition, to assess if boys had a greater benefit from an improved listening environment, compared to the girls.

Research questions

This research was centred upon two research questions; (1) *Does the use of sound amplification system in teaching have a positive effect on reading fluency in children with typical hearing?* and (2) *Do boys benefit more than girls from an improved listening environment in the classroom?* The hypothesis of this research was that the use of sound amplification system would have a positive effect on reading fluency, and that boys would benefit more than girls.

Method

Study design

This research project was constructed as a quasi-experimental pre- and post-test design, where one out of two groups received an intervention. A convenience sampling method was used by including the first school that responded to the information and request to participate that was sent out by email to all schools of interest in the capital area (Oslo). The intervention involved implementing a sound amplification system to be used in teaching. The current research was part of a pilot study for a larger longitudinal research project, where focus will be on how listening environment affect reading fluency, executive functioning and auditory processing in children with hearing impairment. However, because of limited time and extent, the focus of this study is based on how reading fluency alone might be affected by the use of a sound amplification system in teaching children with typical hearing.

Participants

Forty-six children participated in the research, divided into two groups; treatment group (n=24) and control group (n=22). See **Table 4** for more information about background statistics. The distribution of boys and girls in total were uneven, but similar between the groups. Sixteen girls participated in each of the groups, while there were eight and six boys in the treatment and control group respectively. All the children were tested at two different occasions; test time 1 at the beginning of the research period and eight weeks later at test time 2 when the intervention period had finished. They all had non-verbal intelligence scores within the average range, as measured by the Raven's Matrices intelligence test (Raven et al., 2008). In addition, all of them had Norwegian as their native language, shared the same teachers and both classrooms had similar acoustic measurements. The average range of non-verbal intelligence amongst the children, and the similar preconditions in terms of language, teachers and classroom acoustics contributed to reduce the probability of biased results.

[**Table 4** near here.]

Materials and procedure

At the two test times each child was assessed individually, the tests were presented in random order and administered during one session lasting about 30 minutes at both test occasions. The test instructions were given orally. The assessment was conducted by two trained test administrators, in a quiet room in the school. At test time 1 general working memory, non-verbal intelligence and hearing thresholds were assessed (Raven et al., 2008; Smith et al., 2008; Wass, 2009). The teachers and parents filled out a questionnaire about the children's executive functions (Gioia et al., 2015). Reading fluency was assessed at both test time 1 and test time 2 (Klingenberg & Skaar, 2001, 2003).

Non-verbal intelligence was assessed using the subtest Coloured Progressive Matrices from Raven's Matrices Intelligence Test (Raven et al., 2008). The child was presented with 36 geometrical figures with coloured patterns where one piece was missing. The task was to choose the right alternative to finish the pattern (Facon et al., 2011), the figures were ordered by increasing difficulty.

General working memory was assessed using a subtest of the *Sound Information Processing System (SIPS)*, which is a computer-based test battery containing nine tests for examining cognitive functions (Wass, 2009). However, only the subtest *sentence completion and recall* test was assessed in a paper version. The child was asked to fill in the missing word in a series of sentences, and afterwards to repeat the words (Wass et al., 2010).

Hearing thresholds was measured in a pure-tone audiometry, and a high-frequency pure tone average (HFPTA) was calculated based on the thresholds of 500, 1000, 2000 and 4000 Hz. All the children had HFPTA within the average range, 0-20 dB, of typical hearing thresholds.

The questionnaire that the teachers responded to, was the screening version of *Behaviour Rating Inventory of Executive Functioning (BRIEF-2)*. It consisted of 12 questions in relation to the children's behaviour in different social settings (Gioia et al., 2015). The teachers filled out a questionnaire for each child in their group.

Reading fluency was assessed at test time 1 and test time 2 by using the Norwegian reading test *Standardised test in Decoding and Spelling* (Standarisert Test i Avkoding og Staving (STAS) (Klingenberg & Skaar, 2001, 2003)). The main purpose was to collect information about a child's ability to decode and spell words, in addition does the test give an indication for the cause of possible reading challenges (Klingenberg & Skaar, 2001, p. 5). STAS consist of two parts, one which can be conducted in small groups, and the other one for individual assessment only. They both consist of several subtests. Six out of the eight individual subtests were chosen for this research. Two of them contained a continuous list of non-words, while the other four contained continuous lists of meaningful words with increasing difficulty (Klingenberg & Skaar, 2001, 2003). In each of the subtests, the child was asked to read out loud as many words as possible in 40 seconds. Mispronunciations, errors or skipped words was marked, and for each correctly pronounced word one point was given. The total test score was calculated by subtracting the number of errors from the total number of words read within the 40 second time limit. As STAS has been standardised on a sample of 1000 Norwegian children in 2nd to 10th grade (Klingenberg & Skaar, 2001), it was considered appropriate to compare the results to the standardised norms in the manual. The sample used for standardisation was large, and the reliability of STAS considered high, thus it is an appropriate measurement of the ability to decode and spell (Klingenberg & Skaar, 2003; Tempolex, 2017).

Acoustical measurements were conducted in both classrooms, prior to the installation of the sound amplification system, and once while the children were in the classroom. The measurements of background noise level and reverberation times (RTs) were similar in both classrooms, which are listed in **Table 5**.

[**Table 5** near here.]

Statistical analyses

The statistical analyses used to compare the means of reading fluency in this research was an independent t-test and paired samples t-test. The independent t-test was used to examine the mean difference in total from test time 1 to test time 2 across the groups (group 1vs. group 2), and across gender in each of the groups (boys vs. girls). The paired samples t-test was used to explore the means of test scores on STAS (reading fluency) at test time 1 and test time 2 for both groups. Effect size was calculated using Cohen's d, to get an indication of the potential size difference between the groups.

Results

The aim of this research was to examine if the use of sound amplification system in teaching had a positive effect on reading fluency, and if the boys benefitted more than the girls from an improved listening environment. The current research's hypotheses were supported by the results as they indicate a more positive improvement in reading fluency for the treatment group, compared to the control group. The results indicate that there was a significant difference between the groups. The mean difference from test time 1 to test time 2, standard deviation (SD), range and effect size, as measured by Cohen's d, are listed in **Table 6**.

[**Table 6** near here.]

Does the use of sound amplification system have an effect on reading fluency?

The results from the research showed that group 1 had a greater improvement in reading fluency, compared to group 2. The group mean difference in total indicated that the boys and girls in the treatment group (n=24) had a greater difference from test time 1 to test time 2, compared to the boys and girls in the control group (n=22) as shown in **Figure 2**. The bar plot in **Figure 2** display the mean difference from test time 1 to test time 2 for group 1 (M=20.21, SD=18.40) and for group 2 (M=13.95, SD=13.63), with a Confidence Interval (Cis) set to 95%. Although the mean difference in total for the groups are different from each other, the CIs 95% overlap and thus the means are not significantly different from each other.

[**Figure 2** near here.]

Do boys benefit more than girls from an improved listening environment?

The results indicate that the boys improved their reading fluency more after the intervention period, compared to the girls. **Figure 3** display data with mean difference in total for the boys (group 1=21.21, group 2=17.50) and girls (group 1=19.75, group 2=12.63) in both groups, with CIs 95%. These results show that the mean difference for gender across the groups are different from each other, and that the boys in both groups had a greater improvement than the girls. However, there is an overlap of CIs 95% and the mean results are therefore not significantly different.

[**Figure 3** near here.]

Was there a difference in total across the groups?

A paired samples t-test was performed to compare the mean difference in total between the groups (groups 1, group 2) and between gender across the groups (boys group 1, boys group 2) (girls group 1, girls group 2). The results for the groups (group 1, group 2) showed a significant difference ($t(45)=-7.11$, $p=.001$).

Paired sample t-test was performed to compare the mean difference in total for the boys and girls between the groups. The results for the boys between the groups (group 1, group 2) illustrate a significant difference ($t(13)=-4.05$, $p=.001$). This indicate that the mean improvement in reading fluency with the boys, were significantly different from each other. The results for the girls between the groups (group 1, group 2) were significantly different ($t(31)=-5.78$, $p=.001$). This imply that the average improvement in reading fluency for the girls, were significantly different from each other. Thus, there was a significant difference between the groups in the improvement of reading fluency, the boys and girls in group 1 improved significantly compared to the boys and girls in group 2.

Although the results were significant, Cohen's d was used to measure the effect size of the group differences in the sample. In that way, it was possible to indicate if there is a difference between the groups based on the mean difference in total from test time 1 to test time 2 (Field, 2013). An effect size that is measured to 0.02 is considered small, 0.04 medium and 0.08 is considered large as defined by Cohen's d (Field, 2013; Hulme & Snowling, 2009). The effect size measured on the mean difference in total from test time 1 to test time 2 indicate that the difference for group 1 (1.10 SD units) was larger than the difference for group 2 (1.02 SD units). As the difference between the groups was 0.08 SD units, the effect size can be considered as large, as defined by Cohen's d (Field, 2013).

Discussion

The purpose of this research was to examine the effect of an improved listening environment on reading fluency in Norwegian children 9 to 10 years of age, with typical hearing. The results from the current research indicated that an improved listening environment have a positive effect on reading fluency, especially for boys. These results support previous studies that have examined the effect of listening and learning environments in schools for children with and without hearing impairment.

Does the use of sound amplification system in teaching have a positive effect on reading fluency in children with typical hearing?

Several international studies have previously examined how listening environment in ordinary classrooms might affect children's academic development. Their results support the current research that the use of amplified sound do have a positive effect on learning (Duarte da Cruz et al., 2016; Shield & Dockrell, 2008; Tomblin et al., 2014; Zanin & Rance, 2016). Although previous focus in the literature might have differed in some ways, there has been a joint emphasis on the importance of increased audibility and intelligible speech for children, independent of if children have hearing impairment or typical hearing. As the brain is still maturing, children need quieter learning environment for optimised development (Duarte da Cruz et al., 2016; Zanin & Rance, 2016). It is therefore essential that classrooms, and other learning facilities have proper acoustic management to ensure ideal learning situations.

The United States of America, Europe and New Zealand have developed international guidelines for acoustical standards for educational facilities (Shield & Dockrell, 2003). Zanin and Rance (2016) claimed that these guidelines were increasingly important as more children with hearing impairment are integrated in ordinary schools than before. However, studies have shown that the regulations are not followed. Many classrooms are still not ideal listening environments with longer RTs and higher background noise level than recommended (Duarte da Cruz et al., 2016; Shield & Dockrell, 2008; Zanin & Rance, 2016). In their study, Zanin and Rance (2016) emphasised how degradation in speech intelligibility occur at RTs of greater than 0.4-0.5 seconds. Consider the acoustic measurements in the current research, as listed in **Table 5**, the classroom would benefit from the use of alternative ALD in order to improve the listening environment.

Previous studies conducted by Duarte da Cruz et al. (2016) and Zanin and Rance (2016), implied that the use of ALD in teaching improve the listening environment in the classroom. Their results support the current research, in terms of increased performance level in reading and improved speech intelligibility of teachers. Similarly to Duarte da Cruz et al. (2016) and the current research, did the study by Zanin and Rance (2016) imply that the use of ALD had a positive effect on learning, and emphasised that it would benefit all, not only the children with hearing impairment. This statement is supported by the current research findings, as the results indicated a significant difference in reading fluency after using the sound amplification system. Some of the children who participated in the study by Zanin and Rance (2016), chose to not continue to use the remote microphones or other forms of ALD, because it increased the attention to their hearing impairment, and thus negative stigma. As several studies have shown that the use of sound amplification system benefits all children, this could be a feature to emphasise in order to remove some of the negative stigma of using this system in teaching.

Do boys benefit more than girls from an improved listening environment in the classroom?

The results from the current research support the findings in the PISA results from 2015 (Borgonovi et al., 2018), that there is a gender gap amongst boys and girls in reading fluency. Although, the boys in group 1 had a higher mean score in reading fluency than the girls in the same group (see **Table 7** for details), these boys actually had the highest scores amongst all the groups. The results for the boys in group 2, however, correlates with the results from PISA, as they had a lower score on the reading test compared to the girls in the same group, at both test times. Borgonovi et al. (2018) emphasised how the results from the 2016 PIRLS indicated that there was an improvement in boys' and girls' performance level in reading, but the gender gap remained constant. The results from current research support this, as the boys in the control group, despite improvement, were still outperformed by the girls.

[**Table 7** near here.]

Previous studies have compared the performance level in reading for children with hearing impairment, to children with typical hearing. These studies implied that children with hearing impairment score within the average range of academic achievement, but their performance level is significant lower compared to children with typical hearing (Walker et al., 2015; Wass, Löfkvist, et al., 2019). In addition to a lower performance level, the children with hearing impairment tend to keep falling behind as they grow older (Walker et al., 2015). This correlates with the statement in regards to the large gender gap revealed in the 2015 PISA results, stating that the boys scored in the lower levels in reading, but still within the average range (Borgonovi et al., 2018; Kunnskapsdepartementet, 2018b; Mullis & Martin, 2015). The current research presented results showing that all the participants had scores within the average range in reading, but that there was a significant difference in development for the group who used the sound amplification system. Multiple studies support these results, that an improved listening environment increase the potential for learning (Duarte da Cruz et al., 2016; Tomblin et al., 2014; Walker et al., 2015; Wass, Löfkvist, et al., 2019; Zanin & Rance, 2016).

Several studies, including the current research, emphasise the importance a good listening environment can have on academic development. However, it may seem like despite improvement and scores within the average range, that the gender gap in performance level remains. In relation to the PISA 2015 results, the structure of the educational system and if the teaching style is part of the cause for the gender gap have been up for discussion (Borgonovi et al., 2018; Mullis & Martin, 2015). Could it be that the lecture-based way of teaching in primary schools, cause the gender gap in later school ages because the teaching methods favours those who manage to sit still? Sound amplification system, or other forms of ALD, may contribute to better learning prerequisites in classrooms for all children, by providing sufficient improvements of the audibility and speech intelligibility during teaching activities. Duarte da Cruz et al. (2016) accentuated benefits of using a sound amplification system, in addition to enhance speech intelligibility, such as improved speech recognition, increased focus time amongst the children and increased self-esteem. These are aspects that can be valuable in terms of promoting motivation for children who might have challenges with learning, and who are falling behind in their academic development or struggle to keep focus in a busy and noisy classroom.

Limitation and future perspective

The validity of the current research had some limitations in terms of sample size and thus generalizability, no significant difference, time limitations and short intervention period. These are factors that have been considered throughout the research. When doing a similar research study in the future it would be preferable to include more groups of children who are taught in classrooms with different room layouts that affect speech acoustics, to examine and compare the differences in relation to academic skills. In addition, it is recommended to extend the intervention period in order to explore the long-term effects of how an improved listening environment may influence on academic development. No qualitative data was collected about the personal experiences and preferences about using the sound amplification system. To include this in a prospective study would improve the overall understanding of how an improved listening and learning environment might affect both children and teachers. Including these other aspects could possibly strengthen the reliability of the research and the measurements.

Concluding comment

The results indicated that to use a sound amplification system while teaching Norwegian children aged 9 to 10 years old, have a positive effect on their development in reading, and perhaps academic development in general. The boys especially, benefitted from an improved listening environment, compared to girls. This is interesting and encouraging because boys are falling behind in most subjects in school, according to results from PISA and OECD. Introducing new features in teaching, such as sound amplification systems, might improve their academic performance and thus reduce the gender gap in school settings.

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List of abbreviations

ALD	Assistive Listening Device
BRIEF-2	Behaviour Rating Inventory of Executive Functioning
CIs	Confidence Interval
HFPTA	High-Frequency Pure Tone Average
OECD	Organisation for Economic Co-operation and Development
PIRLS	Progress in International Reading Literacy Study
PISA	Programme for International Student Assessment
RTs	Reverberation Times
SIPS	Sound Information Processing System
STAS	Standardised Test for Decoding and Spelling (Norwegian; Standardisert Test for Avkoding og Staving)

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8 Appendices article

Appendix 1. Table: Background statistics.

Table 4. Background characteristics of the participants (N=46), based on total score across the groups.

	Group 1 (T) (n=24)			**Group 2** (C) (n=22)			**Total** (T, C) (n=46)		
Sample descriptive	M/%	*SD*	Range	M/%	*SD*	Range	M/%	*SD*	Range
Age[1]	114.38	3.06	9	116.50	2.43	9	115.39	2.95	11
Boys	33.3% (n=8)	–	–	27.3% (n=6)	–	–	30.4% (n=14)	–	–
Girls	66.7% (n=16)	–	–	72.7% (n=16)	–	–	69.9% (n=32)	–	–
Reading fluency	163.42	52.88	219	158.73	54.56	218	161.17	53.14	242
General working memory	13.58	1.98	7	13.86	1.95	7.5	13.80	1.98	8
Non-verbal intelligence[2]	66.33	26.93	79	55.86	22.68	79	61.33	25.27	79
HFPTA[3]; left/right	8.86 / 10.11	4.33 / 3.17	20 / 13	9.66 / 11.42	3.58 / 8.91	14 / 44	9.25 / 10.75	3.96 / 6.58	20 / 44
Executive functioning	62.54	29.30	79.9	54	23.97	69.9	58.45	26.93	79.9

Notes: [1]In months, [2]Scores in percentile, [3]HFPTA=High-frequency pure tone average.

Appendix 2. Table: Acoustic measurement of classrooms.

Table 5. Acoustic measurement of classrooms.

	Reverberation times[1]		**Background noise level**[2]		**Background noise level extra**[2]	
Classroom	Unoccupied	Occupied	Unoccupied	Occupied	Unoccupied	Occupied
Group 1	0.56	0.40	33	40[3]	41[5]	50[6]
Group 2	0.50	0.48	34	51[4]	40[5]	59[7]

Notes: [1]Measured in seconds, [2]Measured in dB, [3]Children were instructed to be quiet during measurement, [4]Children were not instructed to be quiet, [5]Technological devices; radiators and projector for smartboard in the classrooms were switched on as they would be during class, [6]Children were working individually, [7]Children were having lunch and eating by their desks.

Appendix 3. Table: Descriptive measures of difference and Cohen's d.

Table 6. Descriptive measurements on mean difference in total across groups and gender

	Group 1 (n=24)				**Group 2** (n=22)			
	Difference[1]			Cohen's d[2]	Difference[1]			Cohen's d
	M	*SD*	Range		M	*SD*	Range	
Boys	21.13	19.76	59	1.07	17.50	17.18	52	1.02
Girls	19.75	18.34	69	1.08	12.63	12.45	40	1.01
Total	20.21	18.40	73	1.10	13.95	13.63	57	1.02

Notes: [1]Difference from time 1 to time 2; [2] Cohen's d for difference score calculated: *M/SD=Cohen's d.*

Appendix 4. Figure: Simple Bar Mean.

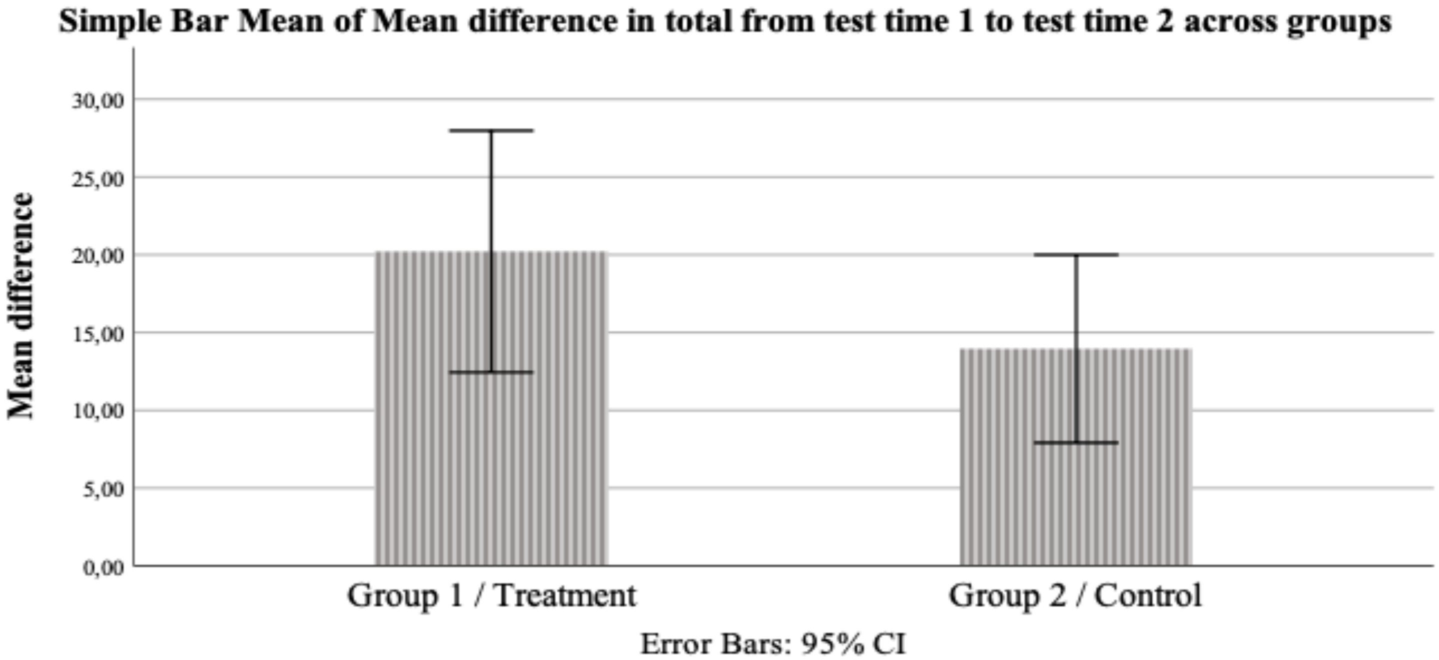

Figure 2. Group mean difference in total across groups, with confidence interval (95%).

Appendix 5. Figure: Clustered Bar Mean.

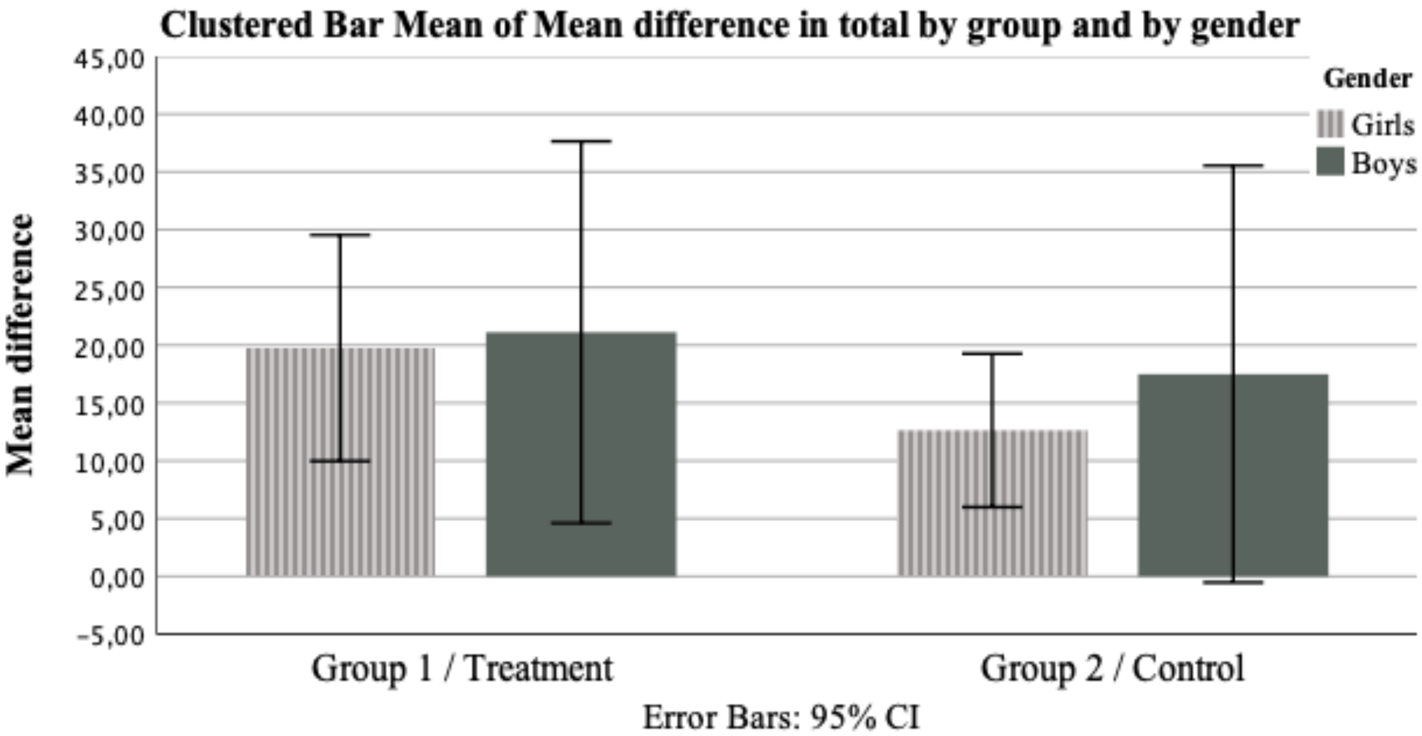

Figure 3. Mean difference in total across groups and gender, with confidence interval (95%).

Appendix 6. Table: Performance measurement on STAS.

Table 7. Performance on measures of reading fluency at test time 1 and test time 2 (n=46)

	Group 1 (n=24)						Group 2 (n=22)					
	Time 1			Time 2			Time 1			Time 2		
	M	*SD*	Range	M	*SD*	Range	M	*SD*	Range	M	*SD*	Range
Boys	173.38	40.16	121	194.50	50.61	139	152.33	77.83	218	169.83	84.12	235
Girls	158.44	58.78	219	178.19	56.07	183	161.13	46.10	166	173.75	49.18	157
Total	163.42	52.88	219	183.63	53.77	183	158.73	54.56	218	172.68	58.44	235

9 Appendices

9.1 Appendix 1. Author guidelines from Journal of Research in Reading

Author Guidelines

Journal of Research in Reading is principally devoted to reports of empirical studies in reading and closely related fields (e.g., spoken language, writing) and to informed reviews of relevant literature. The journal provides a forum for international researchers into literacy. Empirical papers are must be between 5000 and 8000 words in length, including, tables, references and appendices. Brief Research Reports are 3,000 to 5,000 words in length, and review papers are generally around 8,000 words in length. Papers that are longer than the guideline length will be returned prior to review.

Submission of manuscripts: Manuscripts should be submitted online at http://mc.manuscriptcentral.com/jrir. Full instructions and support are available on the site and a user ID and password can be obtained on the first visit. Support can be contacted by phone (+1 434-964-4100) Monday-Friday, or at http://mchelp.manuscriptcentral.com/gethelpnow/index.html. A manuscript will be accepted only on the understanding that it is an original contribution which has not been published previously and is not under consideration for publication elsewhere.

The journal to which you are submitting your manuscript employs a plagiarism detection system. By submitting your manuscript to this journal you accept that your manuscript will be screened for plagiarism, including self-plagiarism. Authors are requested to avoid overlap with previously published work, including their own. However, we regard it acceptable practice for a manuscript to overlap significantly with an author's own academic dissertation/thesis as long as this is mentioned in a cover letter upon submission.

By submitting a manuscript to or reviewing for this publication, your name, email address, and affiliation, and other contact details the publication might require, will be used for the regular operations of the publication, including, when necessary, sharing with the publisher (Wiley) and partners for production and publication. The publication and the publisher recognize the importance of protecting the personal information collected from users in the operation of these services and have practices in place to ensure that steps are taken to maintain the security, integrity, and privacy of the personal data collected and processed. You can learn more at https://authorservices.wiley.com/statements/data-protection-policy.html.

Manuscript specifications: In general, the journal follows the guidelines of the American Psychological Association (6th edition, 2009) for formatting. The entire manuscript, including the abstract, the reference list, and any tables or figures and their captions, should be presented as A4 doubled spaced typescript. It should begin with a title page, giving the title of the paper, a suggested shorter title for running heads and a list of keywords. The manuscript should be anonymised, including the author note and acknowledgements. All pages must be numbered.

Style: APA style should be adopted throughout the manuscript, but English spelling and grammar should be used. Spelling will be made consistent with that in the Oxford English Dictionary. Papers should be concise and written in English in a readily understandable style. Authors should avoid racist or sexist language.

The *Journal* is not able to offer a translation service, but, authors for whom English is a second language may choose to have their manuscript professionally edited before submission to improve the English. A list of independent suppliers of editing services can be found at http://wileyeditingservices.com/en/. All services are paid for and arranged by the author, and use of one of these services does not guarantee acceptance or preference for publication.

Structure: Reports of research should be appropriately structured, normally containing an abstract, introduction, method, results and discussion and a bullet pointed highlights section. Further details are included below.

Keywords: Authors should suggest up to five keywords.

Abstract: The abstract should not exceed 300 words and should normally be structured in the following way with bold marked headings: Background; Methods; Results; Conclusions; **Keywords;** Abbreviations. The abbreviations will apply where authors are using acronyms for tests or abbreviations not in common usage. It should be presented on a separate page.

Implications for Practice: All articles should be submitted with structured Implications for

Practice on a separate page following the abstract. The aim of Implications for Practice is to help teachers, educational psychologists and others working in the field to relate the research reported in the paper to their day-to-day work.

Implications for Practice should take the form of three lists with up to three bullet points in each:

What is already known about this topic

• -----

• -----

• -----

What this paper adds

• -----

• -----

• -----

Implications for theory, policy or practice

• -----

• -----

• -----

Tables and illustrations: Tables should be numbered consecutively, given adequate titles, and typed on new pages. Tables should supplement rather than duplicate text data. Illustrations should be on separate sheets and numbered sequentially. They should be suitable for photographic reproduction. Captions should be typed on a new pages positioned at the end of the manuscript. Within the main body of the manuscript you can indicate where you would like the tables/figure to appear e.g. <Table 1 about here>

Footnotes: These should be avoided and acknowledgements or grant sources should be given at the end of the text.

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Journal Articles:
Lavery, L. & Townsend, M. (1998). Computer-assisted instruction in teaching literacy skills to adults not in paid employment. *New Zealand Journal of Educational Studies*, 33, 181-192.

Books:
Naglieri, J.A. (1999). *Essentials of CAS assessment*. New York: John Wiley & Sons.

Chapters in Books:
Torgesen, J.K. (1996). A model of memory from an information processing perspective: The special case of phonological memory. In G.R. Lyon & N.A. Krasnegor (Eds.), *Attention, memory, and executive function* (pp. 157-184). Baltimore, MD: Brookes.

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9.2 Appendix 2. Information letter sent to schools in recruitment process

UiO : Universitetet i Oslo
Det utdanningsvitenskapelige fakultet v/Institutt for Spesialpedagogikk

Dato: 18. Desember 2018

Vil din skole være med å bidra til å få ny kunnskap om lyttemiljøet i klasserommet og elevenes leseferdigheter?

Vi er to masterstudenter ved Institutt for Spesialpedagogikk som sammen med førsteamanuensis Ulrika Löfkvist ved UiO, professor Gary Rance og Dani Tomlin ved University of Melbourne skal gjennomføre et pilotprosjekt våren 2019.

Formålet er å undersøke hvilken effekt bruk av lydutjevningsanlegg i undervisningen kan ha for elevenes hørsel, leseferdigheter og ikke-verbale evner. Vi ønsker å rekruttere to skoleklasser på 4. trinn, enten fra samme skole eller fra to ulike skoler og deretter gi klassene 10 uker med lydutjevningsanlegg etter tur. Lydutjevningsanlegget består av konsonantkastere (som ser ut som høyttalere) og en lærermikrofon, og gjør lærerens stemme tydeligere for elevene. Vi kontakter derfor skoler i nærheten av Oslo for å høre om det kan være interesse for å delta i et slikt prosjekt.

Prosjektet starter i januar og avsluttes i juni. Vi vil først teste arbeidsminne, hørsel og lesing hos elevene, før en av klassene får ta i bruk lydutjevningsanlegg i 10 uker. Deretter gjennomfører vi en ny runde med de samme testene, før den andre klassen får ta i bruk lydutjevningsanlegg i 10 uker. Etter at begge klassene har hatt 10 uker med og 10 uker uten lydutjevningsanlegg vil alle elevene teste en tredje og siste gang.

Søknad om godkjennelse av prosjektet er sendt til REK (regionale komiteer for medisinsk og helsefaglig forskningsetikk), og vi forventer godkjenning i løpet av desember/første del av januar.

Hvis du har spørsmål eller ønsker mer informasjon, ta kontakt med:

- Andréa Chanell Jønsberg andrecgu@student.uv.uio.no tlf. 99700088
- Charlotte Bruåsdal Larsen charlbla@student.uv.uio.no tlf. 93229476
- Ulrika Löfkvist (veileder) ulrika.lofkvist@isp.uio.no

Med vennlig hilsen

Andréa Chanell Jønsberg Charlotte Bruåsdal Larsen

Postadresse: Universitetet i Oslo, Sem Sælands vei 7, 0371 Oslo
www.uio.no

9.3 Appendix 3. Approval letter from NSD

NORSK SENTER FOR FORSKNINGSDATA

NSD sin vurdering

Prosjekttittel

Lyttemiljø i klasserommet og påvirkning på elevenes oppmerksomhet, arbeidsminne, lytte- og leseferdigheter.

Referansenummer

344540

Registrert

20.12.2018 av Andrea Chanell Jønsberg - andrecgu@uio.no

Behandlingsansvarlig institusjon

Universitetet i Oslo / Det utdanningsvitenskapelige fakultet / Institutt for spesialpedagogikk

Prosjektansvarlig (vitenskapelig ansatt/veileder eller stipendiat)

Ulrika Löfkvist, ulrika.lofkvist@isp.uio.no, tlf: 94832255

Type prosjekt

Forskerprosjekt

Prosjektperiode

01.01.2019 - 20.06.2019

Status

10.01.2019 - Vurdert

Vurdering (1)

10.01.2019 - Vurdert

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet med vedlegg den 10.01.2019, samt i meldingsdialogen mellom innmelder og NSD. Behandlingen kan starte.

MELD ENDRINGER
Dersom behandlingen av personopplysninger endrer seg, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. På våre nettsider informerer vi om hvilke endringer som må meldes. Vent på svar før endringer gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 20.06.2019, og oppbevare personopplysninger til forskningsformål til 28.12.2020. Vi forutsetter at utvalget er informert om varigheten på behandling/oppbevaring av personopplysninger.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte ogberettigede formål, og ikke behandles til nye, uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante ogvnødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).

NSD vurderer at informasjonen om behandlingen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og/eller rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET
NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Kontaktperson hos NSD: Øivind Armando Reinertsen Tlf.
Personverntjenester: 55 58 21 17 (tast 1)

9.4 Appendix 4. Information letter to parents

UiO : **Universitetet i Oslo**
Det utdanningsvitenskapelige fakultet v/Institutt for Spesialpedagogikk

Informasjon til foresatte

Informasjon til foresatte om deltakelse i forskningsprosjektet *«Hvordan påvirker lyttemiljø i skolen barnas kognitive ferdigheter?»*

Ditt/deres barn er herved invitert til å delta i et forskningsprosjekt tilknyttet Universitetet i Oslo. Det er du som foresatt som velger om du vil gi skriftlig samtykke til at ditt barn deltar, og dersom ditt samtykke foreligger vil også barnet bli bedt om skriftlig samtykke. Informert samtykke leveres helst onsdag den 23. januar, senest fredag 25. januar.

Formålet med prosjektet er å undersøke om et tilpasset lyttemiljø i undervisning gir bedre lytteferdigheter, eksekutive funksjoner og leseferdigheter, sammenliknet med å ikke gjøre noen tilpasninger av lyttemiljøet i klasserommet. Prosjektet vil undersøke lyttemiljøet i klasserommet hos barn i alderen 9-10 år gjennom å installere et lydutjevningsanlegg i klasserommet til ditt/deres barn. Lydutjevningsanlegget består av konsonantkastere (som likner høyttalere), en lærermikrofon og elevmikrofoner som forsterker og tydeliggjør stemmen til den som snakker.

Prosjektet er et internasjonalt samarbeid mellom Universitetet i Oslo og University of Melbourne. I tillegg vil Phonak (Sonova AS) bidra med hørselsteknisk utstyr i form av lydutjevningsanlegg, samt måle akustikken i klasserommet før studien starter.

Hva innebærer det for deg å delta i studien?
Prosjektet vil foregå vårsemesteret 2019 og inkludere to 4. klasser ved ditt barns skole. Begge klassene vil bruke lydutjevningsanlegget i 9 uker, men ikke samtidig. Ditt barns klasse vil benytte lydutjevningsanlegget i 9 uker, enten før eller etter den andre klassen. Før, etter og mellom de to periodene vil barnet ditt treffe to forskere (masterstudenter) som skal teste ditt barns lytteferdigheter, leseferdigheter og ikke-språklige ferdigheter. Det tar mellom 25-40 minutter per gang, over til sammen tre ganger. I tillegg kommer du/dere og barnets lærer til å få et spørreskjema å fylle ut, som handler om barnets eksekutive funksjoner. I praksis vil dette innebære at du får noen påstander om barnet som du skal rangere som “aldri et problem”, “i blant et problem” og “ofte et problem”. Det vil ta ca. 10 minutter å fylle ut spørreskjemaet, som skal besvares tre ganger.

Resultatene fra denne pilotstudien vil inngå i to masteroppgaver ved UiO, samt publiseres i vitenskapelige artikler. Prosjektet avsluttes juni 2019, og alt datamateriale vil bli slettet og destruert ved prosjektslutt i desember 2020. Studien vil være helt anonymisert slik at deltakerens identitet ikke blir publisert. Som deltakere i studien har både du/dere og ditt barn rett til å trekke dere når som helst i løpet av forskningsprosjektets periode.

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Personvernombudet ved UiO har blant annet som oppgave å ivareta rettighetene til personer som har registrert personopplysninger om seg hos UiO. Du har rett til å begrense hvilke personopplysninger som er lagret om deg eller barnet ditt. Ved spørsmål knyttet til hvordan personopplysninger om ditt barn er lagret eller håndtert kan Maren Magnus Voll, personvernombudet ved UiO, kontaktes på mail: personvernombud@uio.no. Dersom du/dere likevel opplever at personopplysninger om deg eller ditt barn behandles på en måte som krenker ditt/deres personvern, har du/dere rett til å sende en klage til datatilsynet.

Har du/dere spørsmål til forskningsprosjektet kan dere kontakte følgende:

Prosjektansvarlig:

Ulrika Löfkvist - Førsteamanuens, emneansvarlig i audiopedagogikk ved Institutt for Spesialpedagogikk, Universitet i Oslo
Epost: ulrika.lofkvist@isp.uio.no
Tlf: +47 94832255

Masterstudenter i audiopedagogikk ved Institutt for Spesialpedagogikk, Universitetet i Oslo

Andréa Chanell Jønsberg
Epost: andrecgu@student.uv.uio.no
Tlf.: +4799700088

Charlotte Bruåsdal Larsen
Epost: charlbla@student.uv.uio.no
Tlf.: +4793229476

Med vennlig hilsen

Andréa Chanell Jønsberg

Charlotte Bruåsdal Larsen

Postadresse: Universitetet i Oslo, Sem Sælands vei 7, 0371 Oslo
www.uio.no

Informert samtykke - foresatte

Jeg/vi har lest og forstått at:

- Å delta i studien er frivillig.
- Jeg/vi kan når som helst avbryte samarbeidet uten videre forklaring.
- Ved behov kan jeg/vi kontakte prosjektansvarlig med spørsmål.

Jeg samtykker til at jeg og mitt barn deltar i prosjektet
Barnets fornavn (blokkbokstaver) ....
Sted og dato ....
Din signatur ....

Jeg samtykker til at jeg og mitt barn deltar i prosjektet
Barnets fornavn (blokkbokstaver) ....
Sted og dato ....
Din signatur ....

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www.uio.no

9.5 Appendix 5. Information letter to children

UiO : **Universitetet i Oslo**
Det utdanningsvitenskapelige fakultet v/Institutt for Spesialpedagogikk

Informasjon til elever

Informasjon til elever om deltakelse i forskningsprosjektet *«Hvordan påvirker lyttemiljø i skolen barnas kognitive ferdigheter?»*

Du er herved invitert til å delta i et forskningsprosjekt tilknyttet Universitetet i Oslo. Det er frivillig å delta, og det er dine foresatte som må gi sitt samtykke til at du deltar. Dersom dine foresatte samtykker til at du deltar vil vi i tillegg be om ditt samtykke til å delta. Informert samtykke leveres helst onsdag den 23. januar, senest fredag den 25. januar.

Formålet med prosjektet er å undersøke om et tilpasset lyttemiljø i undervisning gir bedre lytteferdigheter, eksekutive funksjoner og leseferdigheter. Prosjektet vil undersøke lyttemiljøet i klasserommet hos barn i alderen 9-10 år gjennom å installere et lydutjevningsanlegg i klasserommet og bruke det i undervisningen. Lydutjevningsanlegget består av konsonantkastere (som likner høyttalere), lærermikrofon og elevmikrofoner som forsterker og tydeliggjør stemmen til den som snakker.

Hva innebærer det for deg å delta i studien?
Prosjektet vil foregå våren 2019 og inkluderer to klasser på 4. trinn ved din skole. Begge klassene vil bruke lydutjevningsanlegget i 9 uker, men ikke samtidig. Din klasse vil bruke lydutjevningsanlegget i 9 uker, enten før eller etter den andre klassen. Før, etter og mellom de to periodene vil du treffe to forskere (masterstudenter) som skal teste dine lytteferdigheter, leseferdigheter og ikke-språklige ferdigheter. Det tar mellom 25-40 minutter per gang, og dette skal gjøres tre ganger. I tillegg skal dine foresatte og læreren din fylle ut et spørreskjema som gir oss viktig informasjon om hvordan de syntes du planlegger og løser problemer (altså oppmerksomhet og arbeidsminne).

Hva skjer med informasjonen om deg?
Vi vil registrere ditt navn, din alder (bursdagen din) og hvilken skole du går på, men det vil ikke være mulig for andre å identifisere deg, ettersom alle personopplysninger blir anonymisert. For å anonymisere opplysninger om deg, vil du få en unik kode. Informasjonen vi samler inn om deg, det vil si at informasjon fra testene og kartleggingen, knyttes til din unike kode, men ingen andre enn ansvarlige i prosjektet vet hvilken kode som er din. Uvedkommende eller personer som ikke er ansatt i prosjektet, har ikke tilgang til ditt navn eller andre personlige opplysninger.

Informasjonen som er knyttet til koden din oppbevares på et annet sted enn dokumenter med ditt navn eller opplysninger som gjør at du kan bli kjent igjen. All informasjon oppbevares i tråd med gjeldende regler for personvern ved Universitetet i Oslo. Det vil si at informasjonen med kode på oppbevares i et låsbart og brannsikkert skap ved Institutt for Spesialpedagogikk ved Universitetet i Oslo og samtykkeerklæringer (og papirer med ditt navn på) oppbevares i et annet låsbart og

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brannsikkert skap ved Institutt for Spesialpedagogikk ved Universitet i Oslo. Alt materiale vil bli slettet og destruert ved prosjektslutt i desember 2020.

Du og dine foresatte har rett til å få se informasjonen som er lagret om deg, og til å få rettet eventuelle feilaktige opplysninger. Dere har også rett til å begrense personopplysningene, det vil si at opplysningene lagres, men ikke brukes til noe. Hvis du eller foreldrene dine lurer på hvilke opplysninger som er lagret om deg eller har spørsmål til dette, kan dere kontakte Maren Magnus Voll, personvernombudet ved UiO, på mail: personvernombud@uio.no. Dersom dere opplever at opplysningene vi har hentet om deg behandles på en måte som krenker personvernet, har dere rett til å sende en klage til datatilsynet.

Resultatene fra prosjektet vil bli presentert i to masteroppgaver ved Universitetet i Oslo, og vitenskapelige artikler. Når vi presenterer resultatene vil det ikke være mulig å identifisere deg, ettersom alle personopplysninger er anonymisert. Som deltakere i studien har du rett til å trekke dere når som helst i løpet av forskningsprosjektets periode.

Har du/dere spørsmål til forskningsprosjektet kan dere kontakte følgende:
Prosjektansvarlig:
Ulrika Löfkvist - Førsteamanuens, emneansvarlig i audiopedagogikk ved Institutt for Spesialpedagogikk, Universitet i Oslo
Epost: ulrika.lofkvist@isp.uio.no
Tlf: +47 94832255

Masterstudenter i audiopedagogikk ved Institutt for Spesialpedagogikk, Universitetet i Oslo
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Charlotte Bruåsdal Larsen
Epost: charlbla@student.uv.uio.no
Tlf.: +4793229476

Med vennlig hilsen

_____________________________ _____________________________

Andréa Chanell Jønsberg Charlotte Bruåsdal Larsen

Informert samtykke - foresatte

Jeg/vi har lest og forstått at:

● Å delta i studien er frivillig.

● Jeg/vi kan når som helst avbryte samarbeidet uten videre forklaring.

● Ved behov kan jeg/vi kontakte prosjektansvarlig med spørsmål.

Jeg samtykker til å delta i prosjektet
Sted og dato ....
Signatur ....

Jeg samtykker til å delta i prosjektet
Sted og dato ....
Signatur ....

9.6 Appendix 6. Sentence completion and recall test

Sentence Completion and Recall - general working memory

Testen måler komplekst arbeidsminne, altså evnen til å samtidig lære og bearbeide språklig informasjon. Om ønskelig kan svarene spilles inn på en båndspiller; nevn barnets navn og ID-nr. når innspilling starter.

Instruksjon: *Nå kommer du til å få høre setninger hvor det siste ordet mangler. Du skal si det første ordet du tenker på. Du skal også forsøke å huske de ordene som du har sagt, for etterpå spør jeg deg hvilke ord du har sagt og da skal du si dem igjen. Du trenger ikke å si dem i rekkefølge.*

Vi skal først øve litt. Hvis jeg sier: Himmelen er blå, gresset er… (pek på barnet). *Man sitter på en stol, man sover i en…* (pek på barnet). *Hvilke ord sa du?*

Før hver oppgave, forklar barnet hvor mange setninger som kommer (hvor mange ord som skal huskes). Noter i margen til høyre om barnet gjengir andre ord enn de det har sagt fra begynnelsen.

OBS! Gi barnet et hint (første fonem) om barnet ikke husker ordet det har sagt. Marker i blanketten om barnet har fått hint fra testleder. Rett svar med hint fra testleder gir 0.5 p., rett svar uten hint fra testleder gir 1 p.

	HUSKET ORD	JA	NEI	NOTATER
GRAD 1	På føttene har man sko, på hendene har man …			
	Eple kan man spise, saft kan man …			
GRAD 2	Å gå på beina går sakte, å kjøre fly går …			
	Man klipper med en saks, man graver med en …			
	På dagen er det lyst, på natten er det …			
GRAD 3	På føttene har man sko, på hodet har man …			
	En bil har hjul, et fly har …			
	Man skjærer med en kniv, man spiser suppe med en …			
	Gresset er grønt, tomater er …			
GRAD 4	I luften flyr fugler, i havet svømmer …			
	Bøker kan man lese, sanger kan man …			
GRAD 5	En fjær er lett, en stein er …			
	Man slår med en hammer, man maler med en …			
	På vinteren er det kaldt, på sommeren er det …			
GRAD 6	Man spiser mat fra en tallerken, man drikker saft av …			

	Man snakker med munnen, man ser med …			
	Man har melken i kjøleskapet, man har isen i …			
	Maur er små, elefanter er …			
	SUM	______/18		