Does training with the PhonicStick improve phonological awareness?

A meta study including one new pilot study

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SAMMANFATTNING
The PhonicStick är en joystick som utvecklas med avsikt att bli ett kommunikationshjälpmedel att användas för människor med grava fysiska funktionsnedsättningar. Under utvecklingsarbetet undersöks om det även kunde användas för att träna fonologisk medvetenhet hos 6-8-åringar. Undersökningarna visade inte någon statistisk skillnad i fonologisk medvetenhet när detta undersöktes med gängse normerade tester efter träning med the PhonicStick. En förklaring kunde vara att dessa barn redan tränats i att läsa och skriva i skolan. Därför undersöks i en delstudie i detta arbete om en skillnad i resultat på de normerade testen kunde hittas om barnen var 4-5-år istället för 6-8. Delar av ett normerat test för fonologisk medvetenhet och ett bearbetat testmaterial för the PhonicStick användes vid utvärderingen. De 10 undersökta barnen var jämnt fördelade på testgrupp och kontrollgrupp. Dessutom utfördes en metastudie, i vilken alla inom området fonologisk medvetenhet relevanta studier med the PhonicStick utvärderades. Data från dessa studier sammanfattades och bearbetades statistiskt. Endast två skillnader kunde med statistiskt säkerhet (p<0,05) visas efter träning med the PhonicStick: både testgruppen och kontrollgruppen var bättre på posttestet i deltestet ”fonemidentifiering” och testgruppen presterade bättre på deltestet ”ordproduktion” än vad kontrollgruppen gjorde. En möjlig tolkning av resultaten kan vara att det kan finnas en intuitiv fonologisk medvetenhet som inte kan testas med gängse test för fonologisk medvetenhet.

Nyckelord: fonologisk medvetenhet, kommunikationshjälpmedel, PhonicStick, testmaterial av språklig medvetenhet, metastudie

ABSTRACT
The PhonicStick is a joystick which has been developed as a communicative device to be used by people with severe physical disabilities. During the developmental phase the possibility of using this device in order to train the phonological awareness of 6 – 8 year old children was examined. The studies conducted did not show any statistical difference in phonological awareness when this was tested with current tests after the children had trained with the PhonicStick. One explanation for this could be that the children had already begun to read and write in school. Therefore, a part of the present study was aimed at investigating if a difference in results on the norm referenced tests could be obtained if the children were 4-5 years old instead of 6-8. Parts of a norm referenced test for phonological awareness and an adapted test material for the PhonicStick were used for this evaluation. The 10 examined children were equally divided into a test and a control group.

In addition, a meta study was performed, where all the studies relevant to phonological awareness and the PhonicStick were evaluated. Data from these studies were summarized, and processed statistically. Only two statistically significant (p<0.05) differences could be shown after the training with the PhonicStick: both the test group and the control group obtained better results in the posttest in the test of “phoneme identification” and the test group performed better at the test “word production” then the control group. A possible interpretation of the results could be that there might be an intuitive phonological awareness that can not be tested with the current tests for phonological awareness.

Keywords: phonological awareness, communicative device, PhonicStick, test material of phonological awareness, meta study
1. Introduction

1.1. Phonological processes

In written and in oral language one has to not only focus on the semantic (the meaning) or the syntactic (the grammatical structure) information but also the phonological (the sound structure of the language) information.

To be able to learn to read and write a word-decoding ability and an ability to comprehend written texts are needed. There are some precursors to these abilities. These precursor abilities are called phonological processes and there is an abundant body of evidence which says that these are of great importance for the later reading development (De Jong & Van Der Leij, 2002). The term phonological processing refers to the use of the phonological information in processing written and oral language (Wagner & Torgesen, 1987; Elbro, 1996). According to Elbro there are several components that are required for this processing to occur. These components are the so-called phonological processing skills. The different processes overlap each other in different ways. A flaw in one might have a bad influence on another. The processes are called 1) Phoneme discrimination and identification, 2) Retrieval of phonological representations and 3) Phonological awareness. Different researchers might have other labels for these terms but basically they are the same.

1.1.1. Phoneme discrimination and identification.

Phoneme discrimination is the ability to perceptually discriminate between different phonemes i.e that A is different from B while identification means being able to separate them and to give the phonemes different labels i.e that is an A and that is a B. Poor phoneme discrimination and identification might lead to reduced distinctness of phonological representations. An indistinct representation of for example an “s” sound is probably more difficult to remember, to recall and to articulate than a distinct representation.

The usual way to test phoneme discrimination and identification is with nonsense syllables or minimal pairs of words. Minimal pairs of words mean two words that only differ in one phoneme, the subject is asked what sounds are heard or if the pairs of words are identical or not (Elbro, 1996).
Elbro (1996) claims that “Phoneme discrimination may, at least theoretically, contribute indirectly through other phonological processes to differences in reading acquisition”.

1.1.2. *Retrieval of phonological representations*

People with reading disabilities are often inaccurate and slow when naming pictures, geometrical figures, rows of colours, letters and digits. That poor readers are slower and make more errors than normal controls has been shown in many studies (Katz, 1986). Difficulties with these sorts of tasks have been shown to predict reading development later in life. These problems are explained with a deficit in the retrieval of the stored representations in the mental lexicon (Elbro, 1996; Wagner & Torgesen, 1987; Goswami & Bryant, 1990).

1.1.3. *Phonological awareness*

The last of the phonological processing skills is the phonological awareness. This is the process that is of interest in the present study. Phonological awareness is “ones awareness of and access to the phonology of one’s language” (Wagner & Torgesen, 1987). Phonological awareness involves access to the phonological structure of spoken words, rather than to their meanings and grammatical structures. It is the awareness of sounds in spoken language separate from the representation of sounds by written language (Sodoro *et al.*, 2002). Thus the focus of phonological awareness is on the form of the language and not on the meaning of the language.

Phonological awareness is often defined in tests as an ability to compare different sounds and to manipulate sounds without focusing on the words or the utterances of which the sounds are part. Examples of tasks that reveal children’s phonological awareness include the ability to rhyme words, hear if different words start with the same or different sounds, or tell the numbers of phonemes included in single words. Being able to identify separate words in a spoken sentence, to hear the two parts of a compound word, or to hear and separate syllables which also requires phonological awareness (Sodoro *et al.*, 2002; Elbro, 1996).

Although these tasks are clearly different they are actually testing the same underlying ability namely “the ability to shift attention from word meaning to the phonological form of spoken words” (Elbro, 1996). Several longitudinal studies have
shown that phonological awareness is a precursor of the future reading development. This has been shown in many cultures and in many languages such as English, French, Italian, Danish and Swedish (Elbro, 1996). There is consensus in the academic community that phonological awareness plays a major role in the child’s process of learning how to read and write (Elbro, 1996; Goswami & Bryant, 1990; Wagner & Torgesen, 1987; cf. Morais et al., 1986; Harris, 2000, pp. 118-9; Alcock et al., 2010).

1.2. The PhonicStick

The PhonicStick is a joystick, developed at the School of Computing, University of Dundee, Scotland. More precisely it is software programmed to work with a joystick. But for the rest of this study the PhonicStick will mean the joystick although without the programming it is just an ordinary joystick.

The PhonicStick was developed as a result of the finding that people with severe physical disabilities were able to manoeuvre their wheelchairs with the help of a joystick indicating that an AAC (augmentative and alternative communication) device using a joystick might benefit this group (Black et al., 2008, Waller et al., 2008, Ager & Solli, 2009; Kimhag et al. 2010).

The sounds made with the PhonicStick are pre recorded. The PhonicStick can give two types of feedback. Either a phonic is spoken directly when the joystick is moved to the specific location that phonic has or the phonic is spoken when the joystick returns to the middle position. In the present study the first feedback was chosen. The layout of the phonics used in the present study is shown in Figure 1. Since the device produces separate phonemes and lets the user freely explore them and blend them as he/she wants the PhonicStick might be beneficial for the development of a child’s phonological awareness.

![Figure 1. The current placement of the phonics on the PhonicStick used in the present study.](image-url)
Using this device it is possible to produce language sounds separately but language sounds can also be blended into words or nonwords. Up to now the number of phonemes that can be made on the PhonicStick is 6, namely “t”, “l”, “k”, “m”, “o” and “a”, see Figure 1. These 6 phonemes were originally chosen because they are the first 6 phonics taught in the Jolly Phonics programme, which is a part of English children’s curriculum in school (Ager & Solli, 2009; Kimhag & Lindmark, 2009). The phonemes used for the Swedish children were however chosen because of the possibilities of producing actual words. These phonemes were kept in the present study since the more variables that are the same the better when comparing different studies.

This PhonicStick prototype can produce words or nonwords consisting of up to 3 sounds. The developers aim is that this device will be able to produce every phoneme in the English language and combinations consisting of any number of these phonemes. In able to fit all the 42 different phonics of the English language the joystick will have the setup seen in Figure 2. Thus the PhonicStick will in the future be able to produce every word in the English language. The software allows alterations of phonics; therefore the PhonicStick can also be used in other languages. If this will be the case then the users could use it to communicate freely, as an augmentative or alternative communication device (AAC). Most other AAC devices are paper based and consist of different symbols or pictures. This can often limit the spontaneity of the conversation (Ager & Solli, 2009). If the developers succeed in their efforts then the PhonicStick could improve this situation.
When students of the speech pathologist programme at Uppsala University were asked to participate in the development of the PhonicStick one of the aims was to investigate the usefulness of the PhonicSticks as a tool for the development of phonological awareness in children. The idea was that since the device produces separate phonemes and allows the user to explore them freely and blend them as he/she wants it could be worthwhile to investigate further. Several studies have proposed play programmes focusing on segmenting phonemes, making up different words, rhyming etc as a possible way to train phonological awareness (Elbro, 1996). The PhonicStick might be an alternative tool in such activities. A positive aspect is that the children do not have to produce the sounds themselves but can concentrate on using the PhonicStick and listen to the different results. So far none of the studies has been able to prove that training with this device makes any difference in the child’s phonological awareness as tested with norm referenced tests of phonological awareness (Solli & Ager, 2009; Kimhag & Lindmark, 2009; Andersz & Hansson, 2010; Lindström & Peronius, 2010). However it was observed that in some of the studies, children were able to do tasks on the PhonicStick that they were not able to do on the regular tests of phonological awareness. Most studies have included children 6 – 8 years old. Questions have been raised regarding the minimum age at which phonological awareness can be developed.
2. Aims

The aims of the present study were therefore to find the answers to the following questions:

1) Does training with the PhonicStick promote the development of phonological awareness in children at 4 - 5 years of age?

2) Does differences between pre- and posttests for all previous and present test groups and control groups give new information about the development of phonological awareness related to training with the PhonicStick?

To investigate this, the study was set up in two parts. To find an answer to the first question a pilot study was conducted where 4 - 5 year old children were trained with the PhonicStick. The second question was addressed by performing a meta study involving all the raw data from the previous studies with the PhonicStick and also the results from the pilot study mentioned above.
3. Method

3.1. Does training with the PhonicStick promote the development of phonological awareness in children 4 – 5 years of age?

3.1.1. Participants

Initially the study involved 12 children. The inclusion criteria were that the child had Swedish as mother tongue, the child had to be born in the fall of 2005 to the spring of 2006 and had to have access to a computer at home. Information about this study (appendix A) was e-mailed to Uppsala community asking if they could send information about this study to their day care centres in Uppsala. Two day care centres showed an interest for the study. Through these, the parents acquired information (appendix B) about the study and 8 children were recruited, 4 children from each day care centre. The remaining 4 were recruited from acquaintances. Twelve parents approved and signed a consent form (appendix C) before the testing and the training started.

For the randomization the children were divided into 3 groups; one group consisted of the children from one day care centre, one group consisted of the children from the other day care centre and one group consisted of the children of the acquaintances. Half the children from each group were randomized into a test group (hereafter called the PS group) and half from each group were randomized into a control group.

One child from each day care centre dropped out of the study without any parental explanation. Three of the final 10 children were girls and 7 were boys. The mean age of the PS group was 4.77 years (SD 0.34) and the mean age of the control group was 4.65 years (SD 0.39).

Two children showed some phonological difficulties both in an imitation task and in their spontaneous speech. One of these children was in the PS group and the other one was in the control group.
3.1.2. Material

3.1.2.1 Norm referenced test for phonological awareness

The norm referenced tests for phonological awareness used in this study were two parts of the test material *Bedömning av språklig medvetenhet hos förskolebarn och skolbarn (1993)* by Magnusson & Nauclér (1993) namely *fonemidentifikation* and *fonemsegmentation*.

1. Phoneme identification – Magnusson and Nauclér

The first part is called *fonemidentifikation* or phoneme identification and consists of 24 questions separated into 4 groups, one group for every sound, with 6 questions for each group. The child is questioned whether a specific sound appears in a specific word, i.e. is there an “s” sound in “sol”? The child answers by saying yes or no. The test consists of 4 different sounds namely: “t”, “s”, “i” and “o”.

2. Phoneme segmentation - Magnusson and Nauclér

The second part used from Magnusson and Nauclérs test material is called *fonemsegmentering* or phoneme segmentation. It consists of 18 questions. The child is asked to count the phonemes in the words spoken by the researcher i.e. how many sounds are there in the word “apa”? The words consist of 2 to 4 phonemes each and appear in a randomized fashion. The child answers by saying how many sounds there are either orally or by holding up that many fingers.

3.1.2.2 PhonicStick tasks

To test the ability of the child to use the PhonicStick, a test material had to be constructed. This was done by adjusting a test material from a previous study of 6 year old children (Ager & Solli, 2009) to better fit the present study. The tasks were matched to prevent any child from answering the same question twice. The different tasks used for testing the PhonicStick are attached in appendix D.

1. PhonicStick – phoneme production

The child was asked to find specific phonemes on the PhonicStick i.e. can you make “t”? The child was allowed to hear the sound 2 times. The child was also allowed to try until he/she was satisfied with his/her own answer. This task consisted of 6 questions. The child was asked to find all the 6 different phonemes on the PhonicStick.
2. **PhonicStick – word production**

The researcher said a word and the child was asked to “spell” out the word using the PhonicStick. The child was allowed to try until they found the right sounds or until they became bored with the task. This task consisted of 6 questions.

3. **PhonicStick – phoneme isolation**

The child was asked to produce the first or last sound in different words using the PhonicStick, i.e. can you make the beginning of “tiger”? The child was allowed to hear the word two times and to try until he/she was satisfied with his/her own answer. The task consisted of 6 questions.

4. **PhonicStick - training record**

On the training record there was a column for comments and also 3 questions, 1 directed to the child and 2 directed to the parents, as follows. What did your child think about the training with the PhonicStick on a scale from 1 to 5, 1 being very boring and 5 being very funny. The other two questions were focused on the PhonicStick as a training tool. The questions were; how difficult did you find the PhonicStick training to be? And how high is its usability? Both questions were answered by choosing a number on a scale from 1 to 5. Finally there was a space for other comments (appendix E).

Observations by the researcher were made to complement these tasks. In order to acquire some basic background information regarding the children language development an imitation task was performed. The child was asked to imitate certain spoken words from the investigator. These words were the same as the words used in the tasks.

3.1.3. **Procedure**

All children were tested with the norm referenced tests for phonological awareness before the introduction of the PhonicStick. Both the PS group and the control group were introduced to the PhonicStick by the investigator. After this introduction, both groups were tested on tasks comparable to the norm referenced test of phonological awareness but performed using the PhonicStick (appendix 4), see 3.1.2.2.

After this, the PS group practised at home after the family had received information on the use of the PhonicStick, training suggestions and suggestion about training frequency. The information and suggestions were introduced to the parents both
orally and in written form (appendix F). The training was then performed by the parents in the children’s home environment under a period of 14 days. The parents were provided with a training record (appendix E) where they could log how much training their child had achieved. After 14 days both the control group and the PS group were retested with the norm referenced test of phonological awareness and with the PhonicStick tasks, using a different set of test words.

3.1.4. Data analysis
When comparing the test group with the control group according to pre- and posttests, the non-parametric Mann-Whitney U test was used. For comparison of the results from the pre- and posttests within the same group the Wilcoxon signed rank test was used. For all quantitative tests, the significance level, alpha, was set to 0.05 (two-tailed $p$). The highest number of possible correct answers in the tasks with the PhonicStick was six and the answers were on an ordinal scale with no measurable intervals in between; hence the use of the non-parametrical statistic methods. For reasons of clarity the mean values and the standard deviations will be presented instead of nonparametric descriptive statistics (median and range values). Statistics have been carried out using PASW Statistics 18.

3.2. Ethical aspects
The parents had to give their informed consent to allow their child to participate in the study. The child had the right to choose not to participate, but one will have to bear in mind that children might not want to object to their parents or to the researcher, which could be an ethical dilemma. Personal information was collected and stored in a safe at Uppsala University. The participating children were given individual code numbers and no names or dates of birth can be distinguished from the report. No recordings of the children were made.
3.3. Does differences between pre- and posttests for all previous and present test groups and control groups give new information about the development of phonological awareness related to training with the PhonicStick?

3.3.1. Procedure

To answer this question, a meta study was performed. In all the studies involved the phonological awareness tests and PhonicStick tasks had been conducted before and after the PhonicStick training period as pre- and posttests (Solli & Ager, 2009, Andersz & Hansson, 2010, Lindström & Peronius, 2010) see Table 1. The performance of each child involved in these studies was included as was the performance of the children in the pilot study (see 3.1.).

Table 1. An overview of all studies included in the meta study. N/A = Not applicable.

<table>
<thead>
<tr>
<th>Authors of study (year)</th>
<th>Group</th>
<th>Number of children</th>
<th>Gender m/f</th>
<th>Mean age (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ager &amp; Solli (2009)</td>
<td>Test group</td>
<td>23</td>
<td>13/10</td>
<td>7.53 (0.32)</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>23</td>
<td>10/13</td>
<td>7.49 (0.34)</td>
</tr>
<tr>
<td>Ek (2010)</td>
<td>Test group</td>
<td>5</td>
<td>3/2</td>
<td>4.77 (0.34)</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>5</td>
<td>4/1</td>
<td>4.65 (0.39)</td>
</tr>
<tr>
<td>Lindström &amp; Peronius (2010)</td>
<td>Test group</td>
<td>12</td>
<td>N/A</td>
<td>4.21 (0.26)</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>6</td>
<td>N/A</td>
<td>4.39 (0.33)</td>
</tr>
<tr>
<td>Andersz &amp; Hansson (2010)</td>
<td>Test group</td>
<td>10</td>
<td>5/5</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>10</td>
<td>8/2</td>
<td>N/A</td>
</tr>
</tbody>
</table>

3.3.2. Treatment of data

All raw data from all the studies included (see Table 1) in the meta study was summarized in a table were all the different test scores were inserted separately in 1 column for each pretest and 1 column for each posttest.

The next step was to make this table useable. This was done by merging test columns. The ability each test was testing was controlled and thereafter merged with similar tests resulting in 6 test categories. Three test categories for the norm referenced tests of phonological awareness namely “phoneme identification”, “phoneme segmentation” and “phoneme isolation” and 3 test categories for the PhonicStick tasks.
namely “phoneme production”, “word production” and “phoneme isolation (on the PhonicStick)”.

_Merging strategies._ In one study (Ager & Solli, 2009) word production on the PhonicStick was investigated with 3 different tests. The results were added up to make a total score. This total score was then used in the study and put under the new test category “word production”.

One study (Andersz & Hansson, 2010) separated the results of the test “correct phonic” into three categories, namely “correct phonic without prompt or self correction”, “correct phonic after self correction” and “correct phonic after prompt”. These were summarized in the study under the column “total correct phonics”, the results from the last column were used in the present study under the new test category “phoneme production”.

One study (Lindström & Peronius, 2010) had 3 different groups of children. One control group, 1 group that practiced 6 times with the PhonicStick and 1 group that practiced 10 times with the PhonicStick. In this case the 2 tests groups were added together to make a single test group. In this same study the children were tested 3 times i.e. pre-, medial- and posttests. Only the data from the pre- and posttests were used in the present study. Scores showing ceiling effects were excluded, which here means data from children that got a maximum score in both the pre- and posttest.

Differences between pre- and posttests (posttest minus pretest) for each one of the new test categories were calculated and inserted into new columns, 1 column for each test category. For each test category the change in correct answers between pre- and posttest was inserted. In this case change means simply better, worse or the same.

Difference in number of correct answers (posttest result minus pretest result) between the test group and the control group were analyzed with the non-parametric Mann-Whitney U test. This test was also used for comparing the results from the pre- and posttests between the groups regarding change between pre- and posttest (better, same or worse). This analysis was carried out at two different levels. In the first analysis (level 1) “better” was defined as a positive change by 1 correct answer or more. “Worse” was defined as a negative change by 1 correct answer or more. No change was defined as “the same” i.e. these children received the value 0 (-1/0/+1).

In the second analysis (level 2) “better” was defined as a positive change by 2 correct answers or more. “Worse” was defined as a negative change by 2 correct
answers or more. The gap between the results -2 and 2 was defined as “the same” i.e. these children received the value 0 (-1/0/+1).

For all quantitative tests, the significance level, alpha, was set to 0.05 (two-tailed $p$). Statistics have been carried out using PASW Statistics 18. Because the “better, worse or same” column was using nominal data, a non-parametric statistical method was chosen.
4. Results

4.1. Does training with the PhonicStick promote the development of phonological awareness in children 4 - 5 years of age?

Since the children in the study varied in age the randomization might have resulted in a significant difference in age between the PS group and the control group. The mean age of the PS group was 4.77 years (SD 0.34) and the mean age of the control group was 4.65 years (SD 0.39). This difference was however not significant when calculated with a Mann-Whitney U test.

4.1.1. Phonological awareness test - phoneme identification

In the test of Phoneme identification the maximum possible correct answers were 24.

<table>
<thead>
<tr>
<th></th>
<th>Pretest</th>
<th>Posttest</th>
<th>Pretest</th>
<th>Posttest</th>
<th>p</th>
</tr>
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<tr>
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<td>5</td>
<td>18.40</td>
<td>20.00</td>
<td>&lt;.05</td>
</tr>
<tr>
<td>Control group</td>
<td>5</td>
<td>5</td>
<td>12.40</td>
<td>16.40</td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

A positive change in mean numbers of correct answers in both the PS group and control group was received. The change increase was significant in both the test and the control group, calculated with a Wilcoxon signed rank test, see Table 2.

The mean difference between pre- and posttest in the PS group was 1.60 correct answers (SD 0.55). The mean difference between pre- and posttest in the control group was 4.00 correct answers (SD 3.16). A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the PS group and the control group showed a mean rank of 4.10 in the PS group and a mean rank of 6.90 in the control group. The difference between the two groups was not significant (p > .05).

4.1.2. Phonological awareness test - phoneme segmentation

In the test of Phoneme segmentation the maximum possible correct answers were 18.
A negative change in mean numbers of correct answers was received in the PS group, see table 3. A positive change in mean numbers of correct answers was received in the control group, see table 3, although the change decrease and the change increase was not significant in neither PS nor control group, calculated with a Wilcoxon signed rank test.

The mean difference between pre- and posttest in the PS group was -0.20 correct answers ($SD\ 1.92$). The mean difference between pre- and posttest in the control group was 0.60 correct answers ($SD\ 2.70$). A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the PS group and the control group showed a mean rank of 5.20 in the PS group and a mean rank of 5.80 in the control group. The difference between the two groups was not significant ($p > .05$).

4.1.3. PhonicStick task – phoneme production

In the test of Phoneme production the maximum possible correct answers were 6.

The results for the PS group was significantly higher than the control group in both the pre- and the posttest calculated with a Mann-Whitney U test ($p < .05$).

No change in mean numbers of correct answers was received in the PS group, see table 4. A positive change in mean numbers of correct answers was received in the
control group, see table 4, the change increase was not significant in the control group, calculated with a Wilcoxon signed rank test.

There was no mean difference between pre- and posttest in the PS group. The mean difference between pre- and post-test in the control group was 1.20 correct answers (SD 1.48). A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the PS group and the control group showed a mean rank of 4.10 in the PS group and a mean rank of 6.90 in the control group. The difference between the two groups was not significant (p > .05).

4.1.4. PhonicStick task – word production

In the task of word production the maximum possible correct answers were 6.

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>M (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pretest</td>
<td>Posttest</td>
<td>Pretest</td>
</tr>
<tr>
<td>PS group</td>
<td>5</td>
<td>5</td>
<td>2.00 (2.74)</td>
</tr>
<tr>
<td>Control group</td>
<td>5</td>
<td>5</td>
<td>0.40 (0.89)</td>
</tr>
</tbody>
</table>

A positive change in mean numbers of correct answers was received in the PS group, see table 5. This change was however not significant when calculated with a Wilcoxon signed rank test. No change was received in the control group, see Table 5. The mean difference between pre- and post test in the PS group was 0.60 correct answers (SD 0.55). The mean difference between pre- and post test in the control group was 0.00 correct answers (SD 1.41). A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the PS group and the control group showed a mean rank of 6.40 in the PS group and a mean rank of 4.60 in the control group. The difference between the two groups was not significant (p > .05).
4.1.5. *PhonicStick task – phoneme isolation*

In the test of phoneme isolation the maximum possible correct answers were 6.

<table>
<thead>
<tr>
<th></th>
<th><em>n</em></th>
<th><em>M</em> (SD)</th>
<th><em>p</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Phoneme isolation (PS)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pretest</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PS group</td>
<td>5</td>
<td>2.60 (2.07)</td>
<td>ns</td>
</tr>
<tr>
<td>Control group</td>
<td>5</td>
<td>1.20 (1.30)</td>
<td>ns</td>
</tr>
<tr>
<td><strong>Posttest</strong></td>
<td>5</td>
<td>3.00 (2.35)</td>
<td></td>
</tr>
<tr>
<td>Pretest</td>
<td>5</td>
<td>2.40 (2.07)</td>
<td></td>
</tr>
</tbody>
</table>

A positive change in mean numbers of correct answers in both the PS group and control group was received, see table 6, although the change increase was not significant in neither PS nor control group, calculated with a Wilcoxon signed rank test, see Table 6.

The mean difference between pre- and post test in the PS group was 0.40 correct answers (*SD* 1.52). The mean difference between pre- and post test in the control group was 1.20 correct answers (*SD* 2.28). A Mann-Whitney U test calculating the differences of the results in pre- and post tests regarding the PS group and the control group showed a mean rank of 5.00 in the PS group and a mean rank of 6.00 in the control group. The difference between the two groups was not significant (*p* > .05).

4.1.6. *Training record*

When the recorded times in minutes for each child in the test group were added up for the 2 week period of training with the PhonicStick the following results were obtained. The total times varied between 20 - 140 minutes. The mean value for the total amount of minutes was 82 minutes which would equal 6 minutes of training per day. The median value became 101, which better reflects the recorded values, since 2 of the children trained much less than the other 3.

On the training record there was also a column for comments. There was also 3 questions, 1 questions directed to the child and 2 questions for the parents see 3.1.2.2.

The maximum scores on these question was 5 and the lowest was 1. The mean value for the first question directed to the child about how fun the training had been was 2, although two of the participants did not leave an answer for this question. The mean value for the second question directed to the parent about the difficulty of the training was 1.75, although 1 participant did not leave an answer on this question. The mean
value for the third question concerning the usability of the PhonicStick as a training tool was 2.33, although 2 participants did not leave an answer to this question.

4.2. **Does differences between pre- and posttests for all previous and present test groups and control groups give new information about the development of phonological awareness related to training with the PhonicStick?**

An overview of the numbers of participants within the three test categories of phonological awareness and the three test categories of the PhonicStick is given in Table 7.

*Table 7. Total number (n) of participating children for each of the 6 new test categories. Phonological awareness: phoneme identification (phon id), phoneme segmentation (phon seg), phoneme isolation (phon iso). PhonicStick: phoneme production (phon prod), word production (word prod), phoneme isolation (phon iso).*

<table>
<thead>
<tr>
<th>Group</th>
<th>Phon. Awareness</th>
<th>PhonicStick</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>phon id</td>
<td>phon seg</td>
</tr>
<tr>
<td>Test total n</td>
<td>26</td>
<td>38</td>
</tr>
<tr>
<td>Control total n</td>
<td>24</td>
<td>31</td>
</tr>
</tbody>
</table>

4.2.1. **Phoneme identification**

The total number of participants in the test group on phoneme identification was 26 compared to 24 in the control group.

*Table 8. Results from the test category phoneme identification. Mean difference in correct answers (c.a) between pre- and posttest, mean change at level 1, mean change at level 2.*

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean difference in c.a (SD)</th>
<th>p</th>
<th>Mean change Level 1 (SD)</th>
<th>p</th>
<th>Mean change Level 2 (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>26</td>
<td>0.69 (1.59)</td>
<td>0.27 (0.78)</td>
<td>0.19 (0.49)</td>
<td>0.33 (0.82)</td>
<td>0.16 (0.62)</td>
<td>ns</td>
</tr>
<tr>
<td>Control</td>
<td>24</td>
<td>1.12 (2.70)</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td></td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>
A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the test group and the control group showed a mean rank of 24.94 in the test group and a mean rank of 27.10 in the control group. The difference between the two groups was not significant ($p > .05$), see Table 8.

When better was considered as a positive change of 1 correct answer or more, both groups showed a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 8).

When better was considered as a positive change of 2 correct answers or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 8).

### 4.2.2. Phoneme segmentation

The total number of participants in the test group on phoneme segmentation was 38 compared to 31 in the control group.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean difference in c.a ($SD$)</th>
<th>p</th>
<th>Mean change Level 1 ($SD$)</th>
<th>p</th>
<th>Mean change Level 2 ($SD$)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>38</td>
<td>0.74 (2.71)</td>
<td>0.11</td>
<td>(0.76)</td>
<td>0.13</td>
<td>(0.62)</td>
<td>ns</td>
</tr>
<tr>
<td>Control</td>
<td>31</td>
<td>1.48 (2.78)</td>
<td>0.35</td>
<td>(0.84)</td>
<td>0.26</td>
<td>(0.68)</td>
<td>ns</td>
</tr>
<tr>
<td>Total</td>
<td>69</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
</tr>
</tbody>
</table>

A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the test group and the control group showed a mean rank of 32.41 in the test group and a mean rank of 38.18 in the control group. The difference between the two groups was not significant ($p > .05$), see Table 9.

When better was considered as a positive change of 1 correct answer or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 9).

When better was considered as a positive change of 2 correct answers or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 9).
4.2.3. **Phoneme isolation**

The total number of participants in the test group on phoneme isolation was 21 compared to 16 in the control group.

Table 10. Results from the test category phoneme isolation. Mean difference in correct answers (c.a) between pre- and posttest, mean change at level 1, mean change at level 2.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean difference in c.a (SD)</th>
<th>p</th>
<th>Mean change Level 1 (SD)</th>
<th>p</th>
<th>Mean change Level 2 (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>21</td>
<td>1.19 (5.01)</td>
<td></td>
<td>0.19 (0.75)</td>
<td></td>
<td>0.10 (0.70)</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>16</td>
<td>3.88 (5.99)</td>
<td></td>
<td>0.31 (0.87)</td>
<td></td>
<td>0.38 (0.81)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td></td>
<td>ns</td>
<td></td>
<td>ns</td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the test group and the control group showed a mean rank of 17.21 in the test group and a mean rank of 21.34 in the control group. The difference between the two groups was not significant (p > .05), see Table 10.

When better was considered as a positive change of 1 correct answer or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 10).

When better was considered as a positive change of 2 correct answers or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 10).

4.2.4. **PhonicStick task – phoneme production**

The total number of participants in the test group on phoneme production was 43 compared to 20 in the control group.
Table 11. Results from the test category phoneme production. Mean difference in correct answers (c.a) between pre- and posttest, mean change at level 1, mean change at level 2.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean difference in c.a (SD)</th>
<th>p</th>
<th>Mean change Level 1 (SD)</th>
<th>p</th>
<th>Mean change Level 2 (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>43</td>
<td>1.52 (2.85)</td>
<td></td>
<td>0.37 (0.76)</td>
<td></td>
<td>0.30 (0.60)</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td>0.40 (3.10)</td>
<td></td>
<td>0.25 (0.97)</td>
<td></td>
<td>0.15 (0.67)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td></td>
<td>ns</td>
<td></td>
<td>ns</td>
<td></td>
<td>ns</td>
</tr>
</tbody>
</table>

A Mann-Whitney U test calculating the differences of the results in pre- and post-tests regarding the test group and the control group showed a mean rank of 33.47 in the test group and a mean rank of 30.38 in the control group. The difference between the two groups was not significant ($p > .05$), see Table 11.

When better was considered as a positive change of 1 correct answer or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 11).

When better was considered as a positive change of 2 correct answers or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 11).

4.2.5. PhonicStick task – word production

The total number of participants in the test group on word production was 48 compared to 20 in the control group.

Table 12. Results from the test category word production. Mean difference in correct answers (c.a) between pre- and posttest, mean change at level 1, mean change at level 2

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean difference in c.a (SD)</th>
<th>p</th>
<th>Mean change Level 1 (SD)</th>
<th>p</th>
<th>Mean change Level 2 (SD)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>48</td>
<td>2.25 (2.61)</td>
<td>&lt;.05</td>
<td>0.65 (0.56)</td>
<td></td>
<td>0.50 (0.51)</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>20</td>
<td>0.65 (1.23)</td>
<td></td>
<td>0.35 (0.59)</td>
<td></td>
<td>0.20 (0.52)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>68</td>
<td></td>
<td>&lt;.05</td>
<td></td>
<td>&lt;.05</td>
<td></td>
<td>&lt;.05</td>
</tr>
</tbody>
</table>

A Mann-Whitney U test calculating the differences of the results in pre- and posttests regarding the test group and the control group showed a mean rank of 38.14 in the test group and a mean rank of 30.38 in the control group. The difference between the two groups was not significant ($p > .05$), see Table 12.

When better was considered as a positive change of 1 correct answer or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 12).

When better was considered as a positive change of 2 correct answers or more, both groups show a positive change in scores between the pre- and the posttests. The difference between the groups was not significant. (See Table 12).
group and a mean rank of 25.78 in the control group. The difference between the two
groups was significant \( p < .05 \), see Table 12.

When better was considered as a positive change of 1 correct answer or more,
both groups show a positive change in scores between the pre- and the posttests. The
difference between the groups was significant. (See Table 12).

When better was considered as a positive change of 2 correct answers or more,
both groups show a positive change in scores between the pre- and the posttests. The
difference between the groups was significant. (See Table 12).

4.2.6. PhonicStick task – phoneme isolation

The total number of participants in the test group on phoneme isolation was 21
compared to 5 in the control group.

<table>
<thead>
<tr>
<th>Group</th>
<th>n</th>
<th>Mean difference in c.a ( (SD) )</th>
<th>( p )</th>
<th>Mean change Level 1 ( (SD) )</th>
<th>( p )</th>
<th>Mean change Level 2 ( (SD) )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test</td>
<td>21</td>
<td>0.24 (2.07)</td>
<td>0.24 (0.94)</td>
<td>0.00 (0.71)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>5</td>
<td>1.20 (2.28)</td>
<td>0.20 (1.10)</td>
<td>0.40 (0.55)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>ns</td>
<td>ns</td>
<td>ns</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

A Mann-Whitney U test calculating the differences of the results in pre- and post-tests
regarding the test group and the control group showed a mean rank of 12.93 in the test
group and a mean rank of 15.90 in the control group. The difference between the two
groups was not significant \( p > .05 \), see Table 13.

When better was considered as a positive change of 1 correct answer or more,
both groups show a positive change in scores between the pre- and the posttests. The
difference between the groups was however not significant. (See Table 13).

When better was considered as a positive change of 2 correct answers or more, the
test group shows no change in scores between the pre- and the posttests. The control
group shows a positive change in scores between the pre- and the posttests. The
difference between the groups was however not significant. (See Table 13).
5. Discussion

The present study was performed in order to further investigate if training with the PhonicStick could have positive effects on children’s phonological awareness. This was done in two parts. Neither the results of the pilot study nor the meta study showed any indications that the training affected the children’s phonological awareness as measured with norm referenced tests of phonological awareness.

5.1. Does training with the PhonicStick promote the development of phonological awareness in children as young as 4 - 5 years of age?

*Results compared to aim and key questions.* The aim of the present study was to evaluate the PhonicStick as a tool for acquiring phonological awareness in 4 - 5 year old children. One key question in this study was if the PhonicStick training would result in improvements of the phonological awareness among the children in the test group compared to the children in the control group.

Neither the results from the statistical evaluation of the differences between the pre- and posttests regarding the test and the control group nor the differences in pre- and posttests within the same group showed any significant differences (see Table 2-6) with two exceptions. The only significant difference found between the PS group and the control group was on the difference in results on the test “phoneme production”. The results show that the PS group was significantly better than the control group on this test both before and after the training. There should not be a significant difference in results between two groups chosen from the same population at the baseline testing if one is interested in investigating a difference between two groups. It is however positive that this significant difference remained after the training. The only significant difference found within the PS group and within the control group was in the results on the test “phoneme identification”. Both the PS group and the control group performed significantly better in the posttest compared with the pretest. It seems that both groups became significantly better at identifying different phonemes whether they had received training with the PhonicStick or not. These results might show that the act of answering the questions in this test actually might be considered as a practice session of this skill, since even the control group, who to my knowledge did not receive any training, performed better in the posttest.
There was no statistical analysis made on the differences in time spent training and posttest-score. There were only five children in the test group. One of these children only practised for a total of 20 minutes. Because of this the results would have been skewed and basically meaningless.

One aspect that might have implications on the result is the ceiling effect. This means a value where the child received a maximum score in both the pre- and the posttest. When this happened any improvement the child might have experienced will not be shown in the results. Such values were obtained in the test “phoneme production” where two of the children in the PS group received “ceiling scores”. Even though the test group was significantly better already before the training had started, these 2 children might have improved although this could not be seen.

Testing children is not easy. The performance of the child may not properly reflect its actual ability. Some examples of factors that might influence the results are that the child may not be interested in the testing, the child may lose focus somewhere along the way, something may distract the child and/or the child may be shy in front of the tester.

Method discussion. The reason for choosing 4 - 5 year old children to participate in the present study was that these children were probably not accustomed to the types of exercises that the training with the PhonicStick involve. The previous studies included older participants that had already started school and they had already been exposed to literacy teaching. One possible explanation for the lack of positive results in the previous studies was that the training was too easy; the children had already developed their phonological awareness to a level beyond the limits of the tasks used with the PhonicStick.

One possible explanation why the PhonicStick exercises and training did not significantly improve the phonological awareness among the children in the test group might have been the limited number of children involved in the study. The children differed in age between 4.17 and 5.17 years old. Because of the randomization procedure no control was made to ascertain that there was no significant difference in age between the PS and the control group. Luckily when tested there was no significant difference.
The observations from the task where the child imitated the researcher were the following: One child did not pronounce the word “akta” and the word “alltså” correctly. Another child mispronounced the word “kök”. Yet another child did not pronounce the word “mat” correctly. One child mispronounced the words “katt” and “kök”. None of these children were assessed as having any phonological or grammatical problems in their spontaneous speech. Another child mispronounced the words “katt”, “kök”, “tiger” and “alltså”. This child was assessed as having small phonological problems but no grammatical problems. One child did not pronounce the words “tall”, “ofta”, “om”, “mack”, “kök”, “akta” or “alltså” correctly. This child was considered as having moderate phonological problems. This child was assessed to have a slightly low but normal grammatical ability. The two children who were assessed as having difficulties with their phonology were not in the same group, i.e. one was in the test group and one was in the control group. Therefore they should not have influenced the results particularly much.

The most common phonological problem was that the “t” sounds was indistinct, they almost sounded like a “d” sound. For one child an “r” sound was exchanged for an “l” sound. Other common problems were omitting the final sound and another was saying the “sch” sound instead of the “tj” sound. Some of the participating children were quite shy in front of the researcher and did not talk that much; some children hardly said a word, at least not spontaneously, which made the assessment of especially the grammatical functions uncertain.

The selection of the children was really a selection of parents; this might have had the effect that the parents involved were more interested in the language development of their children than the rest of the normal population. Because of this they might also have invested more time in practising with the PhonicStick. If so, the sample is not entirely within the normal population. On the other hand the parents who were acquaintances might have participated in the study for other reasons, such as a favour for the researcher.

There exists no test norm referenced test for 4 - 5 year old children evaluating phonological awareness. The test material used in the present study, Magnusson and Nauclérs test material, is norm referenced on 6 year old children (Magnusson & Nauclér, 1993). The parts chosen from this material were the easiest parts and also the ones deemed to be the most age appropriate by the researcher. When testing
phonological awareness with the PhonicStick a test material had to be constructed. The PhonicStick tasks used in the present study is revised versions of those used in a previous study (Ager & Solli 2009). The revisions made were mainly decreasing the difficulty of the tasks since the study from which the tests were taken studied older children. There were fewer test parts and fewer questions on each part because of the shorter attention span of 4 – 5 year old children. Because this test material is still under construction, improvement can still be made. This might explain why there were a few ceiling effects.

The procedure used in this study, having the parents practise with the children in their home environment should theoretically make it possible to train with the PhonicStick for a longer period of time, make the training more consistent and also make it possible to train at a suitable time for each child. An observed tendency was however that the children enjoyed the training in the beginning but not for the full period. This could clearly be observed in the training records kept by the parents. In the first few days the children trained a lot, with positive comments in the margins of the training records but after a couple of days the practise sessions became scarcer and scarcer. The reason could be that they became bored with the exercises and/or they thought of the training as something they had to do instead of something they were allowed to do. Another problem that surfaced when testing the children in their home environments was that some parents were a bit competitive. They had a hard time not giving advice or hinting at the answer in order for their child to get a “good score”. There is a possibility that the children of these parents were “unofficially” trained at the tasks used to evaluate the children in between the pre- and the posttests. If this was done in the control group it might have influenced the results.

An alternative to home-training could instead be to ask the day care center to help out. The factor of competitive parents could in this way have been avoided. This was considered as a method but was rejected because in order to do the training the child would have to be alone with the teacher every day for 5 – 10 minutes. This seems like a positive aspect but might in fact be impossibly to perform practically.

One of the day care centres involved in the study had started activities promoting phonological awareness. This might very well have had an effect on the results in that the phonological awareness of these children could be higher than that of children in the other day care centre. To avoid this influence the randomization was performed in the
way described under methods. The idea was that for each child group (children from one day care centre, children from the other day care centre and the children of the acquaintances) half the children was placed in the test group and the other half in the control group. However, due to the two children that left the study, the day care centre that was promoting phonological awareness was in the end represented with two children in the test group and one in the control group. The other day care centre had one child in the tests group and two in the control group.

Parental comments of the PhonicStick roughly translated. On the training record there was a column for comments and three questions (see 4.1.6.). The scores for the questions are rather low suggesting that the parents were not satisfied with the device.

A short summary of the most commonly expressed reflections follows:

We had a problem seeing the point of this tool. There were too few sounds. It was difficult to motivate the use of the PhonicStick. Our child was more interested in sounding orally and writing. After a while the training became boring because of too few sounds. There were some technical problems. It was a little boring with only 6 sounds when the training was two whole weeks. Sometimes the button blending the different phonics produced with the PhonicStick did not work. Our child quickly became bored and wanted to do other things. It is difficult to try to keep the child’s interest when the child has not yet understood the term “sounds”, to low phonological awareness? Making words is funny. Exiting at first, and then boring. Too few sounds to be fun for a long time. Sometimes the program didn’t store the sound produced with the PhonicStick, this is particularly troublesome when the child has pointed in the right direction. Great, our child is learning words quickly.

Additional observations. A positive verbal comment about the training according to a few of the parents was that some children started to realise that words can have different lengths. The children were disappointed that a certain word could not be made when another could be made. After experiencing this a few times they started to understand why. This was however not proved by the results.

An observation made by the investigator was that some of the children understood what was required of them at once while other children struggled to understand what they were supposed to do. It seems like phonological awareness is an ability that is
either present or not. If the child has not acquired this ability he/she will not even comprehend the questions. The researcher agrees with the points made by the parents. The training time might have been too long without increasing the difficulty of the tasks. The software suffers from a few flaws. Such as sometimes not storing all the phonics produced or sometimes stops to produce sounds altogether. These problems might not matter when using the PhonicStick for a short time but when the training spans over hundred minutes they induced frustration in both children and parents. Most observations made were however positive. To see a child trying different phonics until they find the correct one is touching and inspirational to say the least.

For future research. A subjective analysis of the results indicated that there might be an age related component. The older children seemed to perform better in all tests than the younger children. With more participants this supposed difference might be shown statistically. Also the test material could be more adapted to this age group in order to avoid the ceiling effect. To shorten the time of practice or to make the training more difficult as you go along, perhaps by inserting new phonemes after a week, might also be beneficial when planning a new study. There might be an advantage to have more than one researcher to avoid systematic errors that can happen if there is only one tester.

5.2. Does differences between pre- and posttests for all previous and present test groups and control groups give new information about the development of phonological awareness related to training with the PhonicStick?

Results compared to aim and key questions. The results do not show that training with the PhonicStick improves the phonological awareness of children, in fact the control group outperformed the test group in all the norm referenced tests for phonological awareness, although not significantly. On the other hand, the test group was better than the control group on the PhonicStick tasks, except for the task of phoneme isolation. The control group’s better result on the task of phoneme isolation may be explained by the low number of participants in this task. As can be seen in Table 13, the number of participants in the control group for this task was only 5 (the lowest number in any test or task). Five children is not an appropriate sample size to make judgments about the whole population.
In one of the PhonicStick tasks namely, “word production” there was a significant difference that was even significant for all three analyses (see table 12). The fact that the difference was significant in all three analyses strengthens the results. Thus the probability that there is a real difference between the test and control group for this task is high. The significant difference between the test and the control group on the “word production” test might stem from the fact that the test group is simply better at using the PhonicStick. But if this was the case, then why was the test group not significantly better at the other PhonicStick tasks as well? The task of word production demands more in terms of phonological awareness than at least the task of phoneme production. The test group children were significantly better than the control group at mixing separate phonemes and blending them into words with the PhonicStick but were not better at producing correct answers to questions in norm referenced tests that are supposed to assess the same skills.

Could there be an ability, that we might call intuitive phonological awareness, that is not assessed by the norm referenced tests of phonological awareness. When a child can freely explore the sounds via direct feedback, without having to find the separate phonemes on his/her own, they might intuitively hear which sound is the correct one. This ability might be a precursor to the later development of phonological awareness. Bolte and Goschke (2005) define intuition as “the ability to judge stimulus properties on the basis of information that is activated in memory but not consciously retrieved”. This definition is used in the present study.

When a test is performed on a child a difference in results is often seen that depends on how the question is asked and what response type is required (Sodoro et al., 2002). Children can for instance be asked to recognize something (e.g., Does this word begin with the "s" sound?) or to produce a response (e.g., Can you tell me the first sound in "sun"?). Sodoro et al. claims that recognition tasks in general are easier than production tasks. Therefore, a child could respond correctly to a task when asked to recognize but be unable to produce a response even though both tasks require the same skill (Sodoro et al., 2002). The results of this meta study might indicate that the more intuitive "PhonicStick response type" tests this possible intuitive phonological awareness but that the norm referenced tests do not.
Method discussion. Some of the studies had several different tests to test a specific ability. In order to get only one value under each column these test scores were added up to make a total difference. This total test score is more one dimensional because of this. In one study (Ager & Solli, 2009) for example “word production” was tested with three different tests which created three different scores. For one child these scores was a positive change by 2 correct answers in the first test, a negative change by 1 in the second and a positive change by 1 in the third test. The total difference for this particular child was a positive change by 2 correct answers (2+-1+1=2). The negative score on the second test is not shown. On the other hand all of these 3 tests tested the same ability and overall this child had improved his results.

One study (Lindström & Peronius, 2010) had three different groups of children. One control group, one group that practiced 6 times with the PhonicStick and one group that practiced 10 times with the PhonicStick. In this case the 2 tests groups were added together to make 1 test group. The negative aspect of this is that the results of the meta analysis does not show what effect the frequency of training has. It is not possible to see if the children that practiced with the PhonicStick 10 times were better than the children who practiced 6 times. In this same study the children were tested 3 times ie. Pre-, medial- and posttests. Only the data from the pre- and the posttests were used in this study. This is also means loss of data. The present study will therefore not show what results the three different groups of children received after half of their training.

Outliers were hopefully removed using the more semi quantitative categories “better, worse and the same”. This could however have had the opposite effect. Some children might have had extreme values but these values could also be a more accurate measure of the child’s ability i.e. a positive change in results by 9 correct answers may very well more accurately reflect the ability of the child than the result “better”. Because of this both the results from the difference between pre- and posttests and the “better, worse and the same” results were accounted for.

For future research. There might be indications of an intuitive phonological awareness that can be tested with the PhonicStick, more specifically with the test of “word production”. If this is so then this ability should be further researched. Then it might be beneficial to utilize all the compass directions of the PhonicStick in order for the
children to access more phonics to produce words with, which might increase the children’s motivation for the training.

5.3. **Conclusions**

The present study could not show that training with the PhonicStick promotes the development of phonological awareness as tested with norm referenced tests. This was the case both for the pilot study including 4-5 year old children and when all the previous and unpublished studies were analyzed as one in the meta study. The results from the meta study showed that for the test of “word production” performed with the PhonicStick, there was a significant difference between the test group and the control group. Why there was not any significant differences on the corresponding norm referenced tests needs further research, which is also needed before the possible clinical use of the PhonicStick.
6. Acknowledgements

My gratitude goes firstly to all children and parents for participating in this study. My supervisor Margareta Jennische and her incurable enthusiasm is greatly appreciated. Many thanks to Emma Ager for her skilful and loyal help. Also Bo Ek for statistical support and to all other persons that has corrected all the different versions of the manuscript.
7. References

Ager, E. & Solli, E. (2009). The PhonicStick: A Swedish study, how do children age 5 and 6 handle the PhonicStick and will the use of it affect their phonological awareness? Master thesis in speech pathology and therapy, Uppsala University.


8. Appendix

A. Information letter to Uppsala Community
B. Information letter to the parents
C. Consent form to parents
D. Test forms for the PhonicStick
E. Training record
F. Information and suggestions for the training with the PhonicStick
Till den det vederbör

I ett projekt vid Uppsala universitet skall under hösten 2010 en metod prövas, som har som mål att stimulera utveckling av fonologisk medvetenhet (lyssna på ljud) hos barn. Detta projekt påbörjades under 2009.


Med vänliga hälsningar,
Tom Ek
Logopedstudent
Appendix B. Information letter to the parents

**Till målsman**


I de tidigare studierna har det framkommit tvetydiga resultat. Barnen lyckades inte få bättre testresultat men forskarna såg att barnen hade utvecklat sina förmågor i vissa aspekter. I de tidigare studierna var barnen runt 6 år gamla. Jag vill undersöka barn i 4-5-årsåldern då dessa barn ännu inte har erhållit någon undervisning som kan påverka deras fonologiska medvetenhet.


Innan vi träffar barnen har ni fått detta informationsbrev och fyllt i ett godkännande om att ert barn medverkar i studien.

Studien utgör magisterexamensarbete på Logopedprogrammet vid Uppsala universitet. Handledare är Margareta Jennische, universitetslektor, Uppsala universitet, Annalu Waller, universitetslektor, University of Dundee samt Emma Ager, legitimerad logoped.

Med vänliga hälsningar,
Tom Ek
Logopedstudent
Samtycke till mitt barns deltagande i studien om barns språkutveckling


Barnets namn: .................................................................
Barnets födelsedatum: ............................................................
Förälders/Vårdnadshavares namn: ............................................................
Emailadress: ...........................................................................
Telefon: ..................................................................................

Ort och datum

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Vårdnadshavares underskrift
Appendix D. Test forms for the PhonicStick

**Tests with the PhonicStick form 1**

*to be used by half the children in session 1 and the other half in session 2*

Child nr:

Date:

**Test 1**

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<th>Comments</th>
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Fonologiska avvikelser i spontantal:

Inga små måttliga stora

Grammatiska avvikelser i spontantal:

Inga små måttliga stora
Tests with the PhonicStick form 2

to be used by half the children in session 1 and the other half in session 2

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Date:

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**Fonologiska avvikelse i spontantal:**

Inga små måttliga stora

**Grammatiska avvikelse i spontantal:**

Inga små måttliga stora
## Träningsschema

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### Barns synpunkter på träning

Hur tyckte ditt barn det var att leka med PhonicStick? 1 = mycket tråkigt 5 = mycket roligt:

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### Förälders synpunkt på PhonicStick som träningshjälpmedel:

Svårighetsgrad: 1 2 3 4 5

Användbarhet: 1 2 3 4 5

Övriga synpunkter:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

47
Träningsidéer PhonicStick


Tips på fri lek kan vara:

- Förälder säger ett ord, barnet gör det första ljudet i ordet med PhonicStick.
- Barnet gör ett ljud med PhonicStick och försöker komma på ord som börjar med det ljudet.
- Barnet sätter ihop flera ljud med PhonicStick för att skapa ord, både riktiga och låtsasord (bara ord med 2 eller 3 ljud).

Om barnet tycker att uppgifterna är för enkla, så börja träna på annat sätt. Exempel på lite svårare övningar kan vara:

- Vilket ljud är sist i det här ordet

Om barnet är ointresserat eller tappar intresset hoppa till nästa övning och gå tillbaka senare, om inte det fungerar så sluta eller ta en paus. Tanken är ditt barn ska träna med detta program en gång om dagen i 14 dagar. Barnet får självklart göra mer än dessa övningar om han/hon finner det vara roligt. Om det inte går att göra dessa övningar en dag så är det ingen fara, det viktiga är att ni skriver ner hur mycket träning barnet har erhållit (se schema nedan).

Med vänliga hälsningar,
Tom Ek, Logopedstudent