The PhonicStick and Language play

Can the PhonicStick be used for the purpose of enabling language play and thereby promote phonological awareness for children with Down’s syndrome?

Erika Lempke
Sara Lindberg-Wesslert

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Supervisors:
Rolf Black
Annalu Waller
Margareta Jennische
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ABSTRACT

Research shows that phonological processing skill is the greatest single predictor for reading ability and it is agreed that phonological awareness specific tasks correlate positively with literacy acquisition in typically developing children. Children with Down’s syndrome are at risk for reading acquisition difficulties, primarily because of their reduced phonological awareness and a phonological awareness based approach to literacy has been shown to be beneficial for them. The aim of the present study was to investigate if the PhonicStick can be used to initiate interest in language play in children with Down’s syndrome, in order to stimulate their reduced phonological awareness. Six children with Down’s syndrome between five and 15 years of age, currently enrolled within the UK educational system, were recruited to participate in six sessions; two sessions of pre- and post testing of their phonological awareness, and four intervention sessions with the PhonicStick. During the intervention sessions, the ability to remember the six phonemes of the PhonicStick, to generate three-phoneme combinations, to produce given target real words or non-words and to perform in phoneme substitution tasks using the PhonicStick were investigated. The results of this study show that the PhonicStick, with advantage, can be used to introduce and enhance phonological awareness in children with Down’s syndrome and that an increase in phonological awareness is possible even during a short time of practise with the PhonicStick. Since children with Down’s syndrome benefit from a phonological awareness based approach to literacy, practising phonological awareness skills through language play with the PhonicStick might also have a future positive effect on their literacy acquisition.

Keywords: Down’s syndrome, phonological awareness, literacy acquisition, the PhonicStick, language play
SAMMANFATTNING (Abstract in Swedish)

Tidigare forskning visar att fonologisk medvetenhet är den främsta prediktorn för läs- och skrivkunnighet och att övning i fonologisk medvetenhet korrelerar positivt med läs- och skrivinlärning hos barn med typisk läs- och skrivutveckling. Barn med Downs syndrom riskerar att utveckla läs- och skrivsvårigheter framförallt till följd av nedsatt fonologisk medvetenhet och det har även visats att en metod för läs- och skrivinlärning baserad på fonologisk medvetenhet, kan gagna dem. Syftet med den här studien var att undersöka om the PhonicStick kan användas för att initiera intresse till språklek hos barn med Downs syndrom, med avsikt att stimulera deras fonologiska medvetenhet. Sex barn med Downs syndrom, i åldrarna fem till 15 år, inskrivna i det brittiska skolsystemet, medverkade i två sessioner bestående av pre- och post testning av fonologisk medvetenhet, och fyra interventionssessioner med the PhonicStick. Under interventionssessionerna undersöcktes förmågan att komma ihåg placering av fonem hos the PhonicStick och med den generera kombinationer av fonem (dvs. ord), generera givna målord och substituera fonem i ord. Resultaten visar att the PhonicStick med fördel kan användas för att introducera och öka den fonologiska medvetenheten hos barn med Downs syndrom och att en ökning är möjlig även efter kort tids träning. Eftersom en metod för läs- och skrivinlärning baserat på fonologisk medvetenhet gagnar barn med Downs syndrom skulle övning av fonologisk medvetenhet genom språklekar med the PhonicStick även kunna ha en långsiktig positiv inverkan på deras läs- och skrivkunnighet.

Nyckelord: Downs syndrom, fonologisk medvetenhet, läs- och skrivutveckling, the PhonicStick, språklek
1. Introduction

Several cognitive impairments associated with Down’s syndrome (DS) reflect on the ability to acquire language and literacy skills in this population. An area of particular concern is reduced phonological awareness (PA) ability, i.e. ability to identify and manipulate sounds in words. The PhonicStick is a speech sound generating joystick, developed within an ongoing project called “Speaking Phonics” at the School of Computing at the University of Dundee in Scotland, designed to enable the experience of the use of sound for children with Complex Communication Needs (CCN). The aim of the present study is to investigate if the PhonicStick can be used to initiate interest in language play in children with Down’s syndrome, in order to stimulate their reduced PA ability. Six children with Down’s syndrome from schools around the Dundee area, between five and fifteen years of age, participated in the study.

In this thesis, questions regarding capability of physically and technically manoeuvring the PhonicStick, its usability in PA specific tasks and how well it can capture the interest and motivation of the participants will be discussed. Previous research will be presented concerning language development in children with DS as well as in typically developing children with the focus of PA and its importance to literacy acquisition. Typical literacy development and the standard approach to literacy teaching in the United Kingdom today will also be described as well as further, more detailed information about the PhonicStick and its purposes and functions.

1.1. Down’s syndrome and language development

1.1.1. Down’s syndrome

Down’s syndrome is a congenital condition caused by extra chromosome 21 material in the cells. In the most common form of DS, Trisomy 21 (94%), the child has a total of three, instead of the typical two, whole chromosomes 21 in all cells. In about 4% of the cases of DS, so called Translocation Trisomy 21, parts of the chromosome 21 have translocated to another chromosome, often chromosome 14. In a third form, Trisomy 21 Mosaic, only a portion of the cells contain the extra chromosome 21. This form shows fewer symptoms than Trisomy 21. There is also a fourth form, Partial Trisomy 21, which is extremely rare, where only parts of three chromosomes 21 appear in each cell.
The most dominating symptoms of DS are cognitive impairments (Annerén et. al., 1996; see Chapman & Hesketh review, 2000).

Language skills are among the most impaired in children with DS compared to other cognitive qualities. Social and emotional development as well as gross and fine motor skills, are not remarkably delayed in children with DS compared to typical development. Linguistic and communicative development on the other hand, is more delayed as well as general cognition, i.e. IQ (Annerén et. al., 1996). Abbduto et al. (2007) agrees that language is one of the most impaired domains of functioning in DS and perhaps also the greatest barrier to independent meaningful inclusion in the community.

1.1.2. **Short-term memory and expressive language in children with Down’s syndrome**

Proficient language skills rely on many factors. For children with Down’s syndrome, poor speech perception, such as auditory processing and hearing impairments, poor speech production, such as oral motor and structural deficiencies, and expressive speech, i.e. deficiencies concerning language use such as vocabulary and syntax, together with low IQ, are all constraints to language development. Among them, low IQ, poor auditory (verbal) short-term memory and difficulties in expressive language have been described to bring particular concern. Reviewing behavioural phenotypes in individuals with DS, Chapman and Hesketh (2000) states the sequence of cognitive and language development as generally following that of typical development but describes broad individual differences in terms of rate (IQs average 50 and range from 30 to 70) with specific, notable phenotypically characteristic domains of delay in verbal short-term memory and expressive language.

**Short-term memory.** Short-term memory for auditorally presented sequences of speech sounds (i.e., phonological memory) has been shown to be an area of particular challenge for children with DS compared to other language related skills (Abbeduto et al., 2007). Adolescents with DS show better visual memory than verbal short-term memory (Marcell & Weeks, 1988). In a study of short-term memory for verbal and visuospatial information with a group of children and teenagers with DS from eight to 17 years of age, performance on verbal tasks was impaired relative to matched control groups, but there were no group differences on visuospatial tasks. The DS group also showed
inferior short-term memory for verbal as opposed to visuospatial information, while controls showed the opposite pattern. Since these findings did not appear to result from a general superiority of nonverbal abilities in the DS group, or from hearing difficulties that might have had an impact on the auditorally presented verbal short-term memory tasks, the results are consistent with the suggestion that DS is associated with a selective impairment of phonological memory (Jarrold & Baddeley, 1997).

Persons with DS also present with poor auditory memory span relative to overall cognitive development (Mackenzie & Hulme, 1987). In comparison to adolescents with cognitive impairments of unknown origin, research shows that sentence repetition is significantly impaired in children with DS, with longer latency and less accuracy. In comparison to their own performance on other tasks, auditory verbal short-term memory is significantly impaired to a normative level typical of expressive language deficit (see Chapman & Hesketh review, 2000).

Two experiments were made investigating abnormally rapid forgetting as a possible reason for poor verbal short-term memory in children with DS (Purser & Jarrold, 2005). No evidence was found to suggest that forgetting is abnormally rapid in phonological memory in DS. Consistent with previous research, results indicated a more general, limited capacity to the phonological short-term memory system (Boudreau, 2002).

Expressive language. Parents of children with DS report that communication skills lag behind daily living and socialization skills as expressive language is significantly weaker than receptive language (see Chapman & Hesketh review, 2000). Expressive language skills are delayed already from very early stages of vocalisation in children with DS. Typically developing children begin to communicate intentionally within their first year of life, for example through imitation and joint attention (Abbeduto et al., 2007). Symbolical communication, with words and/or signs, starts somewhere between twelve and 18 months of age. For children with DS, this transition into symbolic intentional communication can take up to 24 to 36 months (Rondal, 2003).

Babbling is one of the earliest vocalisation patterns where the child is experimenting with uttering sounds of language but not yet producing any recognizable words (Baron, 1993). Abbeduto et al. (2007) describe a delay in the onset of babbling in children with
DS which may reflect the effects of general motor delays and/or the oral structural problems or even the effects of delayed cognitive development in this population. Babbling patterns in children with DS are not only delayed but also different in type compared to typically developing children which could be related to their poor auditory skills. The traditional belief that audition (auditory processing skills including the ability to hear) is only of minor importance to infant vocal development is built on evidence that babbling in deaf and hearing infants is the same. However, a more extensive comparison was made of vocal development in deaf and hearing infants which indicated the opposite. For example, well-formed syllable production was found established in the first ten months of life by hearing infants but not by deaf infants. Thus, this study suggests that audition instead plays an important role in vocal development (Oller & Eilers, 1988).

Hearing and oral-motor structure and function can contribute to problems in language learning and use in individuals with DS (Roberts et al., 2007). Children with DS typically have a high and relatively narrow arched palate, enlarged tonsils and adenoids. They also have a relatively small mouth and jaw area in comparison to their tongue (Strome & Strome, 1992). Children with DS also typically have difficulties of dysarthric character i.e. slowing down and coordinating articulatory movements due to low muscle tone in this area (Hamilton, 1993). The structural characteristics combined with low muscle tone contribute to the difficulty of producing precise speech sounds that individuals with DS have. Other contributing factors to their intelligibility are hearing loss and structural difficulties (Abbeduto et al., 2007).

However, a study by So and Dodd (1994), of phonological behaviour in children with DS acquiring Cantonese revealed similarities to the phonological behaviour of children with DS acquiring English. The children with DS did not differ from the matched non-DS intellectually impaired controls in terms of articulatory/phonetic. This indicates that their poor verbal performances reflect an underlying deficit common to all children with DS, independent of language, and thus can best be explained by problems on the level of phonological assembly rather than articulation.
A relationship has been found between impairments in phonological short-term memory and expressive language difficulties in several neurodevelopmental disorders, including DS (Jarrold et al., 1999; Laws, 2004). Auditory perception, together with cognitive ability, constrains vocabulary growth in individuals with DS. There is a substantial delay in onset of first words and the subsequent acquisition and use of vocabulary in individuals with DS but it has also been found that concrete vocabulary can be significantly improved with repeated exposures. Further, syntax is another area of special challenge for individuals with DS, which distinguishes DS from other neurodevelopmental disorders. Again, cognitive ability and auditory perception also contribute to the problems individuals with DS experience with syntactic learning (Abbeduto et al., 2007).

1.1.3. Sign and gesture supported language and Down’s syndrome

The perceptual deficiencies associated with Down’s syndrome make it difficult to focus attention and maintain concentration which is important in communication and learning. Since children with DS have less trouble with visual perception than auditory perception, they benefit from visually supported communication such as picture, sign and gesture supported language (Annerén et al., 1996). Research shows that gesture production is a strength in children with DS relative to their receptive and expressive language skills. Capone and McGregor (2004) show that gesture use can have substantial communicative value for children with DS considering their often protracted periods of oral speech development. It is also suggested that language learning opportunities can be enhanced if gesture is recognized as a communication attempt with language-impaired children (Abrahamsen et al., 1985; Chan & Iacono, 2001).

1.2. Phonological awareness and literacy

1.2.1. Phonological awareness

The term phonological awareness (PA) is usually used to describe the ability to analyze spoken words into a sequence of their constituent sounds (phonemes) (Cossu et. al., 1993). Fowler (1995) refers to PA as the oral language ability to consciously attend to the sound structure of the language, without regard to meaning. This awareness can be assessed with a great variety of PA tasks such as word or non-word differentiation and repetition, rhyme and alliteration production and detection, phoneme isolation
identifying a constituent phoneme in a certain position of a word such as initial or final position), phoneme segmentation (isolating all constituent phonemes of a word), sound synthesizing (producing a word from a series of sounds), phoneme counting, and substitution (deletion and addition). In other words, PA is used as “a blanket term for a variety of language manipulation skills” (Evans, 1994). Other terms, used by different referred researchers throughout this thesis, are coding or encoding, for segmenting written words into their constituent sounds, for example /k/, /a/ and /t/, decoding, which as well as segmentation includes synthesizing/blending, the sounds into words, /kat/, and recoding for mapping the sounds with orthographical letters. To further explain; decoding novel words require the ability to segment and recall phonological representations corresponding to the letters, hold them in memory and blend them together to form the word, namely to read. Recoding skills are then necessary for writing them.

1.2.2. Phonological awareness and literacy acquisition

The present study is based on the view that phonological awareness plays an important role in learning to read and write. Opinions vary as to how the two relate. Although, whether PA should be seen as one of the essential prerequisites for literacy acquisition (Rose, 2006), as an effect of literacy acquisition (Morais, et al., 1979) or as a combination of both (Adams, 1990), it is agreed that PA tasks correlate positively with literacy acquisition in typically developing children (Bryant & Goswami, 1987).

Reading acquisition can be described in three stages, the logographic, the alphabetic and the orthographic stage. The logographic stage is hence the earliest stage of reading (Frith, 1985). In this stage, associations are made between main graphic features of a whole printed word including its surrounding context, and an unanalyzed spoken word (Kamhi, 1999). Characteristic of this stage is the focus on visual features of the word, rather than its letter names or sounds. (Frith, 1985). In the alphabetic stage, children learn that spoken language can be represented by graphic symbols, or letters, and that each letter has a specific sound (Catts & Kamhi, 1999). This insight relies on PA, an understanding that spoken language can be broken into smaller units than words, namely sounds or phonemes (Lyon, 1999). The realization that the phonemes can be represented in written symbols, makes the alphabetic orthography a logical way to symbolize language (Ball & Blachman, 1991). The children must use these letter-sound
correspondences to be able to decode novel words and become fluent readers (Chall, 1983; Ehri, 1991). In the third, orthographic stage, letter sequences and spelling patterns are used to recognize words visually without sounding out each letter or phoneme. This knowledge is critical for automatic word recognition (Catts & Kamhi, 1999) and fluency and speed in word recognition is critical for comprehension of what is read (Lyon, 1999; Samuels, 1994).

Research shows that phonological processing skill is the greatest single predictor for reading ability (Lundberg et al., 1980; Adams, 1990). In an alphabetic orthography, sometimes more than one letter represents a single phoneme (Häggström, 2007). Therefore, in order to become literate in an alphabetic language, the ability to explicitly analyze and control the phonemic segments of spoken language and consciously control these units in different ways is crucial (Lundberg, 2006; Lundberg et. al., 1988). Since learning to map letters to language sounds is dependent on the ability to reflect on sounds in spoken words, children who find it difficult to segment spoken words into separate sounds might have difficulties in learning to read (Liberman et. al., 1974).

1.2.3. Phoneme based literacy acquisition

Synthetic Phonics. Synthetic phonics is a systematic phoneme based approach to literacy learning used in schools in the UK today. (A phonic is not the same as a phoneme. Phonological or phonemic awareness is the understanding that words are made of discrete sounds, phonemes. The term phonic also includes the relationship between sounds and written symbols). Synthetic phonics emphasizes clearly defined sequences in grapheme/phoneme correspondences, appliance of the highly important skill of blending phonemes into words (synthesizing), appliance of the skill of segmenting words into their constituent sounds in order to spell and blending and segmenting as reversible processes. (Rose, 2006) The phonemes and letters are mapped without using letter names in the beginning of learning (Torgerson et. al., 2006; Bowey, 2006). The synthetic phonics approach to literacy is stated to offer the best way of becoming a fluent reader to the vast majority of young beginners (Rose, 2006). In a longitudinal study evaluating the literacy programme Johnston and Watson (2005) found that synthetic phonics both has an immediate impact on word reading and spelling, as well as sustainable effects over time.
**Jolly phonics.** Jolly Phonics is a commercially available program for literacy teaching based on the synthetic phonics approach. In Jolly Phonics, the phonics are taught in a specific order carefully selected to support learning with intervals from identifying sounds in words to blending sounds into words to reading words. All 42 phonics of the English language are introduced in groups of six, one a day for about nine weeks. The letters are presented as lower case letters and introduced by sounds, rather than names. Each child’s progress is documented in a Sound Book to facilitate parent involvement in their child’s literacy learning (Lloyd, 1998).

### 1.3. Down's syndrome, literacy and language play

**1.3.1. Acquiring literacy with Down’s syndrome**

Learning how to read has a bi-directional relationship to language acquisition. Acquisition of literacy skills may serve to increase language and communication skills as well as language and communication skills may serve to increase acquisition of literacy. Evidence is provided of significant increase in language development corresponding to increased literacy skills in children with Down’s syndrome (Buckley & Bird, 1993). Many of the linguistic skills that are impaired or delayed in DS are skills that are important in acquisition of literacy for typically developing children (Abbeduto et. al., 2007). Continuing development in literacy related skills calls for continued emphasis on literacy acquisition throughout the school years with children with DS (Boudreau, 2002). Cognition, phonological short-term memory and oral (expressive) language are areas described as particularly problematic for language development in children with DS, and thus, learning to read is also likely to be particularly challenging for them (Abbeduto et. al., 2007).

A growing body of literature suggests that many children with DS acquire some level of literacy skill, although level obtained can vary significantly between individuals (Boudreau, 2002). Because of their complex language and cognitive impairments, a great variability in literacy performance is also observed between studies and also between components of literacy, with significantly better word identification skills than novel word decoding (“word attack skills”) and reading comprehension abilities (Evans, 1994; Fowler et al., 1995). Most studies on reading in children with DS show that there are some individuals that cannot read any words at all and that those who can often are
in the beginning stage of reading acquisition (Abbeduto et al., 2007). The number of children with DS learning to read is increasing, although, little is known about what underlying skills are responsible for the literacy acquisition of these children. This has raised the interest to investigate the distinct profiles of development that lead to atypical literacy development in children with DS (Kennedy & Flynn, 2003).

Impairments in IQ, oral (expressive) language and phonological short-term memory as predictors for literacy acquisition in children with DS can be discussed. The relationship between intelligence and reading achievement in persons with DS has only been investigated minimally, and only some support has been found that general IQ can predict literacy acquisition in this population (Carr, 1995). Although a relationship has been found between oral language skills and narrative skills as well as reading comprehension skills, both crucial to literacy, limited research has been done on the relationship between oral language skills and literacy acquisition in children with DS (Boudreau, 2002). Research indicates that short-term memory has a slightly more important role in literacy acquisition. For example, as decoding novel words in part depend on short-term auditory memory skills, the auditory memory impairments in children with DS may very well be a reason to their poor decoding difficulties (So & Dodd, 1994). Research shows that difficulties in speech sound perception in children with DS complicate letter-sound associations and phonological encoding and recoding of written words (Buckley et al., 1996a, 1996b).

### 1.3.2. Phonological awareness and literacy in Down’s syndrome

Phonological awareness skills are shown to be of great importance to literacy acquisition also in children with Down’s syndrome. Kennedy and Flynn (2003) have shown a significant relationship between reduced phonological awareness and reading acquisition difficulties in children with Down’s syndrome. In a study of nine children with DS between 5;6 and 8;10 years of age, the relationship between PA and literacy acquisition was investigated. PA was measured in three different phoneme manipulation tasks; alliteration detection, phoneme isolation and phoneme blending. The results showed a correlation between the scores measured in phoneme awareness and the scores measured in literacy which suggests that children with DS are at risk for difficulties in reading acquisition due to reduced PA skills.
Cossu et al. (1993), argue that not all children depend on PA in order to learn how to read, and provide evidence that some children with DS can learn to read up to the level of a normal 8-year old despite their failure on PA tasks. Evans (1994) agrees that some logographic (whole-word) reading ability can be developed, while alphabetic (analytical/letter-sound knowledge) and phonological skills are largely absent, thus recognizing phonological skills as being particularly relevant to literacy acquisition on the higher, alphabetic, level. In addition, Abbeduto et al. (2007), show that children with DS can benefit from either logographic or alphabetic reading instruction, but that they learn more generalizable skills with alphabetic instruction.

Although Cossu et al. (1993) argue against PA skills as essential prerequisites for literacy acquisition, the possibility that reading might have been acquired faster with adequate PA is also mentioned. The same research also indicates that children with DS do use some normal implicit segmentation skills subconsciously (decoding non-words for example), and that it might be a question of simply not being able to access those abilities metalinguistically in PA tests.

Specific PA training for children with Down’s syndrome. A PA based approach to literacy can be beneficial for children with Down’s syndrome (Kennedy & Flynn, 2002). Explicit PA instructions have positive effects on both PA abilities and literacy acquisition for children of various ages and levels of functioning (Byrne & Fielding-Barnsley 1993; Cunningham 1990; Gillon & Dodd 1995). Previous research also demonstrates that PA based literacy programmes can improve literacy acquisition and speech production for children with speech and language delays. Hence, Kennedy & Flynn (2002) investigated if the same results could be seen in children with DS specifically, using a PA based intervention programme. Three children with DS in the ages of 7;2, 8;4 and 8;10, participated in the six week long intervention. The aim was to examine progress in alliteration detection, initial phoneme isolation (synthesis), spelling of orthographically regular words and rhyme detection. All participants showed improvement in the PA skills targeted in the study which indicates that children with DS can benefit from a PA based approach to literacy.
Language play and phonological awareness in Down’s syndrome. The term language play involves the practice in PA areas of language under playful circumstances. Language play can be initiated in the contexts of games, finger plays, songs, nursery rhymes, poems, stories that contain rhyme, alliteration, and repeating language patterns. Literate environments that support language play also support the development of phonemic awareness (Hall & Moats, 1999). Compared to typically developed children, the conditions of the acquisition of PA through language play are different for children with Down’s syndrome because of their impaired language skills. Black et al. (2008a) describes the relationship as follows: “The ability to segment words into their phonemes is one of the basic skills needed for literacy. Not being able to speak has a negative effect on literacy learning: it limits the opportunity to ‘play’ with sound which impacts on the acquisition of coding and decoding skills; and it limits the development of novel vocabulary which in turn affects the receptive environment necessary for literary learning”.

1.4. The PhonicStick

1.4.1. Speaking phonics

The PhonicStick is a speech sound generating joystick, developed within an ongoing project called “Speaking Phonics” at the School of Computing, University of Dundee, in Scotland, which specializes in Assistive and Healthcare Technologies, Computational systems Interactive systems design and Space technology. The main aim of the project is to develop ways to enable language play and the experience of the use of sound, with the long term goal of supporting phonological awareness and phoneme based literacy learning, for children with Complex Communication Needs, (CCN) (Black et al., 2008b).

1.4.2. Speech generating devices

A speech generating device (SGD) is a type of Augmentative and Alternative Communication (AAC), which can be used in supporting literacy learning and PA in children with CCN. Most existing SGDs are either literacy based or use picture/icon interfaces to access text-to-speech output. This makes generating phonemes and ‘playing’ with sounds impossible without literacy or visual encoding skills (Black et al. 2008a). The PhonicStick is a prototype SGD that provides direct pre-literacy access to
spoken phonemes, and language play, without having to navigate a visual interface, (Black et. al., 2008b).

The PhonicStick provides access to letter sounds (a selection of phonemes) used in the literacy programme Jolly Phonics. By moving the joystick in its eight different compass directions, the user can collect phonemes which the joystick then blends together, generating real words or non-words by the push of a button (Black et. al., 2008b). Auditory feedback for the selected phoneme is also given throughout the collecting process. The button can also be used to repeat the phoneme or blended phonemes generated so far in the collecting process. The idea of a joystick as an access tool for speech output is the observation that children with CCN can have difficulties navigating visual SGD interfaces using a joystick but are able to navigate their motorized wheelchairs using a joystick (Black et. al., 2008a).

A pilot study was conducted at the University of Dundee, testing the underlying concept of the PhonicStick, where seven children between 6;7 and 15;1 years of age, were introduced to the PhonicStick. Three children were from an integrated primary school and four from a special school. Five of the children had some degree of physical and/or learning disability. The results showed that all seven participants, with and without learning disabilities, could remember the six phonemes mapped onto joystick movements and were able to use them to generate three-phoneme novel words without visual mapping of the locations of the sounds. One of the children, who had Down’s syndrome, even used the PhonicStick as an augmentative aid to clarify her dysarthric speech when asked to identify a phoneme (Black et al. 2008a). The phoneme games used in the pilot study were inspired by the memory game “Simon says”. However, only the phonemes corresponding to the first six phonics of the Jolly Phonics programme were evaluated and all phonemes of the full set of English phonics, i.e. 42 phonics, would require considerably more memorising effort and has not yet been tested (Black et al. 2008b).
1.5. Aim

Phonological awareness is thus an area of great concern to the acquisition of literacy in children with Down’s syndrome, and of particular concern due to its importance to high level analytical literacy. Delays in literacy acquisition calls for ways to enhance PA training for children with DS as it has been shown that phoneme based approach to literacy is beneficial for them. The aim of the present study is to investigate if the PhonicStick can be used to initiate interest in language play in children with DS to further stimulate their ability to identify and manipulate phonemes in words. Progress in PA is not expected due to the short time frame of the study, but testing of the ability will take place to make sure not to rule out the possibility of such progress.

This study is based on the presumption that the PhonicStick can be used for language play and thus also be used in order to stimulate PA in children with DS because of its many language related advantages. By using hand gestures to directly access phonemes in the collecting process, The PhonicStick appeals to the visual processing ability which is often of strength to children with DS. Previously presented problems related to auditory short-term memory are facilitated through access to auditory feedback at any time during language play. Since the auditory processing skills are targeted through the auditory channel of output in the PhonicStick, there is also a possibility that these abilities are strengthened through the process of using the PhonicStick in language play.

Questions that this study aims to answer regard the capability of physically and technically manoeuvring the PhonicStick as well as how well it can be used in PA specific tasks. How well the PhonicStick can capture the interest and motivation of the participants is also of interest in the evaluation of the device. The main question of this study is therefore: Can the PhonicStick be used for the purpose of enabling language play for children with DS? The sub targets of this study are:

1) Are the participants able to remember and generate all six phonemes of the PhonicStick without visual mapping?

2) Can the participants, without given target words, use the PhonicStick in order to generate random three - phoneme real words or non-words on their own?
3) Can the participants produce given target real words or non-words using the PhonicStick?

4) Can the participant use the PhonicStick in phoneme substitution tasks?

5) Can the interest and/or enthusiasm of the participants be captured through language play using the PhonicStick?
2. Method

2.1. Participants

Six children with Down’s syndrome, participant A-F, between five and 15 years of age, five girls and one boy, were recruited through the Dundee Speech and Language Therapy Service in Dundee, Scotland. The criteria for inclusion were: diagnosis for Down’s syndrome, current enrolment within the educational system, sufficient physical ability to control a joystick, normal or corrected hearing and ability to assent and to follow instructions.

Four of the participants were enrolled in mainstream schools in the Dundee area, integrated in classes of typically developed peers, and two of the participants were enrolled in a special education needs school. There was no inclusion criteria made concerning literacy level which varied between participants from pre-literacy to emerging literacy. Cognitive development level also varied but was not assessed. Neither vision nor speech production was considered in this study as none of the tasks require these abilities. All participants were English speaking. There was no control group.

2.2. Materials

2.2.1. Phonological awareness test

The Preschool and Primary Inventory of Phonological Awareness (PIPA), The Psychological Corporation, was used to assess the nature and extent of the participant’s PA skills. PIPA was designed for children from the ages of three to seven years and consists of six subtests evaluating the ability to isolate and manipulate alliteration, rhymes, syllable segmentation, letter knowledge, phoneme isolation and segmentation. The whole assessment battery is designed to take 30 minutes to administer. In the present study only the latter two subtests were used, those of phoneme isolation and segmentation. The two subtests were used because they target the two components of PA skills, best related to the purpose of the study. Both subtests were designed for children from four years of age, or older. Each subtest contained a total of twelve target words for the participant to isolate or segment the sounds within. One repetition given
by the researcher was allowed per word in both subtests and four consecutive errors from the participant were allowed before terminating each subtest.

The Phoneme Isolation subtest, of PIPA, assesses phoneme isolation skills in initial position of target words. An example of task instructions is; “Here is a picture of a dog. The first sound of dog is /d/. Let’s try some others. Tell me the first sound of apple”. A booklet with stimulate pictures of each target word is used. Scoring: 1 = correct initial sound produced; 0 = incorrect initial sound produced; NR = no response produced.

The Phoneme Segmentation subtest, of PIPA, assesses phoneme segmentation skills on target words of up to five phonemes. An example of task instructions is; “I’m going to say pig with counters, /p/…/i/…/g/. This time you’re going to do it without the pictures”. Any type of visual counter, for example a button or a piece of paper, is placed in a row on the table in the same number as the number of phonemes in the target word. A booklet with stimulating pictures is used during task instructions but not during tasks. Scoring: 1 = all phonemes segmented correctly; 0 = inadequate number of or incorrect phonemes segmented; NR = no response.

2.2.2. The PhonicStick

The PhonicStick is made out of a computer joystick, by label Logitech, Attack™ 3 Joystick. The actual stick is replaced by a wooden ball to make it easier to handle. The PhonicStick prototype can generate up to three-phoneme words or non-words and is currently programmed with the six phonemes of the first stage of the Jolly Phonics literacy programme (Black et al., 2008a). The first six phonemes, /a/, /i/, /n/, /p/, /s/ and /t/, are appropriate because of the large number of small words that can be generated from this group, e.g. [pin], [tip], [pat], [nat] (Lloyd, 1998). The phonemes are accessed using a method based on an existing stylus text input system (Perlin, 1998). The final version of the PhonicStick is meant to contain the full set of 42 phonics of the Jolly Phonics literacy programme (Black et al., 2008b).

During the process of collecting phonemes, auditory feedback is given automatically for every selected phoneme. A phoneme is selected by moving the joystick back into centre position (Black et al., 2008a). For example, when pushing the joystick to the west position and back to the centre again, the PhonicStick will give the auditory feedback in the form of the phoneme /s/. When pushing the joystick to a position where no phoneme
is placed, auditory feedback is given in the form of a “boink” sound. Further /a/ is in the north position, /t/ is in the south position, /i/ is in the north-west position, /p/ is in the south position followed by an anti-clockwise movement along the circumference to the south-east position and finally /n/ is in the east position (Black et al., 2008b).

2.2.3. Other materials

Other materials used in the study were, a picture schedule with pictures of activities during sessions, forms for demographic data of the participants, evaluation forms of the participants literacy skills, one for before the study and one for after the study and protocols with specific guidelines for each sessions one to six. Further equipment used to video record sessions consisted of a laptop, two speaker units, a video camera, and a tripod.

2.3. Procedure

The study was conducted by two fourth year speech and language therapy students under supervision of the Department of Assistive and Healthcare Technologies in the School of Computing at the University of Dundee. The study consisted of six study sessions; two test sessions and four intervention sessions. The sessions were conducted according to specific study session protocols under game-like formats. A session was terminated when all tasks according to session protocol were completed. No session was longer than 20 minutes to maximize motivation, attention and concentration of the participants. For the same reason, positive feedback was given for effort rather than right answers and help was provided in case of no reply or wrong answers. However,
points were only given for correct answers generated without help in evaluations during intervention sessions.

The study was designed so that all six sessions took place within two weeks. If a session was missed for any reason, the next session would take place as soon as possible and information about this was noted in the report. If additional sessions were needed, a maximum of two replacement sessions would be arranged to make sure that each participant was given equal possibility to contribute to the study.

The sessions took place in a school/learning or home environment during or after school hours. The hours used were decided in consultation with head teachers and teachers of the schools and the parents/guardians. The time range between sessions varied, with a maximum of five days. The sessions were recorded on video to facilitate study analysis.

The sessions were as follows:

- Session one. Introduction and familiarization between the researcher and the participant. Phonological awareness test. Short presentation of the PhonicStick without specific instructions (appendix 1).

- Session two. Introduction of the PhonicStick with specific instructions of phoneme placements. Testing of the ability to remember phoneme placements from introduction. Repetition of phoneme placements in the form of a game inspired by the memory game “Simon says”. Evaluation of motor ability to manoeuvre the PhonicStick (appendix 2).

- Session three. Testing of the ability to remember phoneme placements from previous session, followed by repetition and practice if needed. Practice and evaluation of the ability to randomly blend phonemes into real words or non-words using the six phonemes of the PhonicStick. Practice and evaluation of the ability to generate given target words, using the PhonicStick (appendix 3).

- Session four and five. Testing of the ability to remember phoneme placements from previous session followed by repetition and practice if needed. Practice and evaluation of the ability to randomly blend phonemes into real words or non-
words using the six phonemes of the PhonicStick. Practice and evaluation of the ability to generate given target words, using the PhonicStick. Practice and evaluation of the ability to use the PhonicStick in phoneme substitution tasks (appendix 4).

- Session 6 (appendix 5). Phonological awareness test.

Based on the researchers’ observations during session two, the motor ability to manoeuvre the PhonicStick was evaluated on a scale of one to five. One, being difficult and five, being easy to manoeuvre. Remembrance of phoneme placements was evaluated by tasks inspired by the memory game “Simon says” or by the researchers giving the question “where is...” for example “/a/?” The ability to remember phoneme placements was tested during sessions two, three, four and five. When evaluating the ability to produce random three-phoneme combinations into real words or non-words, difference was kept between answers given with help and those given without help from the researchers. The ability to randomly blend phonemes into real words or non-words using the PhonicStick was practiced and evaluated during sessions three, four and five.

Two tasks were chosen to evaluate the usability the PhonicStick to practice phonological awareness specific skills; target word production and phoneme substitution. Target word production includes phoneme isolation and segmentation as well as synthesizing skills, which would demand the ability to detain the target word in mind. This task was chosen since both phoneme isolation and segmentation skills are also measured in the phonological awareness test of sessions one and six. Target word production was assessed by verbally giving the participant a target real word or non-word to generate, using the PhonicStick. Both real words and non-words were used as target words to minimize the risk of participants being familiar with them previous to the study. The ability to generate target words was practiced and evaluated during sessions three, four and five.

The phoneme substitution task was chosen because it includes many phonological awareness specific skills. In comparison to target word production it demands a higher ability to actively hold the target word in mind while also substituting initial, centre or final phonemes through phoneme deletion and addition. Performance in these types of tasks might give information about other features of the PhonicStick, such as constant
auditory feedback and phoneme complementary gestures as they might facilitate keeping information active in the short-term memory (Annerén et al., 1996). Phoneme substitution tasks were conducted as verbally giving the participants a target word and asking them to substitute initial, centre or final phoneme, thus making a new word. The ability to perform phoneme substitution skills was practiced and evaluated during sessions four and five.

2.4. Procedure Adjustments

Days between sessions varied from zero up to five days because of the restricted time schedule of the researchers. Due to the school holiday that coincided with study schedule, Participant C had nine days between session five and six and Participant E had 14 days between session three and four. For the same reasons, Participant F only attended two out of six sessions.

The PIPA assessments of sessions one and six were adjusted to the situation due to the researcher’s opinion of the participant’s ability to perform according to original test instructions. The same tests were used with all participants, disregarding the upper age limit of seven years. The phoneme isolation subtest instruction; “What is the first sound of dog?” was replaced with; “what does dog start with”? to avoid the confusion with the sound a dog makes, i.e. “woof” (see table 2). Counters were excluded from the Phoneme Segmentation subtest in order to avoid visual stimuli since the usability of the PhonicStick is evaluated alone, without visual stimuli. The order of the target words in the Phoneme Segmentation subtest was also adjusted, in such way that if a target word proved to be too difficult for the participant to segment, a word with fewer phonemes was chosen next by the researcher. Researchers provided help in case of no reply or wrong answer in both subtests. A subtest was terminated after more than four consecutive errors, or less depending on the interest and motivation of the participant.

The order of tasks according to session protocol for the intervention sessions, session two to five, was also sometimes changed to the situation depending on the interest and motivation of the participants. Sessions were terminated when all tasks according to session protocol were completed or earlier in case of participant’s lack of interest or ability to continue, but never exceeded the maximum of 20 minutes.
2.5. **Data analysis**

This study has been analyzed using predominantly observational and exploratory methods. It is a multiple case study where results have been summarized in three tables and discussed from a qualitative perspective. Both researchers filled in the session protocols independently to enable an inter-rater judgment. The session protocols of the two researchers were then compared. The only difference detected, concerned the level of motor ability in Participant C due to her preference to use both hands manoeuvring the PhonicStick. After reviewing the video recordings the researchers’ observations conformed.

2.6. **Ethical aspects**

Before taking part in the study, each participant, their parent/guardian (appendix 6) and school (appendix 7) was given written information about the study in general. The study was approved by The Tayside Committee on Medical Research Ethics Service of the NHS, Scotland. Parents/guardians gave informed consent (appendix 8) and the participants gave informed assent (appendix 9). Separate video release forms were signed by parents/guardians. Study release forms were signed by the head teachers of the three schools. In case of withdrawal from the study, all data prior to withdrawal would only be retained with consent from the parent/guardian and used in the study if appropriate. If not, this data would be excluded from the study analysis. To make sure of anonymity, personal records (name, address, telephone number, age, gender and school year) were only available to the research team during the study and was not kept together with the results or video recordings or presented in the report. All electronic data was collected and stored on the experiment laptop and then transferred electronically to the university computer with password security, only accessible to supervisor A.W. After the study is completed, participants and their parents/guardians will be informed of the outcome of the study. All data will be kept in a secure cabinet at the School of Computing, University of Dundee, Scotland, which can only be accessed by supervisor A.W. Planned storage of collected data is five years.
Ethical aspects were taken under consideration because of the risk of participants feeling stress or inadequacy during sessions due to not understanding or failing the tasks; or to the situation in general, keeping in mind that phonological awareness is known to be problematic for children with Down’s syndrome. To minimize these risks both testing and intervention sessions were kept as playful as possible with focus on giving positive feedback for effort rather than right answers, all in consensus with academic supervisor, A.W.
3. Results and Discussion

3.1. Collected data

Demographic data concerning participants’ age, gender and specifics of diagnosis gathered from the participants’ parents/guardians, results of the phonological awareness tests as well as data concerning PhonicStick related tasks is presented in table 1.

3.1.1. Motor ability to manoeuvre the PhonicStick

Participant A, D and F had good ability to manoeuvre the PhonicStick. The ability of Participant C and E were estimated to a four/five on the scale of motor ability, while Participant B was estimated to a three.

3.1.2. PIPA results

Participant A scored a notably higher result in the Phoneme Isolation than in the Phoneme Segmentation subtest. He showed a notably lower result in the second Phoneme Isolation subtest in comparison to the first and a somewhat lower result in the second Phoneme Segmentation subtest. Participant B showed ability in the second Phonological Isolation subtest but not in the first or in any of the Phoneme Segmentations subtests. Participant C scored a notably higher result in the Phoneme Isolation than in the Phoneme Segmentation subtest. She showed a slightly lower result in both subtests during second testing. Participant D scored a notably higher result in the Phoneme Isolation than in the Phoneme Segmentation subtest. She showed an increase in phoneme isolation ability but a slight decrease in phoneme segmentation ability from first to second testing. Participant E could not perform phoneme isolations in the first testing session but showed a notably high result in the second. She could not perform in any of the Phoneme Segmentation subtests. PIPA was not proceeded beyond trial tasks in either subtests for Participant F.

3.1.3. Remembrance of phoneme placements

All five participants who completed all six sessions, Participant A-E, showed an increasing learning ability of phoneme placements. By session five, three out of five participants, Participant A, C and D, were able to remember all six phoneme placements from the previous session, without repetition. Participant A remembered them all,
already from session three and participant D from session four (see table 1). Participant B generated all six phonemes during the third session after various amount of repetition. Participant E generated all six phonemes during the fifth session after only one repetition, (see table 2).

3.1.4. **Three phoneme combinations**

All five participants who completed all six sessions, Participant A-E, could generate random three-phoneme combinations into real words and non-words with verbal instructions from the researcher. Participant A, C and D, were also able to generate random three-phoneme combinations into real words and non-words without help from the researcher.

3.1.5. **Target word production**

Participants A and C could produce both target real words and non-words using the PhonicStick. Participant D could produce target real words but not non-words. All three participants made progress in producing target words in the following sessions. Participant B and E did not show ability to produce target words.

3.1.6. **Phoneme substitution tasks**

Only participants A, C and D, showed substitution skills on phonemes in initial positions. None of the participants could perform substitutions on phonemes in centre or final positions during the study, (see table 1).
Table 1. Demographic data, results of phonological awareness test and PhonicStick related tasks, of six children with Down’s syndrome: A-F:

Demographic results: age: years:months; gender: male (M)/female (F); motor ability to manoeuvre PhonicStick; scale 1-5 (good ability), Phonological awareness test, PIPA results from session 1 and 6: Phoneme Isolation subtest (PI) and Phoneme Segmentation subtest (PS): score/total score and (target words given), Results from PhonicStick sessions 2 to 5: remembrance of phoneme placements: remembered placements/total nr; ability to generate three phoneme combinations with help: Yes (having ability) or No (having no ability); ability to generate three phoneme combinations without help: Yes (having ability) or No (having no ability); target non-words and target real words: target words produced/target words given; Phoneme substitution tasks: Initial, Centre and/or Final production ability.

<table>
<thead>
<tr>
<th>Participant</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>7:2</td>
<td>6:2</td>
<td>15:3</td>
<td>13:11</td>
<td>5:3</td>
<td>6:3</td>
</tr>
<tr>
<td>Gender</td>
<td>M</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Mosaic Down’s Syndrome</td>
<td>Down’s Syndrome</td>
<td>Down’s Syndrome</td>
<td>Down’s Syndrome</td>
<td>Down’s Syndrome</td>
<td>Down’s Syndrome</td>
</tr>
<tr>
<td>Motor ability to manoeuvre PhonicStick</td>
<td>5/5</td>
<td>3/5</td>
<td>4/5</td>
<td>5/5</td>
<td>4/5</td>
<td>5/5</td>
</tr>
<tr>
<td>PIPA Result :</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PI</td>
<td>1. 9/12 (12)</td>
<td>1. 0/12 (2)</td>
<td>1. 11/12 (12)</td>
<td>1. 7/12 (12)</td>
<td>1. 0/12 (0)</td>
<td>1. 0/12 (0)</td>
</tr>
<tr>
<td>PS</td>
<td>1. 2/12 (6)</td>
<td>1. 0/12 (0)</td>
<td>1. 1/12 (5)</td>
<td>1. 1/12 (4)</td>
<td>1. 0/12 (0)</td>
<td>1. 0/12 (0)</td>
</tr>
<tr>
<td>PI</td>
<td>6. 4/12 (12)</td>
<td>6. 3/12 (12)</td>
<td>6. 10/12 (12)</td>
<td>6. 11/12 (12)</td>
<td>6. 11/12 (12)</td>
<td>6. 11/12 (12)</td>
</tr>
<tr>
<td>PS</td>
<td>6. 1/12 (3)</td>
<td>6. 0/12 (2)</td>
<td>6. 0/12 (2)</td>
<td>6. 0/12 (2)</td>
<td>6. 0/12 (2)</td>
<td>6. 0/12 (2)</td>
</tr>
<tr>
<td>Remembrance of phoneme placements</td>
<td>2.* 3/6</td>
<td>2.* 3/6</td>
<td>2.* 2/6</td>
<td>2.* 4/6</td>
<td>2.* 3/6</td>
<td>2.* -</td>
</tr>
<tr>
<td>Target non-word production</td>
<td>3. 1/2</td>
<td>3. 0/2</td>
<td>3. 1/2</td>
<td>3. 0/2</td>
<td>3. 0/2</td>
<td>3. 0/2</td>
</tr>
<tr>
<td>Target real word production</td>
<td>3. 2/3</td>
<td>3. 0/3</td>
<td>3. 2/3</td>
<td>3. 1/3</td>
<td>3. 0/3</td>
<td>3. 0/3</td>
</tr>
<tr>
<td>4. 3/3</td>
<td>4. 0/3</td>
<td>4. 1/3</td>
<td>4. 0/3</td>
<td>4. 0/3</td>
<td>4. 0/3</td>
<td></td>
</tr>
<tr>
<td>5. 3/3</td>
<td>5. 0/3</td>
<td>5. 2/3</td>
<td>5. 2/3</td>
<td>5. 2/3</td>
<td>5. 2/3</td>
<td></td>
</tr>
</tbody>
</table>

1-6: Session 1-6, *: Testing remembrance from introduction of phoneme placements within same session.
3.1.7. *The PhonicStick interest and motivation*

Observations of interest, gathered from video recordings, concerning for example development, general behaviour and attitude of the participants throughout the study is presented in table 2. All the participants who completed all six sessions, Participant A-E, showed interest and enthusiasm when working with the PhonicStick. They all seemed motivated and could all follow instructions during intervention sessions.

Participant A often showed enthusiasm by laughing and smiling and applauding himself for good effort. He only lost focus on occasion and wanted to complete session tasks. He played “Simon says” on own initiative several times during sessions and even made up his own, not previously presented, target real words and non-words using the six phonemes before generating them. He tended to prefer making real words but showed increasing interest in generating non-words throughout sessions. He didn’t want to stop playing with the PhonicStick at the end of intervention sessions and even asked to play with it during second test session, i.e. session six.

Participant B especially enjoyed generating random three-phoneme combinations into words and pushed the button frequently for auditory feedback. Despite low concentration span her interest and motivation could be captured by variation of tasks, variation of targets within tasks and short and direct instructions and feedback. She was anxious to take back the PhonicStick during researcher’s demonstrations and asked for the PhonicStick during second test session, i.e. session six.

Participant C never lost focus during sessions. She showed motivation during all sessions and always tried to complete tasks. She preferred making real words but also giggled and smiled when randomly blending phonemes into non-words. She wanted to keep making words after completing session protocol and wanted to generate words beyond three phonemes.

Participant D never lost focus during sessions. She showed motivation during all sessions and always tried to complete tasks. She smiled and laughed throughout sessions and though playing with the PhonicStick was “great fun”. She wanted to try again until right answer was generated. She found it especially amusing when
generating “silly” non-words. She wanted to play with the PhonicStick and generated 23 words after second test session, i.e. session six.

Participant E often showed enthusiasm by smiling and laughing throughout sessions. She kept focus during sessions and tried to complete all tasks. She pushed the button for auditory feedback repeatedly. Generated /s/ using the PhonicStick rather than giving a verbal answer and rehearses /p/, on own initiative, which she referred to as the “tricky one”. She wanted to keep playing with the PhonicStick after session protocol was finished and didn’t want to leave sessions.

Although the PhonicStick only occasionally captured the interest of Participant F during her two sessions, she seemed to enjoy interacting with the researchers in general and did not want to leave sessions.

Participants A, B, E and F showed lack of interest and/or concentration at some point during the study. Participant B had difficulties maintaining interest and focus during intervention sessions with the PhonicStick. Alterations in study procedures were necessary in order to recapture and maintain interest. Participant A and C needed encouragement to produce non-words. Participant F showed very little interest in the PhonicStick and session protocols were not completed, (see table 2).
Table 2. Study observations during sessions one to six of six children with Down’s syndrome: A-F.

<table>
<thead>
<tr>
<th>Session</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
<td>Spells and reads. No video to analyze.</td>
<td>Lacks in interest and concentration during testing. During PI subtest: “What’s the first sound of ‘dog’?” Participant answers by barking like a dog. Talks about other things that usually can be related to pictures just seen in PI subtest. Test not proceeded beyond trial tasks in PS subtest. Imitates phonemes generated on PhonicStick, verbally. Follows instructions such as: “push it this way”.</td>
<td>Focused during whole session. Seems motivated. Always tries to complete tasks. Follows instructions well. Smiles at positive feedback from researcher. Very shy and whispers the answers during the PIPA test. Imitates researcher or say the whole word during PS subtest. Is able to segment the word “shoe” during PS subtest.</td>
<td>Follows instructions well and seems motivated and keeps focus during whole session. Spells occasionally during testing. Imitates researcher if not sure about answer. Is able to segment /i/, /g/ of “pig” as well as the word “car” during PS subtest.</td>
<td>No response to instruction in beginning of session. PIPA not proceeded beyond trial tasks in either subtests. Shows determination regarding chair choice. Uses PhonicStick to generate 1st phoneme of “Sara”, on own initiative. Seems to enjoy playing with PhonicStick.</td>
<td>PIPA not proceeded beyond trial tasks in either subtests. Doesn’t follow instructions. Doesn’t imitate researcher.</td>
</tr>
<tr>
<td>Session 2</td>
<td>Laughs, smiles and applauds. Lacks in concentration occasionally: twists and turns on chair but always tries to do what the researcher asks. Plays “Simon says” without researcher. Doesn’t want to stop playing with PhonicStick.</td>
<td>Is able to generate all phonemes with verbal instruction from researcher. Imitates phonemes of PhonicStick verbally. Doesn’t always wait for instructions. Difficulties maintaining concentration. Pushes and pulls PhonicStick around. Seems to concentrate better during “Simon says” if the instructions are short. Quote: “I’ll do it” when researcher is about to show something on PhonicStick. Pushes button frequently, resulting in a 3-phoneme non-word at one point.</td>
<td>Focused during whole session. Seems motivated. Always tries to complete tasks. Follows instructions well. Smiles at positive feedback from researcher. After ten minutes, start using both hands to manoeuvre PhonicStick.</td>
<td>Focused during whole session. Seems motivated and follows instructions well. Smiles and laughs. Generates a 3-phoneme non-word but needs encouragement to push button. Is able to generate a few target words with some verbal help from researcher. Is able to generate first phoneme of “Sara” with PhonicStick and wants to continue with the rest of the constituent phonemes but can only generate /a/ since the PhonicStick doesn’t contain /r/.</td>
<td>Follows instructions well. Keeps focus during whole session. Tries to complete all tasks. Smiles and laughs. Generates /s/ for “Sara” and 1st phoneme of own name. Pushes button quite frequently, repeating phonemes and this results in 2- as well as 3-phoneme words. Refers to /p/ and /i/ as “the tricky ones”. Sometimes replies verbally or with PhonicStick when asked what phoneme was just generated with PhonicStick.</td>
<td>Session protocol not completed. Imitates researchers displaying phoneme placement. Doesn’t follow instructions. PhonicStick only managed to capture the interest during few and short periods of time. Seem to enjoy interacting with the researchers in general and, for example, did not want to leave sessions</td>
</tr>
<tr>
<td>Session 3</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
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<tr>
<td><strong>Laughs, smiles and applauds.</strong> Listens to the researcher and tries to complete the session tasks. Repeats target words on own initiative. Tend to make more real than non-words. After some encouragement from researcher, makes own non-words. Plays with PhonicStick without researcher. Quote: “How about pap?” then generates [pap] on PhonicStick. Loses focus for a while but it’s rather easy for researcher to recapture the attention again.</td>
<td>Follows instructions well in beginning of session. Generates 5/6 phonemes after 2 repetitions, on 1st or 2nd try. Pulls pushes and jerks PhonicStick around when losing concentration. Generates 3-phoneme words when researcher is helping by counting number of phonemes and encourages pushing button. Can generate all six phonemes before session is completed.</td>
<td>Focused during whole session. Seems motivated. Always tries to complete tasks. Follows instructions well. Generates mostly real words. Wants to make words beyond 3 phonemes. Giggles and smiles when blending random phonemes into words. Starts over if “boink”. Seem to prefer generating real words.</td>
<td>Focused during whole session. Seems motivated and follows instructions well. Generates the 6th phoneme on 2nd try. Generates 1st and last phonemes of 3/5 of the target words. Smiles and laughs. Quote: “Wanna try again”.</td>
<td>Follows instructions. Tries to perform all tasks. Easy to recapture participant’s attention when concentration sometimes lacks. Researcher terminates target task after 1st target word. Won’t let go of PhonicStick when researcher asks if she may have a go. Rehearses generating /p/ on own initiative. Generates 3-phoneme words with help from researcher i.e. counting phonemes or encourages pushing button. Smiles and laughs while doing this.</td>
<td>Follows instructions. Tries to perform all tasks. Easy to recapture participant’s attention when concentration sometimes lacks. Researcher terminates target task after 1st target word.</td>
<td>Follows instructions. Tries to perform all tasks. Easy to recapture participant’s attention when concentration sometimes lacks. Researcher terminates target task after 1st target word.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Session 4</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laughs, smiles and applauds. Lacks in concentration occasionally and starts repeating a word by pushing button several times. Easy for researcher to recapture the participant’s attention. Starts generating 3-phoneme words during phoneme substitution task. Tends to prefer real words.</td>
<td>Wants to make [san] together with researcher. Generates /s/ alone. Generates the word again, alone, afterwards but needs encouragement to push the button. Researchers have to recapture participant’s interest frequently by changing tasks or targets within tasks. Perform tasks after a couple of tries with help from researcher.</td>
<td>Follows instructions well. Generates 3 phoneme non-word but needs encouragement to push button. Although, generates target words without help. Sometimes forgets middle position in 3-phoneme words. Giggles and smiles when blending phonemes into words.</td>
<td>Followed during whole session. Seems positive during target word task. Smiles at positive feedback from researchers. Sometimes explain verbally where a certain phoneme is located before generating it. Right phonemes in wrong order in a few words. Notice when the order of phonemes in “ant” gets mixed up: [atn] “that sounds weird”, generates [an] after researcher encourages trying again. Quote: “this is great fun.”</td>
<td>Follows instructions. Tries to perform all tasks. Easy to recapture participant’s attention when concentration sometimes lacks. Doesn’t take own initiative to generate words without targets hence only target words were used during session. Smiles and laughs when generating words with researcher. Is mostly able to generate 1st and sometimes last phonemes of target words.</td>
<td>Follows instructions. Tries to perform all tasks. Easy to recapture participant’s attention when concentration sometimes lacks. Researcher terminates target task after 1st target word.</td>
<td>Follows instructions. Tries to perform all tasks. Easy to recapture participant’s attention when concentration sometimes lacks.</td>
</tr>
</tbody>
</table>

<p>| 35 |</p>
<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Session 5</strong></td>
<td>Laughs, smiles and applauds. Loses focus during phoneme substitution task and rather make 3-phoneme words. Takes the lead of the “Simon says” game and plays without researcher. Generates [sin] which haven’t been generated before.</td>
<td>Enjoys playing with phonemes and makes a 2-phoneme non-word, although needs encouragement to push button. Generates 3-phoneme words when researcher is counting number of phonemes and encouraging pushing button. Difficulties maintaining concentration.</td>
<td>Focused during whole session. Seems motivated. Always tries to complete tasks. Follows instructions well. Wants to make words beyond 3 phonemes. Generates /i/ /a/ /i/ /a/ at 2 different occasions during session. Giggles and smiles when blending phonemes into words.</td>
<td>Focused during whole session. Seems motivated and follows instructions well. Generates 1st and last phonemes of the 3rd target word. Laughs when generating non-words. Quote: “I wanna make the funny one”.</td>
<td>Seems less focused than during earlier sessions. Looks around the room and pushes button frequently. Although tries to perform on every task. Is able to generate /p/ without help for the first time. Is able to generate all six phonemes after only one repetition. Needs encouragement to push the button after collecting 3 phonemes. Generates initial phonemes of almost all target words.</td>
<td></td>
</tr>
<tr>
<td><strong>Session 6</strong></td>
<td>Spells a lot during PIPA. Doesn’t seem interested in PIPA. Lack of concentration. Twists and turns on chair. Puts hands on ears and says random sounds. Imitates researcher during PS subtest. Leans back in chair and sounds out /n/ /a/ /p/: Rather play with PhonicStick than do the PIPA test. Quote: “joystick joystick joystick!”</td>
<td>Wants to play with the PhonicStick and remembers 3/6 phoneme placements.</td>
<td>Focused during whole session. Seems motivated. Always tries to complete tasks. Follows instructions well. Smiles at positive feedback from researcher. Very shy and whispers the answers during the PIPA test. Could make the first sound of “chair” in the PI subtest during session 1 but not during session 6. Researcher doesn’t try the word “car” during PS subtest. Decide to end testing before. Enjoy putting phonemes together into words. Quote: “as, like in Asda”. Generates 23 words after completing session protocol.</td>
<td>Focused during whole session. Seems motivated and follows instructions well. Spells occasionally during testing. Researcher doesn’t try the word “car” during PS subtest. Decide to end testing before. Plays with PhonicStick after PIPA test. Enjoy pushing button to repeat words.</td>
<td>Focused during whole session. Follows instructions. Easy to recapture participant’s attention when concentration sometimes lacks. Both subtests of PIPA are attempted. Imitates researcher during PS subtest. Says the initial phoneme of “car” and “eat” as well as the last phoneme of “mum” in PS subtest. Plays with PhonicStick after PIPA test. Enjoy pushing button to repeat words.</td>
<td></td>
</tr>
</tbody>
</table>
3.1.8. **Literacy evaluations**

Evaluations of the literacy levels pre and post study, as well as any, noticed general attitudes of the participants was gathered from respective teacher and is presented in table 3.

Pre study levels of literacy varied amongst participants. Participant A had “good word attack skills” and could make “initial blends”. Participant B had “reasonable initial sound knowledge”. Participant C was “able to read simple text”, had some level of comprehension and had “difficulties spelling”. Participant D was in the “early stages of level A (pre)”. Participant E could “repeat known words” and knew fifteen phonic sounds. Participant F knew “the sounds and actions for all the initial sounds”, could not “yet blend them” and recognised “some core words”. The teacher of Participant A and B documented both participants’ positive attitude towards the PhonicStick sessions in the “Teacher evaluation form”; Participant A had “enjoyed his time doing phonicstick”. Participant B had “really enjoyed her time with the research team” and was “eager to go and always says she’s worked hard”. None of the teacher evaluations showed results of progress in literacy within study time frame (see table 3).
Table 3. Teachers evaluation of literacy pre- and post study of six children with Down’s syndrome: A-F

<table>
<thead>
<tr>
<th>Participant</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years: months</td>
<td>7:2</td>
<td>6:2</td>
<td>15:3</td>
<td>13:11</td>
<td>5:3</td>
<td>6:3</td>
</tr>
<tr>
<td>Enrolment in integrated or special school</td>
<td>Integrated</td>
<td>Integrated</td>
<td>Special</td>
<td>Special</td>
<td>Integrated</td>
<td>Integrated</td>
</tr>
<tr>
<td>Literacy level pre study</td>
<td>“Good word attack skills. Particularly c-v-c words → initial blends. Making progress.”</td>
<td>“Reasonable initial sound knowledge. Needs large amount of repetition, consolidation. Making slow but steady progress.”</td>
<td>“Able to read simple text Wellington Square level 2 and to complete comprehension sheets. Spelling – has difficulty, does not hear the sounds correctly. Communication – can be difficult to understand, does not form sounds correctly and tends to mumble.”</td>
<td>“Early stages of level A (pre).”</td>
<td>“Can repeat known words, good vocab, understands simple instructions. Knows a few phonic sounds.”</td>
<td>“... knows the sounds and actions for all the initial sounds. She cannot yet blend them. She recognises some core words from her reading scheme.”</td>
</tr>
<tr>
<td>Literacy level post study</td>
<td>No entry</td>
<td>No entry</td>
<td>“Haven’t noticed any difference – not so good anyway when just got back from the holidays.”</td>
<td>No entry</td>
<td>“As of fri 23rd X recognises these sounds: s, a, t, i, p, n, c, k, e, r, m, d, g, o, u.”</td>
<td>All sessions not completed.</td>
</tr>
<tr>
<td>Other info post study</td>
<td>“X has enjoyed his time doing PhonicStick. He particularly likes spending time on computer.”</td>
<td>“X has really enjoyed her time with the research team. She’s eager to go and always says she’s worked hard.”</td>
<td>“Think it would have been better if it hadn’t been before the holiday’s.”</td>
<td>No entry</td>
<td>“X had phonic input everyday following Jolly Phonics programme. It is difficult to ascertain what impact the PhonicStick study had. “</td>
<td>All sessions not completed.</td>
</tr>
</tbody>
</table>
3.2. **Concluding Discussion**

3.2.1. *Progress in phonological awareness*

Progress in Phonological awareness was not expected in any of the participants within the short time frame of the present study. A possible reason for notable progress in the Phoneme Isolation subtest of PIPA in participants B, D and E, could be improvement of PA skills due to exposure to and practice of PA specific tasks with the PhonicStick, (see table 1). Exposure to this type of task is a possible reason especially to the big gap in performance, from no ability to very good ability, between first and second Phoneme Isolation subtest in participant E. A potential learning effect from first PA testing to the second can not be excluded. However, researchers’ growing ability to adapt to the participants in the situation and the positive effect of familiarization between participants and researchers during the process of the study, are other likely reasons for shown progress.

Possible reasons for slightly lower results, in both subtests of second PA testing (see table 1), could very likely have been lack of concentration, interest or motivation in the testing situation (see table 2), partly since by session six, the researchers and sessions were associated with getting to play with the PhonicStick. This is also a very possible reason for the notably lower result of the second Phoneme Isolation subtest for Participant A, (see table 1).

Possible reasons for the big difference of performance between the two subtests could be difficulties in understanding the instructions of the Phoneme segmentation subtest. Phoneme segmentation includes isolating every phoneme of a word, in initial, centre and final positions, at the same time and thus requires a high level of abstract thinking, which according to Annerén et. al. (1996) is low in children with Down’s syndrome. The exclusion of visual counters, which would have lowered the demand of abstract thinking and clarified instructions, could have been a reason to difficulties of understanding the tasks of the Phoneme Segmentation subtest for participants A, C, D and E, (see table 1).
3.2.2. The PhonicStick and phoneme generation

In general, the researchers did not apprehend the motor ability to manoeuvre the PhonicStick to be of great problem to any of the participants, (see table 1). All participants A-E were able to remember all phoneme placements and generate all phonemes of the PhonicStick without visual mapping at one time or another during sessions. Some phoneme placements proved to be more difficult than others to access, in particular /i/ and /p/, but all participants learned all placements after various amount of repetition (see table 1 and 2). Table 1 only displays remembrance from previous session without repetition which is why the ability of Participant B and E is not shown in these test results. The increasing learning ability of phoneme placements in Participant A-E and the fact that they could also generate random three-phoneme real words or non-words, (see table 1), show that the PhonicStick can be used to introduce and practice blending phonemes into words. Notable is that Participant A-E could all remember phoneme placements despite of limited capacity to the phonological short-term memory system related to Down’s syndrome (Boudreau, 2002). This could very likely reflect the positive effect of the complementary gesture of each phoneme, in the sense that it requires a hand movement to be accessed.

3.2.3. The PhonicStick and phonological awareness specific tasks

Target word, production as well as phoneme substitution, demands both phoneme isolation and phoneme segmentation skills. The participants who showed target word and phoneme substitution skills during intervention sessions with the PhonicStick, Participant A, C and D, also showed phoneme isolation skill and some phoneme segmentation skill in the phonological awareness test. The two participants who could not produce target words or phoneme substitutions during sessions, Participant B and E, showed phoneme isolation skill but no phoneme segmentation skill in the PA test, (see table 1). Certain level of segmentation skill is thus crucial to the ability to produce target words and perform phoneme substitutions with the PhonicStick. Isolation skills only, are not sufficient to manage these types of tasks.
Perhaps the most interesting result of the present study is that Participant A, C and D, scored higher in the target word production tasks which, as described, demand segmentation skills, than in the Phoneme Segmentation subtest of PIPA (see table 1). This indicates that these participants manage some phonological awareness specific tasks easier with the PhonicStick than without. These types of tasks demand the ability to actively detain the target word in mind while manipulating its constituent phonemes, which presumably requires certain levels of both abstraction ability and phonological short-term memory skill. These tasks are therefore likely to cause problem for children with Down’s syndrome (Annerén et al., 1996). The results might thus even suggest that some form of support is needed for this population in order for their full capacity to show in these types of tasks.

A possible reason for phonological awareness specific tasks being easier to perform with the PhonicStick than without, is the fact that the PhonicStick can give auditory feedback after any number of phonemes selected. This is likely to compensate the problems that demands of high levels of abstraction ability and phonological short-term memory might bring to children with Down’s syndrome. Participant B and E frequently pushes the button for auditory feedback during intervention sessions. Participant D sometimes produced the right phonemes in the wrong order in the target word tasks. When auditory feedback from the PhonicStick differed from the target word, the participant tried a new combination of the same phonemes until they conformed (see table 2), which further exemplifies the auditory feedback as an advantage of the PhonicStick.

The PhonicStick feature of phoneme complementary gestures might also facilitate keeping information active in the phonological short-term memory and compensate abstraction difficulties. Research shows that gesture production is a strength in children with DS relative to other language abilities including receptive skills (Abrahamsen et al., 1985; Chan & Iacono, 2001). Gestures have further been shown to compensate the perceptual language deficiencies associated with DS which make it difficult to focus attention and maintain concentration, by targeting visual perception rather than auditory (Annerén et al., 1996). Gesture use enhances impressions by utilizing both visual perception skills as well as motor abilities. Presumptions can also be made that the motorical pattern of the sound sequence of a whole word, generated with the
PhonicStick, might ultimately be acquired and learned as one single movement, not unlike letter sequences and spelling patterns in the orthographic stage of reading acquisition (Catts & Kamhi, 1999). If so, this could also reduce the strain on phonological memory but would require further research to be determined.

The fact that the participants can perform phoneme segmentations in target word tasks with the PhonicStick easier than in phoneme segmentation tasks in PIPA (see table 1), might also be a confirmation of the suggestion that children with DS might be able use some phonological awareness skills subconsciously but are not able to access those abilities metalinguistically in PA tests (Cossu et al., 1993).

Possible explanations to the great difference between target word production and phoneme substitution tasks (see table 1) might have been the much higher level of complexity in the phoneme substitution task. A task with lower level of complexity would have been for example a task evaluating just deletion or addition of phonemes and thus a more suitable task for practising phonological awareness skills in this study. Another suggestion is lack of understanding the instructions, again demanding a high level of abstraction, which could have been facilitated by the use of some type of counters.

Participant E spontaneously generated initial sounds of names on two occasions, using the phonemes of the PhonicStick, during both session one and two (see table 2). Together, this and the progress shown in phoneme isolation tests by participants B, D and E (see table 1) indicates that the PhonicStick can with advantage also be used to enhance phoneme isolation skills.

The progress in target word production, which includes phoneme segmentation, in participants A, C and D, (see table 1), indicates that the PhonicStick can be used to enhance phoneme segmentation skills. Since the PhonicStick can be used to enhance both phoneme isolation and segmentation skills, crucial to phoneme substitutions and can give auditory feedback after any number of phonemes during the collecting process, it can also be suitable in order to enhance phoneme substitution skills.
3.2.4. How much fun is the PhonicStick?

All participants who completed all six sessions, Participant A-E, seemed to enjoy working with the PhonicStick. In addition to that they all seemed motivated and could follow instructions, Participant A and E also used the PhonicStick in activities beyond those initiated by the researchers during intervention sessions. All participants A-E, wanted to play with the PhonicStick also after all tasks were completed, or even not included, according to session protocol, i.e. during session six. Although concentration may have lacked occasionally during sessions, the researchers found it rather easy to recapture the attention of the participants by changing task or target within a task. The high requirement of constant variation with Participant B was probably related to her short concentration span, (see table 2). Possible factors to the lack of interest in the PhonicStick shown by Participant F could have been concentration difficulties, difficulties in understanding the instructions of the tasks or simply lack of interest in the actual device. However, Participant F seemed to enjoy interacting with the researchers in general and, for example, did not want to leave sessions, (see table 2). The researchers cannot rule out the possibility that some of the participants enjoyed working with the PhonicStick due to other, for them, positive elements in the session situation, such as positive attention and praise, the novelty of the situation etc. Since the goal of the study was to capture the participants’ interest and motivation in language play using the PhonicStick, all adjustments made to the procedure has mainly had a positive effect on the study results.

3.2.5. Progress in literacy

The variations in literacy levels as well as the variations of teachers’ literacy evaluations, (see table 3), make it difficult to compare literacy levels between participants. Factors to this could be that expectations in the participants varied in relation to level of literacy in class peers and age of the participant and therefore also influenced by type of school they are enrolled in. However, to this study any progress in literacy acquisition was of main importance. The lack of shown progress according to literacy evaluation, (see table 3), was expected due to the short time frame of the study. Although the teacher of Participant C noted that school holiday might have been a reason to the lack of progress in literacy during study, (see table 3), the researchers did not detect any such influence to the results, (see table 3).
Notable is that the children who had the highest levels of literacy skills according to teacher evaluations, (see table 3), Participant A and C according to the researchers interpretation of the evaluations, also showed phonological awareness in both subtests of PIPA, as well as target word and phoneme substitution skills. This supports the assumption that an association exists between literacy and phonological awareness (Rose, 2006; Morais et al., 1979; Adams, 1990; Bryant & Goswami, 1987; Lyon, 1999; Lundberg et al., 1980; Lundberg, 2006). Participant D however, showed a higher level of phonological awareness, (see table 1), than could be expected from her described literacy level. On the other hand, the occurring preference of spelling instead of sounding in both phonological awareness tests, (see table 3), indicates a higher level of literacy than is described for this participant. The participants who could not produce target words using the PhonicStick, were also the youngest, (see table 1), and had not yet learned all the phonics, or reached the level of blending, according to the Jolly Phonics literacy programme, (see table 3). This further indicates the relationship between literacy and phonological awareness.

It is also notable that the two participants who had the highest level of literacy, Participant A and C, (see table 3), showed some hesitance to randomly play with phonemes with the PhonicStick and generally rather made real words than non-words during language play (see table 2). They also had a higher score in real word production than in non-word production in target word tasks (see table 1). This might indicate that children who have reached a certain level of literacy might need more encouragement in the initiation of random phoneme play.

3.3. Conclusion

This study suggests that the PhonicStick, with advantage, can be used to blend phonemes into words and to introduce and enhance phonological awareness skills, such as phoneme isolation, segmentation and substitution, in children with Down’s syndrome. Results show that an increase in phonological awareness is possible even during a short time of practise with the PhonicStick. Some phonological awareness specific tasks are even shown to be more easily performed with the PhonicStick, than
without. The participants of the study showed interest and enthusiasm during exercises with the PhonicStick which also makes it a suitable device for enabling language play.

Since children with Down’s syndrome benefit from a phonological awareness based approach to literacy, practising phonological awareness skills through language play with the PhonicStick might also have a future positive effect on their literacy acquisition. The features of phoneme complementary hand gestures and constant auditory feedback make the PhonicStick suitable to this particular population due to the auditory processing problems related to Down’s syndrome, i.e. limitations to their phonological short-term memory system.

The adjustments made during sessions influenced the results in a positive direction. It could be that, initially, children need a certain amount of adjustments for the PhonicStick to be entertaining. In general, adjustments in regard to specific situation, literacy level, user age and personality etc. might also be needed for all future users in order for the advantages of the PhonicStick to be accessible in best possible way.

### 3.4. Limitations

A longer study might have shown progress not only in the Phoneme Isolation subtest but also in the Phoneme Segmentation subtest of the phonological awareness test, due to working with the PhonicStick.

To be able to minimize the problem of differentiating between participants not being able to understand the task and lack of actual ability, visually aided instructions might have been beneficial, especially in segmentation and substitution tasks. Maybe the participants also would have reached higher results in the Phoneme Segmentation subtest of PIPA if counters had been used.
4. Reference List


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Appendix 1

Session 1

Approximate duration of the session: 20 minutes.

Material: the PhonicStick, computer with software, assent form, phonological awareness test, recording apparatus (2 speaker units, a video camera and a tripod), picture-schedule (paper, book, joystick).

Introduction and familiarization between the researcher and the participant.

Reading the assent form out loud to the participants to make sure they have an opportunity to understand the nature of the study.

Pre-test phonological awareness.

Short presentation of the PhonicStick
Appendix 2

Session 2

<table>
<thead>
<tr>
<th>Name</th>
<th></th>
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<tbody>
<tr>
<td>Date</td>
<td></td>
</tr>
</tbody>
</table>

**Material:** the PhonicStick, computer with software, recording apparatus (2 speaker units, a video camera and a tripod), picture-schedule (joystick, game).

**Introduction:**

“This is a PhonicStick. With the PhonicStick you can make different sounds”.

*When the right sound is achieved, the child will be asked to repeat it. The researcher will proceed to the next sound when it has been repeated two times. The researcher will help the child at any time by guiding him/her the movements of the PhonicStick.*

Try to pull the joystick **towards you.** What do you hear?

“Yes it's a /t/!” Again please. And again!” /

“Try again! What do you hear?”

Now try to pull the joystick **to the side.** What do you hear?

“Yes it's a s/n! Again please. And again!” /

“Try again! What do you hear?”

Try to pull the joystick **to the other side?** What do you hear?

“Yes it's a s/n! Again please. And again!” /

“Try again, what do you hear?”

Try to pull the joystick **up,** what do you hear?

“Yes it's an /a/! Again please. And again!” /

“Try again, what do you hear?”

Now, try to pull the joystick **up left,** what do you hear?

“Yes it’s an /i/! Again please. And again!” /

“Try again, what do you hear?”

Now try to pull the joystick **up right?** What do you hear?

“When you hear that sound, “boink” it means that there is no sound in that spot.”
Try to pull the joystick **towards you and then to the right side**, what do you hear?

“Yes it's a /p/! Again please. And again!” /

“Try again! What do you hear?”

**Part 1**

“Do you remember where the sounds were?”

<table>
<thead>
<tr>
<th>“Where's /s/?”</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Where's /i/?”</td>
</tr>
<tr>
<td>“Where's /u/?”</td>
</tr>
<tr>
<td>“Where's /p/?”</td>
</tr>
<tr>
<td>“Where's /n/?”</td>
</tr>
<tr>
<td>“Where's /a/?”</td>
</tr>
</tbody>
</table>

**Part 2**

*If the child doesn’t remember the placement of the sound, the researcher will help by pointing or directing them to the right location on the PhonicStick, and give equal amount of positive feedback for producing the sound with or without help. The game will then go on until the child has remembered six sounds in a row on their own or for a maximum of five minutes. This is not a test of the rules of the game, but a game to help the child remember the locations of the sounds of the PhonicStick. If the game is too difficult, the researcher will proceed by starting each sentence with “Simon says” and give positive feedback for every try.*

“Do you know the game ‘Simon says’? It goes like this; when I say “Simon says: /t/”, I want you to make a /t/ on the PhonicStick. If I say “Simon says: /a/”, you make an /a/ on the PhonicStick. Can you do that? Here comes the tricky part; If I don’t start with “Simon says” then you don’t make the sound. Have you got any questions? Let’s try it”.

“Simon says /t/ -- /t/
Simon says /a/ -- /a/
/n/ --- good job! I didn’t say Simon says/ Oops I didn’t say Simon says. Let’s try again.
Simon Says’:

| /t/ | /i/ | /p/ | /n/ | /s/ |
|     |     |     |     |     |
| /a/ | /p/ | /n/ | /s/ | /t/* |
| /i/ | /t/ | /i/* | /u/ | /n/ |
| /n/ | /n/ | /a/ | /i/ | /i/* |
| /p/ | /a/* | /s/ | /p/* | /p/ |
| /s/* | /s/ | /t/* | /a/ | /a/ |

| /t/ | /i/ | /p/ | /n/ | /s/ |
|     |     |     |     |     |
| /a/ | /p/* | /n/ | /s/ | /t/ |
| /i/* | /t/ | /i/ | /u/ | /n/* |
| /n/ | /n/ | /a/ | /i/* | /i/ |
| /p/ | /a/* | /s/* | /p/ | /p/ |
| /s/ | /s/ | /t/ | /a/ | /a/ |

| /t/ | /i/ | /p/ | /n/* | /s/ |
|     |     |     |     |     |
| /a/ | /p/* | /n/ | /s/ | /t/ |
| /i/* | /t/ | /i/ | /u/ | /n/ |
| /n/ | /n/ | /a/* | /i/ | /i/ |
| /p/ | /a/ | /s/ | /p/ | /p/ |
| /s/* | /s/ | /t/ | /a/ | /a/ |

Observation of how difficult the joystick is to maneuver: 1 2 3 4 5

Other information:
Appendix 3

Session 3

<table>
<thead>
<tr>
<th>Name</th>
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<tr>
<td>Date</td>
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</tr>
</tbody>
</table>

**Material:** the PhonicStick, computer with software, recording apparatus (2 speaker units, a video camera and a tripod), picture-schedule (joystick, words).

**Part 1**

*The researcher will only help the child after noting if the child remembers the placements of the sounds of the PhonicStick.*

“Do you remember where the sounds were?”

| “Where's /s/?” |          |
|                |          |
| “Where's /i/?” |          |
| “Where's /t/?” |          |
| “Where's /p/?” |          |
| “Where's /n/?” |          |
| “Where's /a/?” |          |

**Part 2**

“There are real words, that mean something and then there are fake words that don’t mean anything in English. ‘Tip’ is that a real word? Yes it is. ‘Nis’, is that a real word? It kind of sounds like one, but it’s not. It doesn’t mean anything. In this next game, you get points for both real words and fake words, because sometimes they’re funnier. Make three sounds in a row, let’s see what happens. The only rule is that you can’t make the same sound twice”.
Part 3
“Do you think we can make the word ‘tin’ together? What does it start with? /t/. Which sound comes last? /n/. (the researcher will help as much as needed).
Now can we try the word ‘sit’?
Now can we try the word ‘nap’?”

<table>
<thead>
<tr>
<th>Word</th>
<th>Correct/incorrect</th>
<th>With/without help</th>
</tr>
</thead>
<tbody>
<tr>
<td>sit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pan</td>
<td></td>
<td></td>
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<tr>
<td>tis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nat</td>
<td></td>
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</table>

Other information:
Appendix 4

Session 4 and 5

<table>
<thead>
<tr>
<th>Name</th>
<th></th>
</tr>
</thead>
<tbody>
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**Material:** the PhonicStick, computer with software, recording apparatus (2 speaker units, a video camera and a tripod), picture-schedule (joystick, words).

**Part 1**

“Do you remember where the sounds were?”

| “Where's /s/?” |   |   |   |
| “Where's /i/?” |   |   |   |
| “Where's /t/?” |   |   |   |
| “Where's /p/?” |   |   |   |
| “Where's /n/?” |   |   |   |
| “Where's /a/?” |   |   |   |

**Part 2**

“Now do you remember any of the words we made together?” (from session 3)

|   |   |   |   |
|   |   |   |   |
|   |   |   |   |

**Part 3**

“Have you thought of any new words since last time?”

|   |   |   |
|   |   |   |
|   |   |   |
Part 4

“Can you make the word ‘tan’? What happens if you change the /t/, in the beginning, for another sound, for example /p/? Oh, that’s a whole other word! Just by changing the first sound! And it rhymes! ‘tan’, ‘pan’.

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Other information:

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Appendix 5

Session 6

Approximate duration of the session: 20 minutes.

Material: the PhonicStick, computer with software, recording apparatus (2 speaker units, a video camera and a tripod), phonological awareness test, picture-schedule, (book, joystick).

Post-test phonological awareness. Testing to see if there is any understanding for words and their constituent sounds already at this stage.
Appendix 6

Information Sheet

The PhonicStick Study

We would like to invite your child to take part in our research study. Before you decide, we would like you to understand why the research is being done and what it would involve for your child. Your child’s speech and language therapist, or one of our team, will go through the information sheet with you and answer any questions you have.

What is the PhonicStick?

The PhonicStick study is a part of an ongoing project called “Speaking Phonics” at the School of Computing, University of Dundee. The “Speaking Phonics” project is investigating ways in which children with speech impairments can use technology to play with sounds and words.

Being able to play with sounds and to hear which sounds make up a word is referred to as phonological awareness. We know that phonological awareness is an important factor in learning to read and write. We also know that children with speech impairments often have poor phonological awareness and often have difficulty with literacy.

In an attempt to tackle this problem, the Speaking Phonics team has built a talking joystick, called the PhonicStick. By moving the joystick in different directions, the user can collect sounds and blend them into spoken words. For example, collecting /c/, /a/, /t/ would generate the spoken word, “cat”.

60
Although the PhonicStick only has six phonics (the first stage of a phonic literacy programme used in schools), a pilot study has shown that children with unintelligible speech can use the PhonicStick to produce these sounds accurately. They can also generate short spoken words. Because the device uses phonics, users do not have to be literate in order to produce spoken words, but can play with sounds and hear what words these sounds make.

**What is the aim of the PhonicStick Study?**

This study is being undertaken by two final year speech and language therapy students, Ms Sara Lindberg-Wesslert and Ms Erika Lempke, as their final year project. (Our contact details, and those of our supervisor, are at the end of this information sheet.)

We want to see whether children with Down’s syndrome can use the PhonicStick to create spoken words. Although the study will not yet be able to prove whether the PhonicStick will help in literacy learning, we need to know if more children can use the device to create words. This will help the engineers to develop the device further. We also want to see whether there might be a change in children’s phonological awareness, even over a short period.

**Why has my child been invited to take part in the study?**

Research shows that children with Down's syndrome are more likely to have reading difficulties because of their reduced ability to play with sound. Even though your child may be progressing well in learning to read, your child’s speech and language therapist believes that your child would be able to use the joystick and would be able to help us evaluate the device.

**Does my child have to take part in the study?**

It is up to you to decide to join the study. We will describe the study and go through this information sheet with you. If you agree that your child can take part, we will then ask you to sign a consent form. We will also ask your child to agree (assent) to taking part in the study. You and your child will be given copies of these forms to keep.
What happens if I wish to withdraw my child from the study?

You are free to withdraw your child at any time, without giving a reason. Your child is also free to withdraw at any time without giving a reason. If your child does not want to take part, we will inform you, the teacher and therapist. Withdrawal from the study would not affect the standard of care or education you or your child receives.

What will my child have to do?

Your child will be seen six times over a period of three weeks. Each session will be approximately 20 and no longer than 40 minutes and will take place during school or at a time which is convenient for you.

Your child will be introduced to the PhonicStick and will be asked to locate the six phonics and to use these sounds to generate words and non-words within a game scenario. For example, she/he may be asked to play a bingo-like game with the researcher to build up words on a card. We will be evaluating how easy/difficult your child finds the PhonicStick to use. In addition, your child’s ability to segment words she/he hears into phonemes will be monitored to evaluate whether or not there is any difference in phonological awareness over the study. This will involve giving your child a short phonological test during the first and last sessions. The researcher will make the sessions as fun as possible so that your child will enjoy the experience.

All sessions will be video-taped to allow the researchers to analyse the data afterwards. The aim of this research is not to ‘test’ your child but to help us to see whether there is potential for the PhonicStick to support phonological awareness for children with Down’s Syndrome.

What are the possible disadvantages and risks of taking part?

Because your child may have difficulty in phonological awareness, she/he may feel stressed during sessions. Mild physical impairments in some children may also make the control of the joystick difficult. To minimise these risks we will ensure that both testing and training sessions are as playful as possible with a focus on giving positive
feedback for effort rather than correct answers. Should your child become tired or unsettled, the session will be stopped. The timing and location of sessions will be discussed in consultation with you, the school and the therapist to avoid any negative impact on your child’s schooling and ongoing speech and language therapy. We do not envisage any other medical, physical or psychological risks in this study.

**What are the possible benefits of taking part?**

In our experience, children enjoy using new technology. They also feel empowered by taking part in research when they realize that they are helping to develop new technology. We cannot promise that the study will help your child, but your child’s involvement will help us to understand how the PhonicStick can be used to support phonological awareness and literacy.

**What happens at the end of the study?**

The analysis of the data will be completed by January 2010. The results of this study will be published in academic journals and presented at academic conferences and will contribute to the ongoing research project to develop the PhonicStick. You, your child’s teacher and therapist will be told of any strategies that seemed to work with your child, as this information may be helpful in her/his ongoing education.

**What if there is a problem?**

If you have a concern about any aspect of this study, you should ask to speak to the academic supervisor, Dr Annalu Waller, who will do her best to answer your questions [ph. 01382 388223]. If you remain unhappy and wish to complain formally, you can do this by speaking to your child’s teacher, their speech and language therapist or the manager of the speech and language therapy service, Morag Dorwood [ph. 01382 346550].
Will my child’s information be kept confidential?

Yes. We will follow ethical and legal practice and all information about your child will be handled in confidence. To ensure anonymity, personal records will only be available to the research team for the duration of the study and will not be kept together with the results and video recordings or be presented in the report. If your child’s data is used for publications or presentations, no reference to her/his identity will be made. If the child’s data is used for publications or presentations, no reference to her/his identity will be made. If any video is data is suitable for presentation or teaching purposes, we will discuss this with you. If you are happy for us to use the material for these purposes, we will ask you to sign separate video release forms.

Who has reviewed this study?

All research in the NHS is looked at by independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by the Tayside Research Ethics Committee.

Who can I contact in connection with this research?

The researchers undertaking the study are:

Ms Sara Lindberg-Wesslert – email: Sara.Lindberg-wesslert.1394@student.uu.se and
Ms Erika Lempke – email: Erika.Lempke.1242@student.uu.se

If you would like to know more about this research and/ or you have questions that cannot be answered by the researchers, please feel free to contact their Academic Supervisor:

Dr. Annalu Waller
Senior Lecturer
School of Computing
University of Dundee
Dundee DD1 4HN.
Phone: at (01382) 388223
Email: awaller@computing.dundee.ac.uk.
Appendix 7

Information Sheet

The PhonicStick Study

We would like to invite one of your pupils to take part in our research study. This information sheet explains the nature of the study. If you have any questions please ask the researchers (contact details at end) or the child’s speech and language therapist.

What is the PhonicStick?

The PhonicStick study is a part of an ongoing project called “Speaking Phonics” at the School of Computing, University of Dundee. The “Speaking Phonics” project is investigating ways in which children with speech impairments can use technology to play with sounds and words.

We know that phonological awareness is an important factor in learning to read and write. We also know that children with speech impairments often have poor phonological awareness and often have difficulty with literacy.

In an attempt to tackle this problem, the Speaking Phonics team has built a talking joystick, called the PhonicStick. By moving the joystick in different directions, the user can collect sounds and blend them into spoken words. For example, collecting /c/, /a/, /t/ would generate the spoken word, “cat”.

Although the PhonicStick only has six phonics (the first stage of the Jolly Phonics literacy programme), a pilot study has shown that children with unintelligible speech can use the PhonicStick to produce these sounds accurately. They can also generate short spoken words. Because the device uses phonics, users do not have to be literate in order to produce spoken words, but can play with sounds and hear what words these sounds make.
What is the aim of the PhonicStick Study?

This study is being undertaken by two final year speech and language therapy students, Ms Sara Lindberg-Wesslert and Ms Erika Lempke, as their final year project. (Our contact details, and those of our supervisor, are at the end of this information sheet.)

We want to see whether children with Down’s syndrome can use the PhonicStick to create spoken words. Although the study will not yet be able to prove whether the PhonicStick will help in literacy learning, we need to know if more children can use the device to create words. This will help the engineers to develop the device further. We also want to see whether there might be a change in children’s phonological awareness, even over a short period.

Why have the children been invited to take part in the study?

Research shows that children with Down's syndrome are more likely to have reading difficulties because of their reduced ability to play with sound. Even though the children may be progressing well in learning to read, the children’s speech and language therapist believes that the children would be able to use the joystick and would be able to help us evaluate the device.

Do the children have to take part in the study?

It is up to the parents/guardians to decide to join the study. We will describe the study and go through this information sheet with them. If they agree that their children can take part, we will then ask them to sign a consent form. We will also ask the children to agree (assent) to taking part in the study. They will be given copies of these forms to keep.
What happens if parents/guardians wish to withdraw their children from the study?

Parents/guardians are free to withdraw their children at any time, without giving a reason. The child is also free to withdraw at any time without giving a reason. If the child does not want to take part, we will inform the parent/guardian, teacher and therapist. Withdrawal from the study would not affect the standard of care or education the child receives.

What does the child have to do?

Each child will be seen six times over a period of three weeks. Each session will be no longer than 40 minutes and will take place during school or at a time decided upon in collaboration between parents, therapists and the school.

The child will be introduced to the PhonicStick and will be asked to locate the six phonics and to use these sounds to generate words and non-words within a game scenario. For example, she/he may be asked to play a “Simon-says” game with the researcher. We will be evaluating how easy/difficult your child finds the PhonicStick to use. In addition, the child’s ability to segment words she/he hears into phonemes will be monitored to evaluate whether or not there is any difference in phonological awareness over the study. This will involve giving the child a short phonological test during the first and last sessions. The researcher will make the sessions as fun as possible so that the child will enjoy the experience.

All sessions will be video-taped to allow the researchers to analyse the data afterwards. The aim of this research is not to ‘test’ the child but to help us to see whether there is potential for the PhonicStick to support phonological awareness for children with Down’s Syndrome.
What are the possible disadvantages and risks of taking part?

Because the child may have difficulty in phonological awareness, she/he may feel stressed during sessions. Mild physical impairments in some children may also make the control of the joystick difficult. To minimise these risks we will ensure that both testing and training sessions are as playful as possible with a focus on giving positive feedback for effort rather than correct answers. Should the child become tired or unsettled, the session will be stopped. The timing and location of sessions will be discussed in consultation with the parent/guardian, the school and the therapist to avoid any negative impact on the child’s schooling and ongoing speech and language therapy. We do not envisage any other medical, physical or psychological risks in this study.

What are the possible benefits of taking part?

In our experience, children enjoy using new technology. They also feel empowered by taking part in research when they realize that they are helping to develop new technology. We cannot promise that the study will help individual children, but the child’s involvement will help us to understand how the PhonicStick can be used to support phonological awareness and literacy.

What happens at the end of the study?

The analysis of the data will be completed by January 2010. The results of this study will be published in academic journals and presented at academic conferences and will contribute to the ongoing research project to develop the PhonicStick. Parents, teachers and therapists will be told of any strategies that seemed to work with each child, as this information may be helpful in her/his ongoing education.
What if there is a problem?

If you have a concern about any aspect of this study, you should ask to speak to the academic supervisor, Dr Annalu Waller, who will do her best to answer your questions [ph. 01382 388223]. If you remain unhappy and wish to complain formally, you can do this by speaking to the child’s speech and language therapist or the manager of the speech and language therapy service, Morag Dorwood [ph. 01382 346550].

Will the child’s information be kept confidential?

Yes. We will follow ethical and legal practice and all information about each child will be handled in confidence. To ensure anonymity, personal records will only be available to the research team for the duration of the study and will not be kept together with the results and video recordings or be presented in the report. If the child’s data is used for publications or presentations, no reference to her/his identity will be made. If any video is suitable for presentation or teaching purposes, we will discuss this with parents/guardians and ask them to sign separate video release forms. Parents/guardians will be given the option of anonymising the participants’ faces.

Who has reviewed this study?

All research in the NHS is looked at by independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by the Tayside Research Ethics Committee.

Who can I contact in connection with this research?

The researchers undertaking the study are:

Ms Sara Lindberg-Wesslert – email: Sara.Lindberg-wesslert.1394@student.uu.se and
Ms Erika Lempke – email: Erika.Lempke.1242@student.uu.se
If you would like to know more about this research and/or you have questions that cannot be answered by the researchers, please feel free to contact their Academic Supervisor:

Dr. Annalu Waller  
Senior Lecturer  
School of Computing  
University of Dundee  
Dundee DD1 4HN.  
Phone: (01382) 388223  
Email: awaller@computing.dundee.ac.uk.
CONSENT FORM

Investigating the use of the PhonicStick to facilitate preliterate language play for children with Down’s Syndrome.

Name of Researcher:
_____________________________________________________________________

1. I confirm that I have read and understand the information sheet dated ......................
   (version ............) for the above study. I have had the opportunity to consider the
   information, ask questions and have had these answered satisfactorily.

2. I understand that my child’s participation is voluntary and that I am free to withdraw my
   child from the study at any time without giving any reason, without my or my child’s
   medical care or legal rights being affected.

3. I understand that relevant sections of my medical notes and data collected during the
   study, may be looked at by individuals from the research team, from regulatory
   authorities or from the NHS Trust, where it is relevant to my taking part in this
   research. I give permission for these individuals to have access to my records.

4. I agree to take part in the above study.
Name of Child  Name of Parent/Guardian

Relationship to Child  Signature  Date

Name of Person taking Consent  Signature  Date

When completed: 1 for participant; 1 for researcher site file.