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Brief research report

Digital game -based training of early reading skills:

Overview of the GraphoGame method in a highly transparent orthography

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Abstract

Learning to read in a language with a transparent orthography is generally quick and easy. To be able to read any words, learners need to know how to connect the smallest spoken language units, phonemes, into the written counterparts, graphemes. However, even learning the basic alphabetic principle has proven difficult for some learners. Here we focus on children who struggle to learn to read in Finnish that has a highly transparent orthography. In an attempt to provide efficient early preventative support for such learners, a technology-enhanced learning environment, GraphoGame, was developed. The GraphoGame method focuses on the specific problematic areas of each individual learner using a phonics type drilling, starting from training the letter-sound connections before introducing larger units. Here we provide an overview of the GraphoGame method together with research findings.

Keywords: digital learning game; reading support; letter knowledge; GraphoGame; dyslexia

Learning to read in Finnish

The transparent orthography of the Finnish language is extremely simple and systematic. There are only 24 phonemes in Finnish. Each phoneme is represented in all contexts it appears always with one and the same single grapheme. The grapheme-phoneme correspondence is also bidirectionally regular. There is only one exception to this rule: instead of a single grapheme the velar nasal phoneme /ŋ/ is represented by a two-letter grapheme *ng*. Thus, learning the basic alphabetic principle in Finnish is a quick and easy task. Just by knowing the letter sounds learners can read any words or pseudowords they encounter by assembling letters in the order they appear.

Those Finnish children who have difficulties in reading typically struggle at first with learning the simple grapheme-phoneme correspondences but later their difficulties are manifested mainly in reading fluency rather than accuracy. The specific difficulties in learning grapheme-phoneme correspondences have been attributed to the possible poor perceptual differentiation of acoustically similar phonemes (Lyytinen, Erskine, Kujala, Ojanen, & Richardson, 2009). If learners have difficulties in perceiving and/or categorizing the central distinguishing features of phonemes, this is likely to cause problems when trying to learn the connections between written and spoken language units (Lyytinen et al., 2009). In fact, the Jyväskylä Longitudinal Study of Dyslexia (JLD), in which the language and reading skill development of 100 children with a familial risk of dyslexia has been followed from birth onwards (see e.g. Lyytinen, Erskine, Tolvanen, & Torppa, 2006), has demonstrated that letter knowledge is the single most accurate predictor of later reading skills prior school entry. Letter knowledge has also been found to be a strong predictor of reading development in learners of non-transparent orthographies (Elbro, Borstrøm, & Petersen, 1998; Lonigan, Burgess, & Anthony, 2000). These findings have provided a foundation on which researchers

in Jyväskylä developed a digital learning environment, GraphoGame[1], specifically designed to support learning of those children who struggle with grapheme-phoneme correspondences.

Description of GraphoGame

The learning content of GraphoGame has been designed based on research findings that indicate what specific difficulties struggling learners typically have. The game starts from drilling the basic letter-sound connections providing learners a good opportunity to perceive differences in phonemes and map them into specific visual counterparts.

GraphoGame includes tasks in which the child hears a spoken letter sound and is asked to find the matching letter among the alternatives shown on the screen. On more advanced levels the game also trains correspondences between spoken and written syllables, words and pseudowords. Since the game provides hundreds of repetitions of the same correspondences learners have an opportunity to learn the connections and also become faster in connecting spoken language units to corresponding written language units, thus providing a foundation for the automatization of these connections. The tasks are embedded in various fantasy contexts (see Figure 1), which are expected to make the game more interesting to children. There are also other types of tasks, such as word-forming tasks and initial phoneme recognition tasks that support the development of child's phonological awareness skills which are known to be important for developing reading skills (e.g. Elbro et al., 1998; Lonigan et al., 2000; Lyytinen et al., 2006).

Figure 1 about here

The adaptation of the game determines what kind of content (letters, syllables or words) is included to the learning tasks on the basis of the player's responses in the previous

tasks. Because of the adaptation, the player's overall success rate in the game is typically around 80%. The adaptation tries to maintain the optimal level of challenge for each individual child, so that the child does not feel that the game is too easy, but has a chance to experience success in reading tasks that outside the game context might end in a failure.

GraphoGame is available without charge for all learners of Finnish from its online site (lukimat.fi). Currently there are four Finnish versions available for different stages of reading acquisition, from drilling letter-sound connections to enhancing reading fluency. GraphoGame versions have also been developed for children, who are learning Finnish as a second language. These versions take into account the features of Finnish language that may be difficult for children coming from a different language background. Pennala, Richardson, Ylinen, Lyytinen, and Martin (2013) have studied the effectiveness of GraphoGame version for Russian-speaking first graders. The game trains 'quantity' which means linguistic length and refers to the categorical and phonemic distinction between short and long sounds or segments. In Finnish changes in quantity may change the meaning of words, so correct representations of phonological quantity and the accurate perception of sound duration are necessary in order to spell words correctly. Phonological quantity and durational features of speech in general have been shown to be problematic for dyslexic Finnish native learners (Richardson, Leppänen, Leiwo, & Lyytinen, 2003) and are also problematic to non-native learners whose ~~1st~~first language does not have such phonological distinctions (Richardson, Thomson, Scott, & Goswami, 2004). In Pennala et al.'s study (2013) four children participated in a three-week intervention, which included daily 20-minute GraphoGame sessions at school. The results suggest that the game was able to improve children's accuracy in phonemic length perception.

GraphoGame collects data on children's responses in game tasks and playing times and stores them on an online server. These data can be used to evaluate the player's results in

the tasks, their progress in the game, and whether the adaptation techniques are working as expected. Various methods of analysis have been developed to help the researchers understand children's reading acquisition in the GraphoGame context.

Most game versions include specific 'assessment tasks' that evaluate child's current skill level for example in connecting letters to sounds, or spoken words to written words. A study by Heinola, Latvala, Heikkilä, and Lyytinen (2010) shows that the scores of the in-game assessment tasks correlate highly with the scores of traditional tasks that evaluate emergent reading skills (from r=.69 to r=.86), and that the scores of the GraphoGame assessment tasks completed in kindergarten at the age 6 predict child's risk for encountering problems in reading acquisition during the first years of school.

Short overview of GraphoGame research

In this section we will give a short overview of GraphoGame intervention studies that have been conducted concerning the effects of GraphoGame on children's basic reading skills, reading speed, and motivation in the Finnish language context.

The effects on reading skills

Saine, Lerkkanen, Ahonen, Tolvanen, and Lyytinen (2010, 2011, 2013) compared the effects of two remedial reading interventions, one including GraphoGame sessions, on the reading development of first graders with low pre-reading skills (N = 50). Both interventions consisted of four weekly sessions of 45 minutes over a period of 28 weeks. In the GraphoGame intervention children used the game during the first 15 minutes of each session, and in the remedial reading intervention the first 15 minutes were used for traditional pre-reading activities. The results suggest that GraphoGame intervention was more effective in enhancing children's letter knowledge, reading accuracy, fluency, and spelling, and the gains

were still maintained 16 months after the intervention. Hintikka, Aro, and Lyytinen (2005) also studied the effects of GraphoGame on first graders with poor pre-reading skills (N = 44), but with a shorter and less intensive intervention. Half of the children were randomly assigned to the intervention group which used GraphoGame over a 6-week period at school, for a total of 170 minutes. Training produced accelerated growth in letter naming in contrast to control group that only received regular instruction, but no difference was found in reading skills. However, the intervention was more effective than regular instruction alone in increasing the syllable and word reading skills of children who had low phonological awareness skills and attention difficulties.

Uusitalo-Malmivaara (2009) compared in her doctoral dissertation the effects of three 10-week interventions, one of which consisted of GraphoGame sessions, on the reading development of first graders with poor pre-reading skills. One of the other interventions trained early literacy by emphasizing syllabic rhythm with various exercises, and the third intervention aimed at enhancing literacy skills by shared book reading at home. The GraphoGame intervention consisted of three 15-minute sessions per week at school, but not all teachers were able to follow this schedule. However, although children's reading skills improved, the results of the intervention groups did not differ from those of the control group. In another doctoral study ~~by~~ Peltomaa (2014) investigated the effects of GraphoGame ~~were investigated~~ on first graders who had problems in reading and writing. The children (n = 36) used GraphoGame at home or at school during the fall semester of first grade at least twice a week, resulting in mean playing time of 3 hours 35 minutes. Children also received special education for two hours per week during this time. However, the results did not reveal any extra benefit from GraphoGame training. Both of these studies suggest that relatively infrequent use of GraphoGame with a low total playing time does not produce clear learning gains in children with literacy problems.

Also younger children seem to benefit from GraphoGame training. In the study of Lovio, Halttunen, Lyytinen, Näätänen, and Kujala (2012) six-year-old kindergarten children with poor pre-reading skills played either GraphoGame (n = 16) or a math game (n = 13) for a total of 3 hours over a 3-week period. The game was used either at kindergarten in the supervision of a researcher or at home in the supervision of a parent. This brief training with GraphoGame improved especially children's phonological processing skills and writing of words and non-words in comparison to math training. EEG data was also collected from 10 children in each group, and the analysis suggests that GraphoGame training might be beneficial in modulating the neural basis of phonetic discrimination.

The effectiveness of GraphoGame in enhancing children's reading speed has been investigated by Heikkilä, Aro, Närhi, Westerholm, and Ahonen (2013). They compared three different training methods to increase syllable reading speed of second and third graders (N = 150) who received special education because of problems in reading fluency. All training programs consisted of 10 GraphoGame sessions that took place at schools over a period of 2 to 3 weeks. One group trained with a blend of two-letter syllables, second with four-letter frequent syllables, and third with four-letter infrequent syllables. The fourth group was a control group that did not use GraphoGame. The training increased children's reading speed on trained syllables, and a transfer effect to word level was evident for the group which trained with four-letter infrequent syllables. No effect on the reading speed of text was found.

Children's enjoyment of GraphoGame

Children's self-reports suggest that they find playing GraphoGame enjoyable, and most of the parents and teachers also report that children are eager to play the game (Ronimus, 2012; Ronimus, Kujala, Tolvanen, & Lyytinen, 2014). According to parents and teachers children concentrate well while playing GraphoGame, and better than in traditional

learning situations (Ronimus, 2012). The study of Ronimus et al. (2014) suggests that children's concentration during gaming seems to be unaffected by specific features of the game, but a reward system that introduces new task types and increases the child's opportunities for making their own selections, seems to increase playing times children's enjoyment during the first sessions with GraphoGame and improve children's concentration during playing.

However, GraphoGame is typically used quite infrequently, especially at homes (Ronimus, 2012). It is recommended that children who struggle in reading acquisition play GraphoGame for 10-15 minutes at least once a day, preferably more often. This rarely happens if a researcher is not actively involved during the intervention and encouraging teachers and parents to follow the training schedule. Children seldom use the game on their own initiative, which makes the role of adults important in the implementation of GraphoGame training (Ronimus, 2012).

Conclusions

GraphoGame has been found to be effective in supporting children's reading acquisition in Finnish and also other languages as well as both with transparent orthographies and non-transparent orthographies (see Richardson & Lyytinen, 2014 for an overview), but the best results are typically achieved with intensive training that includes several training sessions within a week. The challenge is to motivate children and their teachers and parents to commit to regular training.
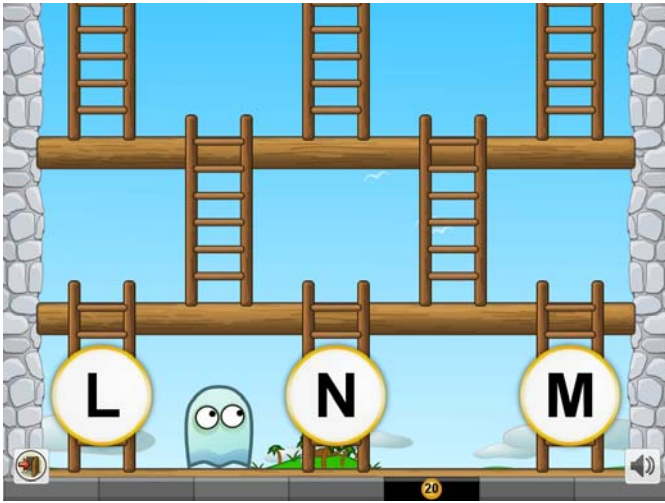
Figure 1. Here is a screenshot of one of the GraphoGame tasks. In this task the player is expected to select the letter that matches the spoken sound. The ghost climbs the ladder if the selection is correct, and falls down if the selection is incorrect.

Notes

1. GraphoGame is the registered trademark of the University of Jyväskylä and Niilo Mäki Foundation for a noncommercial computerized game aimed at learning to read (graphogame.com).

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