Investigating language acquisition in Zambia: mapping vowel confusion of *a*, *e* and *i* between English and ciNyanja

Psychology master´s Thesis

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INVESTIGATING LANGUAGE ACQUISITION IN ZAMBIA: MAPPING VOWEL CONFUSION OF *A*, *E* AND *I* BETWEEN ENGLISH AND CINYANJA

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Abstract

Recent studies conducted in Zambia indicate that majority of children fail in one of the most essential life skills, literacy. Literacy begins by understanding the connections between letters and sounds. Previous research suggests that poor readers in Zambia have difficulties in learning correct letter-sound connections for vowels *a*, *e* and *i* in their mother tongue ciNyanja due to recitation of English letter names. Previous research findings are based on samples of children chosen by their low literacy level, which could have had an effect on results. This study aims to find out whether this phenomenon can be seen in a random sample of schoolgoers (n = 145). Data was collected from literacy application GraphoGame projects which were conducted in the Lusaka primary school district. A group level cross-tabulation, individual analysis and comparison against a analogical language data sample show confusion with certain vowel combinations. Differentiation challenge seems to be derived from English naming of vowel letters, for example, when English letter *e* is name as [i:], which contains auditory domination of *i*, when *i* is pronounced in ciNyanja as [i] and *e* as [e]. Confusion was seen especially with combinations including letter *e*. Based on previous research with poorly reading children, and this current research with average schoolgoers, it seems likely that children are unable to differentiate these two alphabet codes, which are therefore perceived partially as one in Lusaka school district. The findings of this study strongly motivate taking letter-sound confusion into account in literacy teaching in the Lusaka district and prioritizing the mastery of mother tongue. Additional research is called for to further explore these problematics and enhance literacy acquisition in the Zambian region.

Keywords: vowel confusion, GraphoGame, ciNyanja, Zambia

VOWEL CONFUSION OF *A, E* AND *I* BETWEEN ENGLISH AND CINYANJA

LUKUTAIDON KEHITYKSESTÄ SAMBIASSA: VOKAALIEN *A, E* JA *I* SEKOITTUMINEN ENGLANNIN JA CINYANJAN KIELEN VÄLILLÄ

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Abstrakti

Sambiassa tehdyt tutkimukset osoittavat, että lukutaito jää saavuttamatta valtaosalta lapsista. Lukutaito alkaa kirjainten ja äänteiden välisen yhteyden ymmärtämisellä. Aiempi heikkojen lukijoiden parissa tehty tutkimus osoittaa sambialaisilla lapsilla olevan vaikeuksia vokaalien *a, e* ja *i* kirjain-äänneyhteyksien muodostamisessa englannin kielen vaikutusten vuoksi. Lukutaidon tasolla voi olla vaikutusta tutkimustuloksiin. Tämä tutkimus pyrkii selvittämään vokaalien mahdollista sekoittumista käyttämällä satunnaistettua tavallisista koululaisista koostuvaa otosta. Aineisto kerättiin Lusakan koulualueella tehdyistä lukutaitopeli GraphoGame –tutkimuksista. Ryhmätason ristiintaulukointi, yksilöllinen analyysi ja vertailu vastaavaan kieliaineistoon viittaavat vokaalien sekoittumiseen. Vokaalien erottelun vaikeus vaikuttaa johtuvan englanninkielisten kirjainten nimeämisestä, sillä esimerkiksi kirjain *e* lausutaan englanniksi [i:], kun taas ciNyanjassa *i* lausutaan [i] ja e lausutaan [e]. Erottelun vaikeus näkyi yhdistelmissä, jossa esiintyi kirjain *e*. Aiemmin tehdyn heikkoja lukijoita koskevan ja tämän nykyisen tutkimuksen perusteella vaikuttaa siltä, että Lusakan koulualueen lapset eivät kykene erottelemaan näitä kahta erilaista kielijärjestelmää, jotka ilmeisesti käsitetään osittain samana. Tutkimustulosten perusteella voidaan suositella kirjain-äänne –sekoittumisen huomiointia lukutaidon opetuksessa Lusakan alueella ja äidinkielen opetuksen merkityksen lisäämistä. Jatkotutkimusta tarvitaan vokaalien sekoittumisen syy-seuraussuhteiden kartoittamiseksi ja lukutaidon edistämiseksi Sambiassa.

Avainsanat: vokaalien sekoittuminen, GraphoGame, ciNyanja, Sambia

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1. INTRODUCTION

Literacy is considered the single best investment for enabling children to develop skills that will benefit them throughout their lives (Dickinson & Neuman, 2006). Failing in literacy acquisition increases significantly multiple developmental risks and literacy levels correlate with factors related to wellbeing (Lyytinen, Erskine, Kujala, Ojanen & Richardson, 2009). Due to these reasons effective primary education has been high on the Zambian government´s political agenda (Chileshe et al., 2007). Despite these efforts the results lag far behind when compared to other Sub-Saharan countries. The school system is not adequately serving the large majority of pupils in Zambia (Chileshe et al., 2007; Musonda, Kaba & Nakazwe, 2011) and illiteracy is high (Unicef, 2013). Inadequately trained teachers and their insufficient instruction medium knowledge hinder first graders literacy acquisition (Jere-Folotiya, 2014). Reading acquisition on a system level depends on various interrelated factors such as pedagogy, the education system, culture, students´ own interests and activities (Välijärvi et al., 2003). However, one possible and under-researched explanation for the literacy results is the vowel differentiation dynamics caused by heavy emphasis of colonial English language over native mother tongues such as ciNyanja. These language systems differ in their alphabet codes, pronunciation and letter-sound relation transparency. Transparency in language describes how much of a direct link there is between written graphemes, such as letters, and their auditory counterparts. ciNyanja is a transparent language (Ojanen, Kujala, Richardson & Lyytinen, 2013; Jere-Folotiya, 2014) unlike English, which is considered as opaque and phonetically highly complex language (McGuinness, 2004). Simultaneous exposure to two contradictory language systems can be harmful for literacy acquisition (McGuinness, 2004). Systematic vowel confusion might be one explanatory factor for poor literacy levels. Previous research suggests that in Zambia this can be seen as systematic confusion between vowels *a*, *e* and *i* because alphabet codes are in collision and children are not using local language alphabet names (Ojanen et al., 2013).

2. ENGLISH AND CINYANJA LANGUAGES IN ZAMBIA

Languages can be divided on the basis of the rules of the writing system into the categories of opaque or transparent. The transparent language has significantly fewer letter-sound combinations and is therefore easier to learn than opaque one which can have numerous letter-sound combinations (Aro, 2004). In Lusaka area, transparent ciNyanja is widely spoken mother tongue and opaque English is being used as highly common second language. Table 1 demonstrates key differences in pronunciation of a transparent ciNyanja and opaque English in phonological level (Ojanen et al., 2013).

Table 1. ***Sounds of English and ciNyanja vowels (Ojanen et al., 2013).***

Letter	English sound	ciNyanja sound
a	[ei]	[a]
e	[i:]	[e]
i	[ai]	[i]

Importance of transparency in literacy acquisition was demonstrated in a comparison study of 13 European languages, which stated that the rate of development in English is more than twice as slow as in the transparent language systems (Seymour, Aro & Erskine, 2003). Opaque languages are phonetically more challenging to learn. Therefore literacy acquisition and phonological awareness develops faster in transparent languages than in opaque ones, even without prior language exposure (McGuinness, 2004). Phonological awareness refers to the ability to recognize and manipulate phonemes (language sounds) apart from graphemes, their symbolical counterparts. Proper understanding of letter-sound connections between sounds and letters is important in acquiring literacy for the development of phonological awareness (Stahl, Duffy-Hester & Stahl, 1998). Development of phonetic awareness can be at risk if a child does not receive systematic auditory input for meaning. Often this awareness is taught as an introduction to teaching letter sounds in Zambian schools, where teachers have insufficient understanding of the instruction language (Jere-Folotiya, 2014).

2.1 English and ciNyanja in Zambian school system

The situation in Zambia offers interesting natural environment to study native language literacy acquisition alongside universal second language. English language heritage in Zambia originated from the period of British South African Company rule from 1890 to 1923, the time when adult education was predominantly run by Christian missionaries and colonial rule instituted more formal and professional control over schooling (Luchembe, 2009). British Empire ruled till 24th October in 1964, when Zambia gained independence. During the years 1966-1996 English was the language of education. In 1996 Zambian government produced a comprehensive policy statement for education, called Educating Our Future, stating that initial literacy and numeracy would be developed through a language which was familiar to children (Linehan, 2004). This policy became effective gradually. In 1999 the Primary Reading Program was implemented at each of seven primary grade levels by introducing mother tongue languages into school education and it succeeded on a larger scale (Sampa, 1999). From 2013 native languages such as ciNyanja are being taught grades 1 through 12 and English tuition begins at second grade. Native languages are only optional subjects in all levels of school leaving examinations and English is held compulsory (Examinations Council of Zambia, 2013). ciNyanja (Town Nyanja) is part of Bantu languages and it is the most common language in Lusaka. ciNyanja is one of the main languages in the Zambian educational environment (Muhau, 2005, Kachenga, 2008; Kaoma, 2008, Jere-Folotiya, 2014). One of the common Zambian languages, Bemba, is a typical mother tongue among teachers in Lusaka even though they teach ciNyanja, setting challenges for literacy acquisition (Jere-Folotiya, 2014). In the growing capital of Zambia, ciNyanja receives influence from English and many Zambian native languages. Zambia has total of 73 of local spoken languages in Zambia (Serpell, 1978) or 20 mutually unintelligible clusters of languages or 80 if one counts all the dialects (William & Cooke, 2002). Therefore ciNyanja is under constant change due to a lack of written cultural material, which creates difficulties for research and setting grammar rules (Gray, Lubasi & Bwalya, 2013). The effectiveness of school system was evaluated in Early Grade Reading Assessment in urban Lusaka and rural Eastern province areas (Collins et al., 2012). 50% of grade 2 pupils were unable to name a single letter sound in the EGRA letter naming task in a common Bemba language. According to the study teachers at the primary level had not received training in how to teach letter sounds or phonemics during their pre-service training (Collins et al., 2012). Another EGRA evaluation was conducted in 2012 in ciNyanja language in urban Lusaka and rural Eastern province areas (Sampa, in preparation). In this evaluation only 6 children in the total of 364 sample passed the limit of acceptable level (40% score) in the letter-sound test. 50% of grade 2 and 42% of grade 3 pupils were unable to name a single letter sound. In decoding tasks 88% of grade 2 and 75% of grade 3 pupils were unable to read a single unfamiliar word.

2.2 Literacy application GraphoGame

Phonemic differentiation is considered as the first and most important target for literacy acquisition which is effectively trained through the Finnish literacy application GraphoGame (Lyytinen, Erskine, Kujala, Ojanen & Richardson, 2009). It trains three overlapping levels, which are partial alphabetic stage, full-alphabetic stage, and the consolidated alphabetic stage (Saine, Lerkkanen, Ahonen, Tolvanen & Lyytinen, 2011). Levels are based upon Ehris & McCormicks (1998) earlier theory about phases of word learning. This theory supports GraphoGame methodology and it can be applied as a flexible theoretical framework in reading acquisition (Beech, 2005).

When playing GraphoGame, the child hears the sound of the target item played through a head set and then the player has to choose the right item among visual distractors. Game goes through a series of levels and gradually the child is able to construct letters into small words and then larger words (Grapholearning.info**).** GraphoGame keeps players in the zone of proximal development by adapting individually to player´s skill level (Lyytinen, Erskine, Kujala, Ojanen & Richardson, 2009). The game is generally played in 10-15 minute intervals and it has in-built motivational rewards for a child not to lose interest in repetitive practice. GraphoGame might be a method to positively affect the motivation and attitudes towards learning as it rewards players with joy from success and enhances willingness to read (Saine, Lerkkanen, Ahonen, Tolvanen & Lyytinen, 2011). GraphoGame was first tested in 2005 with eight Zambian children with poor reading skills in a intervention which contained also English GraphoGame research (Ojanen, 2007; Ojanen, Kujala, Richardson & Lyytinen, 2013). It also has a positive effect on Zambian children´s reading acquisition on individual (Ojanen et al., 2013) and group levels (Chilufya, 2008) and as a tool for teachers (Jere-Folotiya et al., 2013; Jere-Folotiya, 2014). Additionally, GraphoGame can be used as a tool to assess literacy development data. This data can be used for example to analyze success percentages and error patterns in learning process, such as confusion probabilities between vowels.

3. ARE VOWELS *A*, *E* AND *I* CONFUSED IN CINYANJA LANGUAGE?

This study aims to reveal letter-sound confusion between learning vowels *a*, *e* and *i*, which is hypothesized to act as a hindrance to literacy acquisition based on vowel confusion among pupils in Lusaka district. Based on all previous studies of the subject (Ojanen, 2007; Ojanen et al., 2013), vowels *a, e* and *i* are hypothesized to have atypical confusion probability between languages among poorly reading grade ones in Lusaka. The general differentiation performance with these vowels was significantly poorer than with other letters in average (Ojanen, 2013). Some children in Ojanen et al. (2013) study (n=63) were not able to differentiate between the most problematic phonemes even after extended practice with the literacy application Literate Game, GraphoGame´s predecessor. With Literate Game, Ojanen et al. (2013) showed that children in Lusaka district have difficulties with vowels *a, e* and *i* even though the vowels are consistent in the ciNyanja language. Literate Game had by default game content, which letters *a* and *i* to choose in the early stages of the game which could have biased the results (Ojanen, 2007). Previous findings suggest that children´s phonetic awareness development is at risk because learning environment gives inconsistent auditory input to children. Wrong answers seemed to derive from English alphabet names due to cultural colonial background and overlap of English and Zambian native language teaching (Ojanen et al, 2013). This overlap can be seen for example when letter *e* name is in ciNyanja as “e” but in English *a* in English it is [ei]. It is speculated that these auditory attributes are causing hindrances in literacy mastery with poorly reading children (Ojanen, 2007; Ojanen et al., 2013).

4. METHODS

This study used data collected from GraphoGame interventions in Lusaka School district, Zambia, 2013-2014. Data was analyzed on group and individual level.

4.1 Research method and design

GraphoGame collects data about players´ performance with letter-sound differentiation by saving playing data item into game logs. Game logs enable detailed analysis of the learning process dynamics by observing error patterns and repetitions needed for consistent learning outcomes. All game logs were first processed in SPSS 22 for averages per letter-pair combination and then cross-tabulated in Excel for group level comparison of all letters (Appendix 1). The Daisy Graph was used for individual level interpretation. Group level results were compared against a Finnish language sample (V. Rantanen, personal communication, September 2014). Cross-tabulation of letter-pairs is robust method which was chosen because it produces sufficient information between letter combinations and their confusion rates. More advanced statistical methods provided theoretically inconsistent results which is why cross-tabulation was chosen to provide clear overview of the situation.

4.2 Sample

GraphoGame interventions have been conducted in collaboration with Universities of Zambia and Jyväskylä and Centre for Promotion of Literacy in sub-Saharan Africa (CAPOLSA). CAPOLSA has provided auditory content and quality control for GraphoGame. This study used cumulatively gained data from GraphoGame ciNyanja players in the Lusaka school district. Data consisted of all players who have played GraphoGame between the years 2012 and 2014 in several randomized interventions. All interventions foundations lie on the voluntary participation of schools, rectors and teachers, children and their parents. Given the circumstances and permissions, these reading interventions can be seen ethically acceptable and unharmful for participants.

Interventions were carried out in the field by research assistants, who distributed tablets, trained teachers, and collected the data. Participants were using GraphoGame in school environment. Participants, who had less than 120min of exposure, were excluded from the sample. Exposure of 120min or more can be used for assessment purposes because at that point player has been well exposed to all phonemes. Unusual and duplicate accounts were excluded from the sample, which consisted originally of 3639 player accounts. This sample consists of 145 grade one players who had appropriate background information and who had played comparable GraphoGame versions for more than two hours in 2013-2014 in Lusaka school district, Zambia. Data has several deficits which can create bias within the sample and need to be addressed. Unknown factors are players´ language background, possible learning difficulties and playing environments´ background noise levels. Possible device malfunctions and headset use is also unknown. Children´s actual age can also vary highly from reported age since there was no supervisor present all time. According to data 101 players were five to eight years old. It is possible that children might have played under other player´s account, which can generate misleading results, or they may have used demo test player account which means that no data was saved onto server. It is also possible that some exposure time was gained by having a trial field open and players absent, which causes inaccurate exposure time measurement in the game´s inner timer. There is no reliable way to track these factors which compromise validity. The sample situation is common for GraphoGame research over distance, where data is collected in one location and analyzed in the other. All versions were played on 7-inch Android tablets in this sample. This sample was compared against a Finnish data sample, which consists of 82731 Ekapeli players who have played the game from 2007 to 2014 (V. Rantanen, personal communication, 2014). The code varies moderately between Finnish and ciNyanja game versions. The results from this data can be considered exploratory due to these limitations.

4.3 Adaptation engine

Adaptation generates tailored learning situations for players. It aims to present optimized content according to players´ learning capabilities within their proximal zone of development. GraphoGame´s adaptation engine aims to optimize player´s learning curve by adjusting adaptive difficulty gradient by regulating players´ success rate and aiming to give 80% known content and 20% items which are still to be learned. It uses cumulative data gathered from items in every single trial presented. Trial can be defined as a single game event, in which the player has the option to choose a visual representation of the given auditory target stimulus among distractors, which are false items. The features determined by the adaptation include the number of player´s choices, possible appearing speed of the items on screen, item content and difficulty level. Choosing game content from letters takes place by randomization in the beginning. After ten to fifteen minutes of playing, adaptation engine starts using last ten trial´s success percent weighted by item knowledge. The game contains both rehearse trials and assessment tasks for letters, syllables and words. For creating individually tailored trials, the adaptation engine takes into account general amount of represented items before choosing either difficult or easy trial for the player´s next trial. In easy trials target item is chosen from letters which the player has already known and distractor items vary by their level of mastery. Fast learners proceed faster from letters to words and slower learners keep rehearsing for a longer time those items which they have mastered. After player´s weighted success average achieves certain value, adaptation engine interprets that given item as mastered and proceeds to more challenging trials and content.

4.4 Analyzing tools for letter confusion

Trial field data from games which use dimension adaptation engines is generally rather difficult to interpret as the game adapts according to player´s current success percentage and making single trial contents unique. Game logs contain known and unknown items trial-wise on the server which are used for adaptation engine´s trial modeling and research. Data is updated in every trial generating more data pool for adaptation engine to generate optimized trials. In research this is done by using Daisy Graphs and a Target-Distractor Confusion -variable, both aim to describe confusion and success rates of a single item when compared to distractors. The Daisy Graph -method was developed by Janne Kujala and it batches data into a visual graph, which is used to estimate letter-sound confusion probability. It shows what is the likelihood of knowing the difference between the target item and the distractor. It is suitable for individual level analysis and for a technical reasons it always leaves some items invisible to researcher.

A new variable was developed for this study (M. Pekkarinen, personal communication, August 2014). Target-Distractor Confusion -variable uses the same data as Daisy Graph tool but it can be used to give information from all letter-sound combinations in group level. It uses four counters, which count total number of trials, correct answers, selections and visibility target and distractor wise. Target-Distractor Confusion -variable can be used to describe probability for letter wise likelihood of distractor selection. Variable takes into account those distractors which have been visible in trials but have not been chosen and is therefore more powerful tool than its predecessor, which did not count all the items and therefore the predecessor gave inconsistent results with the data. Target-Distractor Confusion -variable gives consistent results (M. Pekkarinen, personal communication, August 2014; V. Rantanen, personal communication, September 2014).

4.5 Target-Distractor Confusion –variable

Target-Distractor Confusion -variable describes confusion probability in percentages in a matrix where each letter-letter combination is represented. Letter pairs in this study are described in a way where the *italicized* target comes first and the distractor second in [brackets]. This following example represents single game trial, where a child hears sound of target item *a* through head phones and tries to choose letter *a* from among visual distractors [b] and [c]. This algorithm can be presented in a matrix, which has two values: [correct_count, total_count]. [total_count] count increases in two cases. First, if the distractor gets chosen instead of the target item, the distractor count will increase by one. Secondly, if the target is chosen correctly, then all items present in the field will have an increase of one. The [correct_count] increases only if the target item is chosen correctly.

If a player chooses distractor [b] instead of target item *a* after first trial where player has three letters visible, matrix will be updated as following:

a[a] = [0 , 0]   a[b] = [0 , 1]   a[c] = [0 , 0]

When the choice is false, [total_count] counter will increase by one distractor wise and [correct_count] counter stays the same.

If a player chooses target item in the next trial, matrix will be updated as follows:

a[a] = [1 , 1]   a[b] = [1 , 2]   a[c] = [1 , 1]

If target item is chosen it means that player has been able to differentiate it from among distractors. This increases the values of both correct and total counters by one.

Adding fourth distractor [d] when a player chooses distractor [d] over target *a* changes the matrix as follows:

a[a] = [2 , 2]   a[b] = [2 , 3]

a[c] = [2 , 2]   a[d] = [0 , 1]

Matrix grows as the child proceeds in the game and it is used to generate two kinds of values. Each letter pair has two values, one for number (n#) of appearances in trials and other for confusion probability (n|n). Based on previous matrix, number of appearances and a relation to probability is used in the following algorithm:

(correct_count/total_count) / total_count

a|a# = 2, a|a = 1 - 2/2 = 0.00

a|b# = 3, a|b = 1 - 2/3 = 0.34

a|c# = 2, a|c = 1 - 2/2 = 0.00

a|d# = 1, a|d = 1 - 0/1 = 1.00

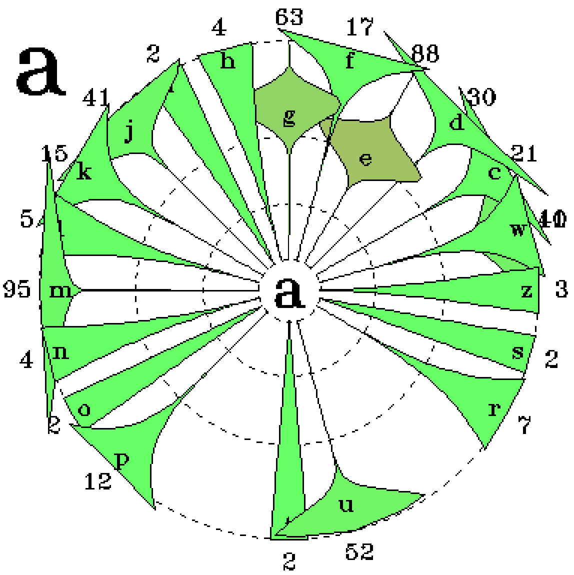
Confusion probability for target *a* to be taken as distractor [b] is 34% in this example (a-b = 34%).

5. RESULTS

5.1 Individual case analysis

Daisy Graph is an illustrative tool used to demonstrate letter pair confusion at individual level. The output of the tool is called a Daisy Graph, which describes how a player has differentiated target letters amongst distractors. The target letter is presented in the middle of the graph (see Illustration 1). In the circle farthest from the middle are the distractor letters, which have been presented in the game at the same time as the target letter has been presented (Graphogame.com). For each target – distractor -pair an estimation of successful selections is provided by calculating the mean of accurate selections. The widest part of the "petal" shows the probability of selecting correctly the target stimulus when it is presented with a particular distractor based on adaptation data. The outmost circle depicts 100 % probability, the second circle 75%, the third 50%, and the innermost circle depicts 0% probability of discriminating correctly the two items. Number at outer circle represents the amount of trials where letter has been as a distractor (Graphogame.com). It is important to notice that adaptation makes each graph unique and drawing conclusions on less than five trials is questionable. Three players with different literacy levels were chosen to showcase confusion of the target letters (*a*, *e* and *i*) of this study. These players were selected out of sample to represent vowel confusion. Target item repetition of ten trials or over was a criterion for their selection. The majority of Daisy Graphs in this sample differ significantly from this selection due to adaptation and length of exposure time. Some players in this study did not have these letter pairs at all in their trials. Illustration 1 describes an example of a player, who, according to the data, is an eight year old girl from Lusaka, whose GraphoGame exposure time is 04:25:13 and whose success rate, a percentage of correct answers out of from whole gaming time, was 69%. This Daisy Graph describes the situation at that the end of playing.

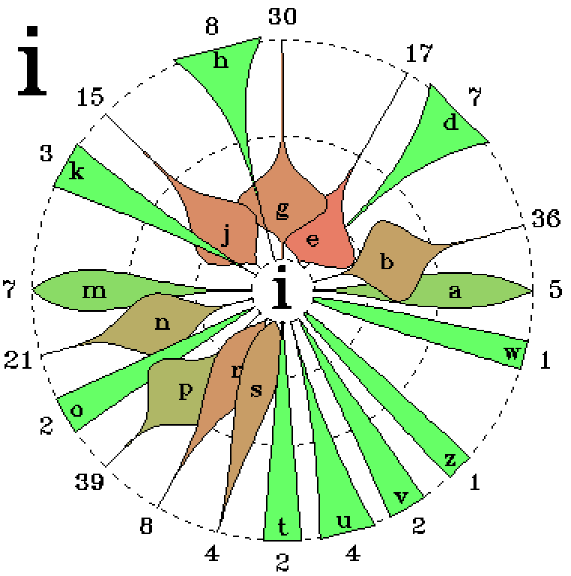
Illustration 1. Confusion of target item *a* when [e] is presented as distractor.



According to the data this player has been able to differentiate target *a* well apart from distractors, except the letter pair *a*-[e] which has success rate only above 75% even though the pair has been trialed 88 times. Combination of *a*-[g] has also been difficult to differentiate when compared to other letters.

The player in Illustration 2 represents final results of a child, who has had generally significant trouble with phonological awareness. According to data he was a seven year old boy, who had played GraphoGame with exposure time of 8:55:17 and with a total success percent of 45% at the end of playing.

Illustration 2. Player with severe differentiation difficulties. Target *i* is systematically confused with distractor [e].

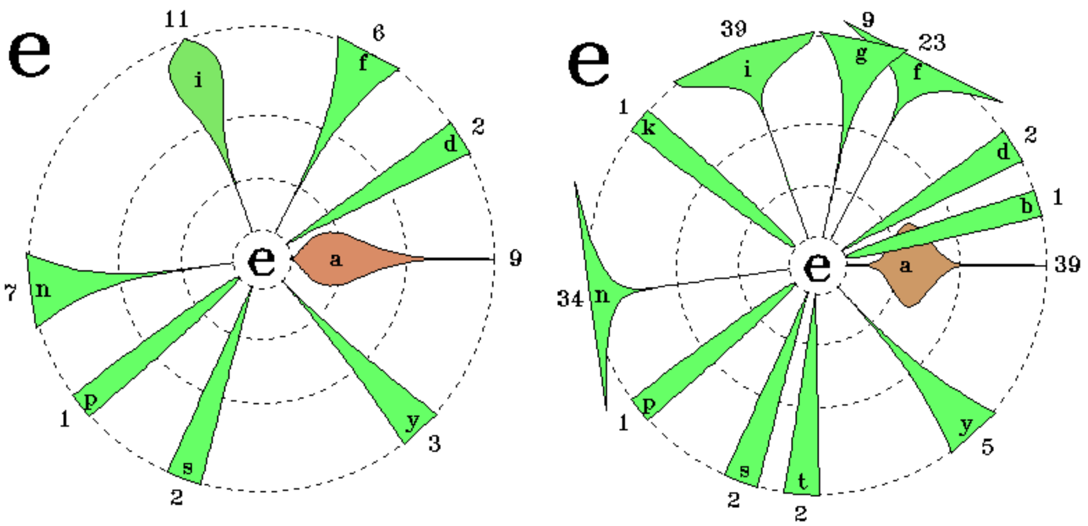


The player in Illustration 2 has had severe difficulties in recognition of target *i* apart from distractors [j], [g], [b], [p], [n] and [e], while [e] has been most often chosen distractor. The probability of choosing [e] over target *i* is under guessing ratio of 50%, meaning that the player has chosen systematically distractor [e] over *i* in over 50% of the trials. It is possible that the player has had other learning difficulties.

Daisy Graphs in Illustration 3 are from a six year old girl, whose exposure time was 4:40:46 at the end of playing. First Daisy Graph on the left is from her first full play day and second on the right is from her last play day showing data accumulation, adaptation and learning process.

Illustration 3. Player development over time and persistent challenge in differentiation of target *e* and distractor [a].

1. **Data from first play day**
2. **All data till last play day**



This player has made systematic errors with letter pair *e*-[a] getting less than 50% out of nine trials right in the beginning. *e*-[i] –combination has been less challenging in the beginning. Success percentage average shifted during playing in both items, but with *e*-[a] it is still less than other success percentages at the last play day.

5.2 Group level analysis

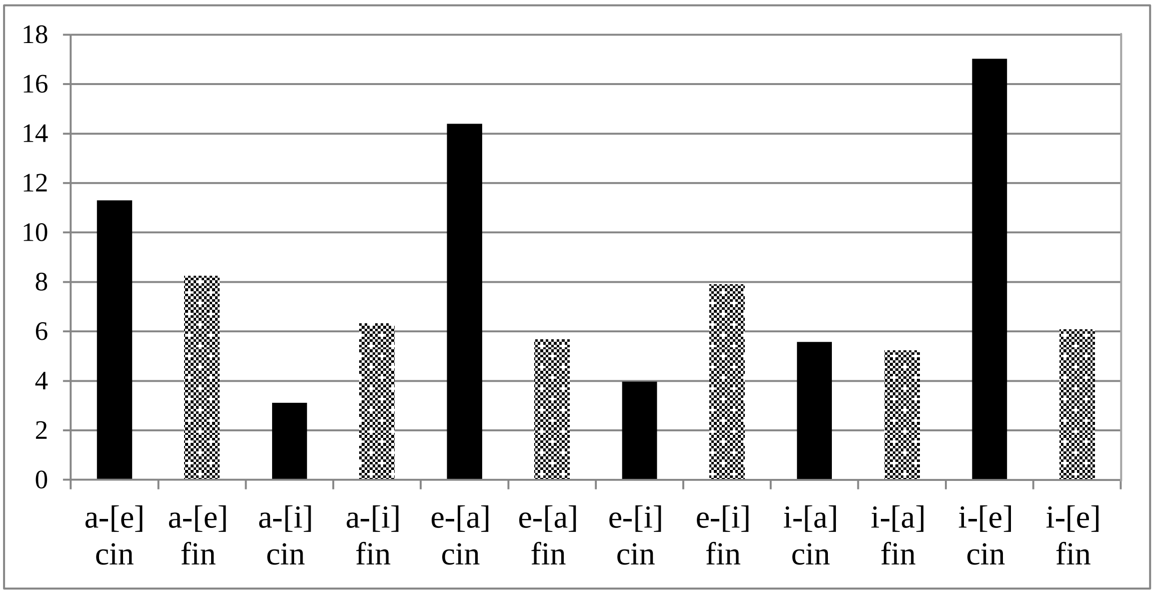
This sample contains in total of 529 letter pair combinations which were presented in 514 922 trials or 3551,18 trials per player on average. Confusion average of letter pair combinations in ciNyanja data sample was 7.1%, and in transparent Finnish language data sample 7,56%. From ciNyanja data, 111 letter pairs had confusion probability for over 10% and 21 letter pairs had confusion probability for over 14%. Most difficult *target*-[distractor] letter pairs to differentiate in ciNyanja were *m*-[n] (32%) and *d*-[b] (30%) and *w*-[u] (25%), meaning that when *m* has been presented as target, players have chosen distractor [*n*] with 32% probability (see Appendix 1). It is line with theory of visual and auditory confusion which can be seen when compared to Finnish data sample, where three most confused letter pairs were *d*-[b] (17%), *m*-[n] (15%) and *p*-[b] (15%). Confusion seems to be common if a letter has auditory and visual resemblance. Three in all most often confused single letters in ciNyanja were *n* (11,2%), *l* (10,0%) and *y* (9,9%), and in Finnish language *n* (12,5%), *o* (10,6%) and *p* (10,1%). Least confused letters in ciNyanja were *o* (2,5%), *z* (3,2%) and *e* (3,9%). General confusion probabilities of these letters are for *a* 4,61%, *e* 3,92% and for *i* 7,17% when all combinations are taken into account, and in Finnish counterpart confusion probabilities are 6,03% (*a*), 6,32% (*e*) and 5,57% (*i*). Table 2 presents key numbers for all vowel combination under vowel confusion hypothesis. Confusion probability was calculated by using Target-Distractor Confusion -variable to provide robust descriptive. Amount of trials per player contains large variation due to adaptation and individual differences, but it can be used to give an overview of the situation.

Table 2. *Letter pair trials and players in ciNyanja data*. Italicized *target* item is first and second letter in [brackets] is the distractor.

Target-[distractor] pair	*a*-[e]	*a*-[i]	*e*-[a]	*e*-[i]	*i*-[a]	*i*-[e]
Total of letter pair trials	1340	506	640	247	609	936
Number of trial players	98	92	70	53	80	80
Average of trials per player	13,81	5,56	9,27	4,75	7,71	11,85
Average confusion probability estimates in percentages	11,3	3,11	14,39	3,97	5,57	17,08

It seems that if item *e* is presented as target or distractor in ciNyanja, it will be likely be confusing for the player except when *i* is presented as a distractor. Combinations of *a* and *i* are distinguished well in ciNyanja when compared against whole letter pair average (7,1%). Players in Finnish sample do not seem to confuse these letter pairs when compared to each other or to whole data average (7,56%).

Table 3. ***Letter sound confusion probability percentages of letter pairs a, e and i in ciNyanja and Finnish language.*** Target item is presented first and distractor is in [brackets]. Black column represents ciNyanja sample. Grey column with shattered pattern represents Finnish sample (data from V. Rantanen, personal communication, September 2014).



6. Discussion

Based on the results of this study, it seems that ciNyanja language vowels *a*, *e* and *i* are confusing for children in Lusaka district, meaning that the letter in [brackets] is often confused to *italicized* one in combinations of *a*-[e], *e*-[a] and *i*-[e] due to English language exposure. According to data, vowel *e* is generally one of the easiest letters to master and among least confused with average confusion probability of 3,9%, which is well below whole sample average (7.1%). However, letter pair *i*-[e] had confusion probability of 17,03% and it was 12th most often confused letter pair out of whole sample. When percentage represents confusion probability, vowel *e* appears to be confusing in combinations *a*-[e] (11,3%), *i*-[e] (17,03%) and *e*-[a] (14,39%) above ciNyanja average (7,1%) and more often that with other letters. Letter *e* appears to have a controversial position between alphabet systems, because the results could be explained by English exposure effects (see Table 4).

Table 4. ***Vowels in ciNyanja and English***.

ciNyanja target-distractor combination		English language sound and letters	
Auditorily presented ciNyanja target item	Visual distractor selected instead of target item	English sound for ciNyanja distractor	English letter for English sound
a	e	[i:]	e
e	a	[ei]	a
i	e	[i:]	e

English letters *e* and *i* and their sounds form a complex network regarding ciNyanja, which is recitated and therefore confusing for children. Results of this study are not directly comparable to Ojanen´s et al. (2013) results because the data collection methods, gaming devices and game engines are moderately different. Game content in laptop-based Literate

Game (Ojanen, 2007) was in a series of fixed sets, whereas current GraphoGame uses adaptation engine to provide individualized learning content according to player´s success. Nevertheless, these results are in line with Ojanen´s (2007, Ojanen et al., 2013) findings about vowel confusion, except with the letter *a*. In a previous study (Ojanen et al., 2013), when letter *a* was presented as target item, it was often confused with distractor [i]. In English letter *a* is pronounced as [ei] and this ciNyanja vowel confusion seen in the results can be caused by domination of sound [i] in it. In this study letter *a* was confused with *i* only in 3,11% of the cases. It might be explained due to adaptation, exposure time and differences in game content. In Ojanen´s (2007) study game content was fixed and held letters *a* and *i* within the first trials and inexperienced usage might have lead to error patterns. In this study with more dynamic assessment 92 players had combination *a*-[i] in total of 506 times and with average of 5,5 times per player. However, four players played 207 out of 506 *a*-[i] trials. Their DaisyGraph analysis suggest that one of them have had confusion between *a* and *i* despite 34 repetitions. Other three players had differentiated *a* clearly from *i*. Two other letter pairs, *e*-[i] and *i*-[a] were not highly confusing. Letter pair *e*-[i] had confusion probability only of 3,97% but it was trialed only in total of 247 times. Player with highest number of *e*-[i] trials (39) differentiated letters *e* and *i* well according to DaisyGraph analysis. Combination of *i*-[a] was trialed 609 times with average confusion probability of 5,57%. Four players had played 214 out of 609 trials. Adaptation can repeat the same item for many times to individual players for to maintain their individual success rate which biases item distribution between all players. Group level analysis shows also another interesting detail. According to Finnish and ciNyanja data comparison one of the least confused single letters in ciNyanja was *o* with general confusion percentage of 2,5% whereas in Finnish language *o* was among the most difficult ones with average of 10,6% against all letters. Game engine presents letter *o* frequently in the beginning of both language versions, but it is hypothesized to be difficult letter due to gaming engine, which processes needs to be researched. As Finnish and ciNyanja languages are considered to be highly transparent languages, this difference can be seen as otherwise peculiar.

Baseline is that this data analysis suggests vowel confusion, which endangers development of phonological awareness. Phonological awareness and letter knowledge are considered as one of the most important predictors of child ´s reading and spelling acquisition (Adams, 1990; Share, 1995; Goswami, 2003; Ziegler & Goswami, 2005; Lonigan, 2006).

Vowel confusion of *a*, *e*, and *i* between English and ciNyanja appears to be one of the barriers to learning acquisition in Lusaka school district. It is difficult to imagine a reason for such a systematic and narrow confusion without including too early second language exposure into equation. It is notable that this takes place even after school policy changes towards native tongues and children are still learning native language letters in second language. Currently children are being exposed to at least two different language systems simultaneously and inconsistently, which is against general theory of mastering one language first before acquiring the second one (t. ex. Adams, 1990; McGuinness, 2004). It is possible that the variety of language backgrounds causes effects yet unknown in detail at classroom level. Participants´ unknown mother tongue background and for example, school performance, and a lack of supervision, poses a validity threat for this study. Language environment demands more attention for generalization of the results. It might be interesting to find bilingual children as a comparison group, because it could provide reliable triangulation if the comparison group consisted of children whose mother tongue is English and second language ciNyanja. A Finnish sample can provide only indicative information for comparison due to different learning environment and culture. Connections and differentiation on letter level between languages can depend on language system and environment between Finland and Zambia. Interventions might also have had an effect on learning. GraphoGame seems to have a positive effect on grade one learning outcomes when used by less experienced teachers (Jere-Folotiya, 2014). Personal factors such as player behavior and response styles have an effect on error marginal, which is unknown in this study. Another limitation of this study is relatively small number of repetition times of letter pairs due to adaptation and exposure times. It is also possible that players have had one or more user accounts during interventions because of user errors and broken devices, which have had undefined effects on their learning and game adaptation. In the future it might be effective to collect information about other socio-demographical factors and do research about their possible effects. Confusion can be studied further on by increasing exposure time in GraphoGame based interventions and adding variables with the same or methodologically more advanced design with external pre- and post- test. Comparability of the results could be increased by unifying external testing methodology. There is also a need to develop more descriptive and precise data analysis methods to use. One intriguing research method in the future for GraphoGame data would be analysis of the adaptation curve. Adaptation data based gradient could be reliable way to find out how fast each letter is being learned, but currently data tool does not provide a way to analyze that. It might be worth to analyze confusion percentage and frequency if it would be possible to separate them into an adaptation curve variable. Daisy Graphs on group level would be also an interesting application for the research in the future. Currently Daisy Graph can be used only for individual assessment.

In general, effective practice in mother tongue is needed in order to prevent school drop- out on account of failures in literacy tests and to increase efficient learning outcomes, which could be achieved by upgrading teaching qualification requirements (Chileshe et al., 2007, Jere-Folotiya, 2014). Currently teachers are reinforcing semantic mispronunciations and misinterpretations by repeating grammatically incorrect language content (Muhau, 2005;Jere-Folotiya, 2014). It can be hypothesized that vowels should be learned first and combined later on with consonants for to expedite mother tongue mastery. Even though teachers endorse the use of local languages (Jere-Folotiya, 2014), multilingualism sets severe challenges for the development of phonological awareness, training of phonetics and teacher qualifications. Based on previous studies it seems possible that one major obstacle in literacy acquisition is inadequate teacher training (Muhau, 2005, Jere-Folotiya, 2014). Currently students´ suffer from insufficient understanding of the instructional medium, which is one of the reasons why the results of education are poor in general (Williams & Cooke, 2002). Both this study, and Ojanen´s findings (Ojanen, 2007; Ojanen et al., 2013), reveal an actual phenomenon which needs to be taken into consideration when planning primary education system and curriculum to prevent challenges in literacy acquisition and adverse societal effects. It is recommended that literacy should be taught in a language children are most proficient in and that letter-sound connection instructions are revised. The findings of this study suggest securing the development of phonological awareness by emphasizing mother tongue tuition by improving teacher education and considering deferment of English language exposure.

References

Adams, M.J. (1990) *Beginning to read: Thinking and Learning About Print*. *First MIT Press*. Retrieved from http://www.google.fi/books?hl=fi&lr=&id=P_Hk7-n8i1AC&oi=fnd&pg=PR5&dq=M.+J.+(1990).+Beginning+to+read677:+Thinking+and+learning+about+print.&ots=PmTG0762LL&sig=EsUFa8z7om1eXpkzXyrG5XsyyDg&redir_esc=y#v=onepage&q&f=false

Aro, M. (2004) Learning to read: The effect of orthography. University of Jyväskylä. Studies in Education, Psychology and Social Research. ISBN 951-391722-3.

Beech, J. Ehri's model of phases of learning to read: a brief critique (2005). *Journal of Research in Reading*, ISSN 0141-0423 Volume 28, Issue 1, 2005, pp 50–58. PDF-document. Retrieved from http://www.le.ac.uk/psychology/jrb/PDFs/Beech_on_Ehri_2005.PDF

Chileshe, J., Musonda, L., Mushibwe, T., Bonnevie, H., Jorgensen, H., Kiernan, M. (2007). Review of the Ministry of Education in Zambia. *Norwegian Agency for Development Cooperation.* Retrieved from https://www.google.fi/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CDcQFjAB&url=http%3A%2F%2Fwww.norad.no%2Fen%2Ftools-and-publications%2Fpublications%2Fpublication%2F_attachment%2F107619%3F_download=true%26_ts=11ebb1bf2ad&ei=V7NJUdiOMcbbsgbB0oCIAw&uh

Chilufya, James (2008). The Effect of Computer-assisted Letter- sound Correspondence Training on Learning to Read in Zambia. *Master´s thesis of Psychology. University of Jyväskylä, Finland*. PDF-document. Retrieved from https://jyx.jyu.fi/dspace/bitstream/handle/123456789/18963/URN_NBN_fi_jyu-200809305771.pdf?sequence=1

Census of Population and Housing. 2011. Preliminary population figures. Retrieved from https://unstats.un.org/unsd/demographic/sources/census/2010_PHC/Zambia/PreliminaryReport.pdf

Collins, P., De Galbert, P., Hartwell, A., Kochetkova, E., Mulcahy-Dunn, A., Nimbalkar, A. and Ralaingita, W. 2012. Pupil Performance, Pedagogic Practice, and School Management: An SSME Pilot in Zambia. Washington, DC, US Agency for International Development. https://www.eddataglobal.org/documents /index.cfm?fuseactionpubDetail&ID=426

Dickinson, D. and Neuman, S. (2006). *Handbook of Early Literacy Research, Vol. 2*. - Guilford Press. ISBN 1-59385-184-7

Ehri, L., McCormick, S. *Phases of Word Learning: Implications for Instruction with Delayed and Disabled Readers*. *Reading and Writing Quarterly: Overcoming Learning Difficulties*. Volume 14, Issue 2, 1998. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/1057356980140202

Examinations Council of Zambia. 2013. Data search. Retrieved from http://www.exams-council.org.zm/index.php?option=com_content&view=article&id=67&Itemid=5

Goswami, Usha. (2003, 1st edition). *In The Handbook of Early Literacy Research. In Early Phonological Development and the Acquisition of Literacy.* Edited by Susan B. Neuman, David K. Dickinson, *Guilford Press*. P. 111. Retrieved from http://www.google.fi/books?hl=fi&lr=&id=afiqtIdRQGwC&oi=fnd&pg=PA111&dq=Literacy+acquisition+in+transparent&ots=5xO3SKTIUA&sig=kSpceq0PU2OXCEgPcTCyEQxdPmI&redir_esc=y#v=onepage&q=Literacy%20acquisition%20in%20transparent&f=false

Grapholearning.info, University of Jyväskylä and Niilo Mäki Institute. Retrieved from http://grapholearning.info/graphogame

Gray, Lubasi & Bwalya (2013). Town Nyanja: A learner´s guide to Zambia´s emerging national language. Lulu.com. 1300756004, 9781300756002. Retrieved from http://www.google.it/books?hl=fi&lr=&id=uuejBAAAQBAJ&oi=fnd&pg=PA5&dq=vowel+nyanja&ots=czw_GV7eia&sig=BrzcNJ1_yhcsH20Yvi8_JdKbrzI&redir_esc=y#v=onepage&q=vowel%20nyanja&f=false

Heugh, K. (2011). Theory and practice – language education models in Africa: research, design, decision-making and outcomes. In Ouane, A. and Glanz, C. (eds). Optimising Learning, Education and Publishing in Africa: The Language Factor. A Review and Analysis of Theory and Practice in Mother-Tongue and Bilingual Education in sub-Saharan Africa, 105-156. Hamburg and Tunis Belvédère: UNESCO Institute for Lifelong Learning (UIL) and the Association for the Development of Education in Africa (ADEA)/African Development Bank. http://unesdoc.unesco.org/images/0021/002126/212602e.pdf

Jere-Folotiya, J. (2014). *Influences of Grade one Zambian Teachers and GraphoGame on Initial Literacy Acquisition: Lusaka District*. Jyväskylä Studies in Education, Psychology and Social Research 503. ISBN 978-951-39-5800-8.

Jere-Folotiya, J., Chansa-Kabali T., Munachaka, J., Sampa F., Yalukanda, C., Westerholm, J., Serpell, R. & Lyytinen, H. (2013). *The effect of using a mobile literacy game to improve literacy levels of grade one learners in Zambian schools.* University of Zambia, Department of Psychology, Lusaka, Zambia. [b] USAID Read to Succeed Education project, Lusaka, Zambia. [c] Center for the Promotion of literacy in Sub-Saharan Africa (CAPOLSA), University of Zambia, Department of Psychology, Lusaka, Zambia. [d] Niilo Mäki Institute, University of Jyväskylä, Finland. AGORA Human Technology Center, University of Jyväskylä, Finland. Retrieved from http://download.springer.com/static/pdf/251/art%3A10.1007%2Fs11423-014-93429.pdf?auth66=1414929688_77ea611c4396a70cc47069e80f93fb48&ext=.pdf

Kachenga, G. (2008) *The Effect of Using Computer Literate Game in the Teaching of Reading Literacy Skills in Zambia*. Master's thesis of Psychology. University of Jyväskylä. Department of Psychology. Retrieved from https://jyx.jyu.fi/dspace/bitstream/handle/123456789/18962/URN_NBN_fi_jyu-200809305768.pdf?sequence=1

Kaoma, S. (2008). *Does the Literate Game help 3rd and 4th Grade Zambian Children Learn How to Read.* Master Thesis of Psychology. University of Jyvaskylä. Department of Psychology. Retrieved from https://jyx.jyu.fi/dspace/bitstream/handle/123456789/18968/URN_NBN_fi_jyu-200810035781.pdf?sequence=1

Lonigan, C. *Conceptualizing Phonological Processing Skills in Prereaders*. (2006). In Dickinson, D., Neuman, S. Handbook of Early Literacy Research, 2006. Volume 2, pp. 77-89. The Guilford Press. ISBN 1-59385-184-7

Luchembe, M. (2009). *Adult Education in Zambia during the Colonial Period: Challenges in the Post-Independence Era.* Department of Adult Education and Extension Studies. University of Zambia Centre for the Study of International Cooperation in Education (CICE), Hiroshima University. http://www.ibrarian.net/navon/paper/Adult_Education_in_Zambia_during_the_Colonial_Per.pdf?paperid=17917413

Lyytinen, H., Erskine, J., Kujala, J., Ojanen, E. & Richardson, U. (2009). In search of a science-based application: A learning tool for reading acquisition. *Scandinavian Journal of Psychology, 50*, 668–675. Retrieved from http://onlinelibrary.wiley.com/store/10.1111/j.1467-9450.2009.00791.x/asset/j.1467-9450.2009.00791.x.pdf?v=1&t=hbta4bi9&s=a58a9f5ef7bf8b1a88d218166a718b5a7398b22b

MacBride-Chang, C., & Kail, R. (2002). *Cross–Cultural Similarities in the Predictors of Reading Acquisition. Child Development*. Sep/Oct2002, Vol. 73 Issue 5. http://web.a.ebscohost.com/ehost/detail?sid=db8457de-b207-4aef-abca-194cc83ee9c7%40sessionmgr4001&vid=1&hid=4206&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3d%3d#db=afh&AN=7351721

McGuinness, D. (2004). *Early Reading Instruction. What Science Really Tells Us about How to Teach Reading*. Library of Congress Cataloging-in Publication Data. ISBN 0-262-13438-1. Retrieved from http://books.google.fi/books?hl=fi&lr=&id=geCphXcHm30C&oi=fnd&pg=PR7&dq=Early+Reading+Instruction.+What+Science+Really+Tells+Us+about+How+to+Teach+Reading&ots=9XQZ-ckQcd&sig=bUTy0sDJFnXf_mGOVepgc2rudIY&redir_esc=y#v=onepage&q&f=false

Ministry of Education of Republic of Zambia. (2010). *Implementation Framework 2011-2015. Education for All: Poverty Reduction Through Rural Investment, Human Capital and Infrastructure Development*. Retrieved from http://planipolis.iiep.unesco.org/upload/Zambia/Zambia_Education_Sector_NIF_III_2011_2015_Final_Draft.pdf

Muhau, Progress. (2005). *Comparison of learning to read silozi with pupils of different vernacular backgrounds*. Graduation thesis. Psychology Department of University of Jyväskylä. http://dspace.unza.zm:8080/xmlui/bitstream/handle/123456789/3055/Main%20Document.pdf?sequence=2

Musonda, B., Kaba, A., Nakazwe, T. (2011). *Trends in Achievement Levels of Grade 6 Pupils in Zambia*. Southern and Eastern Africa Consortium for Monitoring Educational Quality. Number 1 (June 2011).

Ojanen, E., Kujala, J., Richardson, U., & Lyytinen, H. (2013). *Technology-Enhanced Literacy Learning in Zambia: Observations from a Multilingual Literacy Environment.* Insights on Learning Disabilities: From Prevailing Theories to Validated Practices, 10 (2), 103-127.

Ojanen, E. (2007) *Sewero La-ma-u – A Phonetic Approach to Literacy Teaching in Zambia. Master's thesis of psychology*. University of Jyväskylä, Department of Psychology July. Retrieved from https://jyx.jyu.fi/dspace/bitstream/handle/123456789/10983/URN_NBN_fi_jyu-20072.pdf?sequence=1

Richardson, U., Lyytinen, H. (2014). *The GraphoGame Method: The Theoretical and Methodological Background of the Technology-Enchanced Learning Environment for Learning to Read.* An Interdisciplinary Journal on Humans in ICT Environments. ISSN: 1795-6889. Volume 10(1), May 2014, 39–60. PDF-document. Retrieved from http://www.humantechnology.jyu.fi/articles/volume10/2014/Richardson_Lyytinen.pdf

Robson, C. (2002). *Real World Research. A Resource for Social Scientists and Practitioner-Researchers*. 2nd Ed. Blackwell Publishing.

Rubagumya, C.M. (1989). *Language in Education in Africa*. Multilingual Matter Ltd.

Saine, L., Lerkkanen, M-K., Ahonen, T., Tolvanen, A., Lyytinen, H. (2011). *Computer-Assisted Remedial Reading Intervention for School Beginners at Risk for Reading Disability.* In Child Development, May/June 2011, Volume 82, Number 3, pp. 1013-1028.

Sampa, F. (1999). World Bank. Zambia's Primary Reading Program: *Improving Access and Quality Education in Basic Schools*. Research coordinated by the Ministry of Education of Zambia. Francis K. Sampa. Association for the Development of Education in Africa. Retrieved from http://www.adeanet.org/adeaPortal/publications/downloadcenter/publications/04_zambia_eng_web.pdf

Sampa, F. In preparation. The Status Of Basic Reading Skill In Cinyanja Among Zambian Grade 2 Children.

Serpell, R., (1978). *Language in Zambia*. Edited by Sirarpi Ohannessian & Mubanga E. Kashoki. International African Institute. High Holborn, London. ISBN WC1V 7BW ISBN 0 85302 054 X.

Seymour, P., Aro, M. & Erskine, J. (2003). Foundation literacy acquisition in European orthographies. British Journal of Psychology (2003), 94, 143–174. 2003 The British Psychological Society. Retrieved from http://onlinelibrary.wiley.com/store/10.1348/000712603321661859/asset/000712603321661859.pdf?v=1&t=i2d2bjip&s=7fba67604d0a24bf45f69907d1d64aec9e6b4e40

Share, D. (1995) *Phonological recoding and self-teaching: sine qua non of reading acquisition*. *Cognition, Volume 55, Issue 2*, p. 151-218. Elsewire. Retrieved from http://www.sciencedirect.com/science/article/pii/0010027794006452

Stahl, S., Duffy-Hester, A., & Stahl, K. (1998). *Everything you wanted to know about phonics (but were afraid to ask)*. Reading Research Quarterly. Vol. 33, No. 3. International Reading Association (pp. 338–355). Retrieved from http://onlinelibrary.wiley.com/store/10.1598/RRQ.33.3.5/asset/RRQ.33.3.5.pdf?v=1&t=hc4mmb8k&s=9129618b54b51c1098b08193dc6ee4d99a3238d7

The World Bank. Data search. Retrieved from http://search.worldbank.org/data?qterm=zambia&language=EN

Unicef. (2013). Data search. Retrieved from http://www.unicef.org/infobycountry/zambia_statistics.html

Välijärvi, P., Kupari, P., Linnakylä, P., Reinikainen, P., Sulkunen, S., Törnroos, J., Arffman, I. (2003). *The Finnish Success in PISA – and some reasons behind it.* Institute for Educational Research, University of Jyväskylä. http://ktl.jyu.fi/img/portal/8302/PISA_2003_screen.pdf

William, E. & Cooke, J. (2002). *Pathways and Labyrinths: Language and Education in Development.* Tesol Quaterly. Vol. 36, No. 3, Autumn 2002. Retrieved from http://onlinelibrary.wiley.com/store/10.2307/3588415/asset/3588415.pdf?v=1&t=hegwwd1q&s=1989f8c950f0b93f569e3c31dabc68de624425a5

Ziegler, Johannes C., Goswami, Usha (2005). *Reading Acquisition, Developmental Dyslexia, and Skilled Reading Across Languages: A Psycholinguistic Grain Size Theory. Psychological Bulletin, Vol 131(1)*. Retrieved from http://psycnet.apa.org/journals/bul/

Appendix 1.1

Target

Distractor	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	r	s
a		0,076	0,040	0,057	0,144	0,090	0,108	0,150	0,056	0,021	0,079	0,114	0,028	0,072	0,032	0,073	0,088	0,052
b	0,039		0,013	0,303	0,015	0,095	0,120	0,147	0,063	0,110	0,044	0,064	0,059	0,113	0,029	0,190	0,056	0,034
c	0,019	0,053		0,083	0,050	0,111	0,124	0,181	0,096	0,092	0,073	0,080	0,034	0,078	0,021	0,059	0,030	0,105
d	0,044	0,239	0,064		0,050	0,095	0,137	0,123	0,068	0,095	0,027	0,099	0,032	0,101	0,023	0,154	0,062	0,027
e	0,113	0,047	0,040	0,088		0,065	0,088	0,071	0,170	0,057	0,046	0,089	0,068	0,086	0,037	0,103	0,080	0,028
f	0,025	0,040	0,073	0,098	0,064		0,084	0,075	0,038	0,101	0,021	0,096	0,045	0,075	0,019	0,057	0,083	0,056
g	0,092	0,091	0,110	0,166	0,100	0,129		0,122	0,102	0,216	0,059	0,085	0,054	0,105	0,019	0,079	0,129	0,029
h	0,059	0,031	0,083	0,082	0,016	0,100	0,067		0,040	0,112	0,037	0,109	0,074	0,110	0,022	0,078	0,069	0,040
i	0,031	0,050	0,042	0,030	0,040	0,054	0,045	0,045		0,111	0,022	0,151	0,040	0,065	0,027	0,106	0,055	0,022
j	0,038	0,046	0,063	0,074	0,012	0,072	0,121	0,084	0,087		0,059	0,122	0,042	0,096	0,021	0,059	0,087	0,042
k	0,078	0,056	0,054	0,109	0,010	0,050	0,115	0,128	0,084	0,079		0,112	0,059	0,095	0,025	0,030	0,061	0,027
l	0,043	0,043	0,082	0,061	0,026	0,060	0,044	0,101	0,113	0,098	0,068		0,072	0,133	0,028	0,084	0,144	0,033
m	0,021	0,076	0,062	0,077	0,026	0,095	0,133	0,102	0,062	0,046	0,065	0,211		0,323	0,017	0,118	0,038	0,034
n	0,013	0,095	0,040	0,052	0,054	0,089	0,119	0,110	0,025	0,074	0,056	0,152	0,152		0,042	0,056	0,054	0,045
o	0,076	0,128	0,057	0,046	0,058	0,048	0,053	0,082	0,061	0,059	0,042	0,093	0,076	0,131		0,072	0,035	0,066
p	0,059	0,166	0,074	0,148	0,050	0,066	0,100	0,166	0,075	0,112	0,037	0,080	0,035	0,122	0,022		0,105	0,016
r	0,037	0,045	0,023	0,074	0,037	0,075	0,079	0,072	0,076	0,055	0,039	0,152	0,028	0,117	0,020	0,111		0,054
s	0,052	0,044	0,082	0,080	0,019	0,101	0,042	0,043	0,060	0,069	0,064	0,088	0,049	0,128	0,036	0,057	0,065	
t	0,052	0,017	0,087	0,136	0,068	0,095	0,029	0,026	0,041	0,163	0,067	0,123	0,049	0,092	0,024	0,136	0,057	0,058
u	0,065	0,083	0,013	0,107	0,032	0,068	0,112	0,079	0,071	0,073	0,038	0,103	0,093	0,196	0,030	0,083	0,095	0,047
v	0,045	0,055	0,050	0,083	0,006	0,131	0,066	0,110	0,044	0,071	0,065	0,072	0,045	0,074	0,015	0,079	0,073	0,031
w	0,021	0,069	0,040	0,086	0,031	0,105	0,098	0,086	0,040	0,101	0,044	0,075	0,081	0,113	0,024	0,082	0,071	0,027
y	0,027	0,068	0,044	0,048	0,023	0,132	0,045	0,115	0,116	0,096	0,029	0,031	0,027	0,088	0,015	0,056	0,064	0,017
z	0,011	0,023	0,039	0,043	0,079	0,056	0,089	0,032	0,064	0,108	0,056	0,065	0,025	0,061	0,027	0,035	0,049	0,069
Average	0,046	0,071	0,056	0,094	0,039	0,086	0,087	0,095	0,072	0,092	0,049	0,103	0,055	0,112	0,025	0,086	0,071	0,041

Appendix 1.1

Chart presents target items and their confusion probablilities when distactor item has been played as auditory stimulus and target item as visual target and the player has chosen distractor instead of target item. Number represents the complementary confusion probability out of 1.

Appendix 1.2

Distractor	Target t	u	v	w	y	z
a	0,045	0,039	0,087	0,070	0,045	0,033
b	0,074	0,030	0,094	0,121	0,014	0,053
c	0,046	0,029	0,023	0,075	0,101	0,031
d	0,088	0,046	0,014	0,037	0,065	0,057
e	0,057	0,052	0,014	0,084	0,183	0,018
f	0,128	0,051	0,106	0,074	0,112	0,029
g	0,064	0,060	0,041	0,086	0,095	0,015
h	0,049	0,070	0,067	0,154	0,104	0,002
i	0,071	0,046	0,083	0,066	0,145	0,019
j	0,061	0,027	0,084	0,094	0,165	0,045
k	0,034	0,045	0,066	0,053	0,023	0,012
l	0,085	0,051	0,100	0,034	0,182	0,049
m	0,100	0,056	0,055	0,133	0,067	0,064
n	0,069	0,135	0,097	0,107	0,101	0,048
o	0,076	0,102	0,059	0,065	0,057	0,053
p	0,086	0,062	0,016	0,022	0,089	0,019
r	0,071	0,031	0,065	0,053	0,161	0,024
s	0,077	0,084	0,056	0,121	0,077	0,037
t		0,059	0,088	0,047	0,080	0,018
u	0,075		0,117	0,247	0,061	0,017
v	0,052	0,026		0,113	0,107	0,027
w	0,056	0,050	0,113		0,138	0,016
y	0,043	0,053	0,068	0,067		0,052
z	0,042	0,028	0,154	0,077	0,061	
Average	0,068	0,054	0,072	0,088	0,099	0,032

Appendix 1.2
Chart presents target items and their confusion probablilities when distactor item has been played as auditory stimulus and target item as visual target and the player has chosen distractor instead of target item. Number represents the complementary confusion probability out of 1.