

## **PHONOLOGICAL AWARENESS, SHORT-TERM MEMORY AND READING IN DEAF/HH BEGINNING READERS**

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### **ABSTRACT**

The purpose of the present study was to investigate the relation between short-term memory, phonological awareness, and reading acquisition in Greek deaf early readers. Twelve deaf students and twelve normally hearing controls were employed in the study. Phonological awareness was tested using an optical oddity task, a rhyming task and a same-different matching task. Short-term memory was evaluated using a number recall task, a non-word repetition task and a recall task involving word sequences. Furthermore, reading was evaluated using single vowels and consonants, syllables of regular and more complex structure, words and non-words. Results suggested a weak relationship between phonological awareness and reading. On the other hand, the relationship between short-term memory and reading was clearly established. The present findings may apply to the teaching of reading in deaf students and provide valuable insight into future research.

### **PHONOLOGICAL AWARENESS, READING AND DEAFNESS**

Phonological awareness skills are considered to be one of the most important predictors of academic achievements in areas such as reading. Several studies have shown that deaf good readers are better at rhyme judgment and rhyme production tasks than those who are poor readers, though these skills are typically less developed than in hearing readers (Campbell & Wright, 1988, Charlier & Leybaert, 2000, Dodd & Hermelin, 1977, Dyer & MacSweeney, 2003, Hanson & Fowler, 1987, Hanson & MacGarr, 1989, Sterne & Goswami, 2000, Trezek & Wang, 2006). The main factor seems to be the development of accurate phonological representations on the base of the phonological units which are 'linguistically defined primitives related to articulatory gestures' (Hanson, 1991, as cited in Colin et al, 2007, p. 139-140).

However it is not yet clear if deaf students are able to develop a phonological strategy for reading successfully. A number of studies in deaf students have shown little or no evidence for phonological coding in either reading or spelling in comparison studies with hearing students on lexical decision tasks (Waters & Doehring, 1990, Merrills, Leybaert & Alegria, 1995, Beech & Harris, 1997, Harris & Beech, 1998, Nielsen & Luetke- Stahlman, 2002). Beech and Harris (1997) Hearing students seem more likely to mistakenly identify a nonword (e.g., merd) as a real word or reject a real word with an irregular spelling (e.g., once). Leybaert and Alegria (1995) found similar evidence of a lack of phonological coding in spelling in French native speakers deaf students.

Studies on deaf readers have yet to answer the question of whether 'phonological awareness precedes or follows excellence in reading in profoundly deaf individuals' (Goldin-Meadow & Mayberry, 2001, p. 224, as cited in Colin et al, 2007, p. 140). It is likely that deaf readers gain access to phonological units like syllables and phonemes through their experience in reading. On the other hand, phonological awareness could precede, and indeed favor, the development of reading in deaf readers.

There is, nevertheless, some evidence for phonological awareness in primary-school deaf children. Sterne and Goswami (2000) used a task in which children had to match a picture with a homophone (e.g., boiz as a match for a picture of two boys).

The correct homophone had to be distinguished from three distractor items that differed by one letter (i.e. roiz, beiz, and boin). Although the deaf children were not as accurate as their hearing peers, they found that the performance of the deaf children was pretty good, suggesting that some phonemic knowledge may be available to deaf students. In addition to this, Sterne and Goswami found that the deaf students had syllabic knowledge that was equivalent—on both syllable tapping and comparison of the length of picture names—to hearing students, and their ability to make rhyme judgments was above chance even though it was inferior to that of RA controls. Harris and Beech (1998) also found that a small number of deaf children performed well on their sound-similarity task, and in Beech and Harris (1997, as cited in Harris, & Moreno, 2004, p 254) there was a small but significant effect of homophony for the deaf children, with homophonic nonwords producing more errors than nonhomophonic nonwords.

## **SHORT-TERM MEMORY, READING AND DEAFNESS**

Over the past two decades researches have demonstrated that performance on WM and STM tasks can predict academic achievement in areas such as reading (Cain, 2006; Cain & Oak hill, 2006, as cited in Hamilton, 2011, p. 402), language comprehension (Engle Carullo, & Collins, 1991, as cited in Hamilton, 2011, p. 402), mathematics (Geary, Hoard, Nugent, & Byrd-Craven, 2007; Jarvis & Gathercole, 2003, as cited in Hamilton, 2011, p. 402) and science (Gathercole & Alloway, 2008; Gathercole & Pickering, 2000; Gathercole, Pickering, Knight, & Stegmann, 2004; Jarvis & Gathercole, 2003, as cited in Hamilton, 2011, p. 402). Deficits in WM and STM can potentially prevent students' ability to succeed in school (Alloway, Gathercole, Kirkwood, & Elliott, 2009, as cited in Hamilton, 2011, p. 402).

Alongside PA, phonetic coding of linguistic items (digits, words, etc.) into short-term memory (STM) is also an important predictor of reading development in hearing children (Wagner & Torgeson, 1987, as cited in Koo et al, 2008, p. 86). Hearing students have been shown to use a phonetic code during short-term recall of linguistic stimuli (Conrad, 1964, 1973, 1977; Healy, 1982), though, the encoding strategy employed by deaf students, particularly those who are prelingually deaf, during STM tasks is less clear. The code they are using are visuospatial since ASL<sup>1</sup> is visuospatial and not phonetic.

Bebko (1984, as cited in Hamilton, 2011, p. 403) has observed that deaf individuals have greater difficulty with sequential memory processing tasks than hearing individuals. Specifically, deaf students compared to hearing students have difficulties in recalling digits, printed words, pictures, American Sign Language (ASL) signs (for deaf subjects) from English words (for hearing subjects) and fingerspelled words (for deaf subjects) from English words (for hearing subjects). A considerable number of researchers have tried to interpret this deficit. Some of them attribute it to the longer articulation length of signs in comparison to speech, others to the shorter decay rate of visual/sign memory compared to that of echoic/ speech-based memory and some of them to the formational complexity of signs versus speech. A recent research of Marschark & Wauters (2008) has shown that deaf children do not use sequential processing strategies in comparison to hearing children, and that this may account for some of their linguistic WM deficit and language comprehension difficulties. The purpose of this study was to investigate the relation between short-term memory, phonological awareness, and learning reading by Greek deaf early readers.

## **METHOD**

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<sup>1</sup> ASL: American Sign Language

## Participants

Two groups of 20 children in each group participated in this study. The first group was composed of 10 deaf children using Greek Sign Language and of 10 hard of hearing students (HH) using mostly oral language. The age of this group ranged from 8 to 10 years. The second was composed from hearing students aged 7 years, native speakers of Greek language (H). The tests were administered to both groups in two different periods. The first tests were administered in October, before students were taught how to read, and the second in March after both groups were taught how to read.

## Design

*Phonological awareness.* The tasks which are used to measure phonological awareness were oddity test (both in phoneme and syllable), rhyming test and same-different matching test (both in phoneme and syllable). The three tests were presented in hearing children orally whereas in deaf and hard of hearing students by “speechreading” in the first place. If children couldn’t understand the speech read words, the words of the tests were presented in written form in a paper, and the students were asked to recognize the phoneme or the syllable visually.

*Short-term memory.* The tasks used to measure short-term memory examined student’s ability in serial recall of digits, nonwords and words. The three tests were presented in hearing children orally whereas in deaf and hard hearing in written form in computer. Written numbers, words and nonwords were presented to D/HH students who were then asked to recognize each one of them.

*Reading.* The tasks used to measure the ability to read examined student’s ability in reading letters, groups of two or three letters, words and nonwords. The testing words were presented in written form to deaf, hard-hearing and hearing students. Written numbers, words and nonwords were presented to students, and D/HH students were asked to recognize each.

## RESULTS

Data were analyzed through the statistical software SPSS. The Paired- Samples T test and the Independent Samples t-Test were used to compare the different groups. The dependent variable was reading and the independent ones were short-term memory and phonological awareness. The first analysis showed that there is no significant effect of short-term memory in reading in the first period (October) neither for deaf nor deaf and hard hearing nor for hearing students since for both groups  $p > .05$  (Table 1). However, in the second period (March) for the group of deaf and hard hearing students there was a significant effect of the task “Serial recall of nonwords” in reading ( $p = .04 < .05$ ) while for the group of hearing students there was a significant effect of the task “Serial recall of words” in reading ( $p = .04 < .05$ ) (see Table 1). Also the affection between phonological awareness tasks and reading tasks in the first period (October) was not statistically important neither for deaf and hard of hearing nor for hearing students since for both groups  $p > .05$  (Table 2). In the second test (March) a significant effect was found in the task “Rhyming test” ( $p = .03 < .05$ ) in reading for deaf and hard hearing students, a significant effect was also found in the tasks “Rhyming test” ( $p = .03 < .05$ ) and “Same- different matching test (syllable)” ( $p = .00 < .05$ ) in reading for the hearing students (see Table 2). The final analysis (see Table 3) revealed, that for the majority of the tasks, i.e phonological awareness, short-term memory and reading there was a significant difference between October and March test results regarding both groups of students ( $p < .05$ ). Nevertheless, deaf and hard of hearing students didn’t have a significant difference in reading consonants ( $p = .19 > .05$ ) and reading consonant, vowels syllables ( $p = .21 > .05$ ) compared to the hearing group.

**Table 1:** Effect of short- term memory in the ability of reading

Short-term memory			t	p
Serial recall of digits	OCTOB.	D / HH	-,952	,355
		H	,849	,401
	MAR.	D / HH	,505	,621
		H	-,269	,789
Serial recall of nonwords	OCTOB.	D / HH	1,107	,284
		H	,036	,971
	MAR.	D / HH	1,975	,045
		H	,899	,375
Serial recall of words	OCTOB.	D / HH	-	-
		H	1,074	,290
	MAR.	D / HH	1,346	,198
		H	2,164	,037

Note: OCTOB: October, MAR: March, p<.05

**Table 2:** Effect of phonological awareness in the ability of reading

Phonological Awareness			t	p
Oddity test (syllable)	OCTOB.	D / HH	,064	,950
		H	1,965	,058
	MAR.	D / HH	,612	,551
		H	-,182	,857
Oddity test (phoneme)	OCTOB.	D / HH	-1,543	,145
		H	,530	,600
	MAR.	D / HH	,058	,955
		H	1,242	,223
Rhyming test	OCTOB.	D / HH	-,109	,915
		H	1,315	,198
	MAR.	D / HH	,156	,041
		H	-2,256	,031
Same- different matching test (syllable)	OCTOB.	D / HH	,829	,421
		H	,529	,600
	MAR.	D / HH	-1,034	,320
		H	4,163	,001
Same- different matching test (phoneme)	OCTOB.	D / HH	,361	,723
		H	1,905	,066
	MAR.	D / HH	-,007	,995
		H	1,435	,161

**Table 3:** Mean difference of short term memory tasks, phonological tasks and reading tasks

			t	p
Oddity test (syllable)	D / HH		-4,292	,000
	H		-11,865	,001
Oddity test (phoneme)	D / HH		-8,753	,000
	H		-9,718	,001
Rhyming test	D / HH		-5,604	,000
	H		-10,666	,001
Same- different matching test (syllable)	D / HH		-2,349	,030
	H		-5,761	,001
Same- different matching test (phoneme)	D / HH		-3,322	,004
	H		-10,389	,001
Serial recall of digits	D / HH		-3,455	,003
	H		-5,824	,001
Serial recall of nonwords	D / HH		-4,310	,000
	H		-4,359	,001
Serial recall of words	D / HH		-3,986	,001
	H		-,597	,554
Reading consonant	D / HH		1,372	,187
	H		-5,863	,001
Reading vowels	D / HH		-10,032	,000
	H		-5,063	,001
Reading vowel, consonant syllables	D / HH		-3,437	,003
	H		-9,531	,001
Reading consonant, vowel syllables	D / HH		-2,704	,015
	H		-7,017	,001
Reading consonant, consonant, vowel syllables	D / HH		-1,287	,215
	H		-11,805	,001
Reading vowel, consonant nonsyllables	D / HH		-4,532	,000
	H		-9,514	,001
Reading consonant, vowel, vowel nonsyllables	D / HH		-2,673	,016
	H		-9,272	,001
Reading words	D / HH		-	-
	H		-8,166	,001
Reading nonwords	D / HH		-6,810	,000
	H		-12,020	,001

## **DISCUSSION**

### **Phonological awareness and reading**

Phonological awareness skills are considered to be one of the most important predictors of academic achievement in reading. Researches of deaf/hard hearing students have shown little or no evidence regarding phonological coding in reading (Waters & Doehring, 1990, Merrills, Leybaert & Alegria, 1995, Beech & Harris, 1997, Harris & Beech, 1998, Nielsen & Luetke- Stahlman, 2002). In the recent study it was also found no significant effect of the phonological awareness tasks in reading although there was a significant difference from October to March (see Table 1 and 3) showing that teaching could be a factor contributing to increasing phonological awareness.

Several studies have shown that despite the fact that deaf students have not conquered fully the phonological code, deaf good readers are able to do rhyme judgments although lagging behind hearing readers (Campbell & Wright, 1988, Charlier & Leybaert, 2000, Dodd & Hermelin, 1977, Dyer & MacSweeney, 2003, Hanson & Fowler, 1987, Hanson & MacGarr, 1989, Sterne & Goswami, 2000, Trezek & Wang, 2006). As seen in Table 3 deaf/ hard hearing students have a statistical significant difference in Rhyming test from October to March and that this factor had a statistically significant effect in reading.

### **Short-term memory and reading**

The results on short term memory tasks revealed that deaf and hard of hearing students, compared to the hearing group, although there was a significant difference in the results of the three tasks between October and March, only serial recall of nonwords had a statistical significant effect in reading (see Table 1 and 3). This result is consistent with other studies in English (Bedco, 1984, Marschark & Wauters, 2008) and can be attributed to the fact that deaf and hard hearing students use a code which is much more visuospatial, since ASL and GSL<sup>2</sup> are visuospatial and not phonetic.

Marschark & Wauters (2008) also suggested that this deficit of deaf/hard hearing students in short term memory may account for some language comprehension difficulties. This study also showed that this deficit affect reading compared to the hearing group where serial recall of words seem to affect significantly reading (Table 1).

## **SUMMARY AND CONCLUSIONS**

The goal of this study was to study the relation of phonological awareness and short-term memory skills to reading proficiency in Greek deaf and hard hearing students. In Greece, the books which are used in primary schools in order to help deaf and hard hearing students to learn reading are the same with the books which are used for hearing students. This means that student first have to develop a phonological strategy and then learn to read. Studies in Greek have shown that this is the better way for a hearing student to develop reading proficiency. But the question is whether “phonological awareness precedes or follows excellence in reading in profoundly deaf individuals” (Goldin-Meadow & Mayberry, 2001, p. 224, as cited in Colin et al, 2007, p. 140) and if the phonological strategy used in the books is assisting deaf/hard hearing students to read. This study showed that deaf children do not rely solely in phonological awareness skills to learn reading, as do the hearing children and therefore the methods and materials/books used in teaching reading to deaf students may be different than the ones used for hearing students.

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<sup>2</sup> GSL: Greek Sign Language

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