A DESCRIPTIVE STUDY OF WORKING MEMORY, PHONOLOGICAL AWARENESS AND LITERACY PERFORMANCE OF PEOPLE WHO USE AAC

María Luisa Gómez Taibo
Pilar Vieiro Iglesias
Universidade da Coruña
María Sotillo Méndez
Universidad Autónoma de Madrid
and
María del Salvador González Raposo
Universidad de los Andes

Ten cerebral palsied adolescents and young adults with complex communicative needs who use augmentative and alternative communication were studied. They were classified according to their high versus low working memory capacity and according to their high versus low phonological skills into two groups of participants. These groups were compared on their performance in reading tests –an orthographic knowledge test, a word test and a pseudoword reading test- and in the spelling of words, pseudowords and pictures' names. Statistical differences were found between high vs. low phonological skills groups, and between high and low working memory groups. High working memory capacity group scored significantly higher than low working memory group in the orthographic and word reading tests. The high phonological skills group outperformed the low phonological skills group in the word reading test and in the spelling of pseudowords and pictures' names. From a descriptive point of view, phonological skills and working memory, factors known to be highly predictive of literacy skills in people without disabilities, also hold as important variables for the participants in our study. Implications of the results are discussed.

Literacy encompasses both, reading and writing (Koppenhaver and Yoder, 1993). It is a well known fact the enormous effort that people with complex communication needs face in developing basic reading and spelling skills (Berninger and Gans, 1986; Blischak, 1994; Dahlgren Sandberg, 2001; Dahlgren Sandberg and Hjelmquist, 1996a, b; 1997; Foley, 1993; Foley and Pollatsek, 1999; McNaughton, 1998; Vandervelden and Siegel, 1999).

The poor literacy skills exhibited by people who use AAC are usually attributed to intrinsic and extrinsic factors (Basil, 1998). Intrinsic factors can be broadly divided into four areas of impairment: physical, sensory/perceptual, language and cognitive (Smith and Blischak, 1997; Sturm, 1998). The most frequent quoted intrinsic factors are individual conditions, problems in memory capacity, deficits in speech and language abilities (e.g., reduced expressive vocabulary, limited verbal comprehension), perceptual difficulties (e.g., visual, auditory) and importance of self as a reader (Dahlgren Sandberg, 1998; Dahlgren Sandberg and Hjelmquist, 1996b, 1997; Smith, 1989, 1992a, 1992b). Home and school learning and literacy experiences are the most studied extrinsic factors. The results of research on home literacy experiences in disabled children show reduced opportunities to use printed materials (Light and Kelford Smith, 1993), restricted access to literacy events, less active participation in story reading process, passive roles in interactive patterns, limited use of language (Dahlgren Sandberg, 1998; Light, Binger and Kelford Smith, 1994; Pierce and McWilliam, 1993), and low priorities and expectancies for literacy development (Light and McNaughton, 1993). At school, children who use AAC have limited access to formal instruction and lack of exposure to the general curriculum, they receive less instructional time than peers without disabilities (Koppenhaver and Yoder, 1992), and they spend more time in non literacy activities than in any single literacy activity during their literacy instructional time (Koppenhaver, 1991).

A useful point of departure for the investigation of literacy development in people who use Augmentative and Alternative Communication -AAC (Smith and Blischak, 1997; Yoder, 2001) is the wealth of information on literacy development in the general population. Despite the fact that reading and writing need to be specifically learned, in learning to read and spell children must have certain phonological, linguistic and cognitive aspects well developed (Vieiro, 2003). Some of these prerequisite skills include phonological awareness, rime and alliteration, well developed lexical representations, both the phonological specificity of lexical representations and the store of sight words; a rich semantic memory, and a broad working memory capacity (Vieiro, 2007).

According to dual-route cognitive models of reading and writing (Coltheart, 1985; Patterson, Marshall and Coltheart, 1985; Seidenberg, 1985), there are two routes in lexical access. In sight word reading, readers form connections between the visual configuration of written words and their meanings in memory. These connections are learned by rote and require much practice (Baron, 1979; Coltheart, Davelaar, Johassen and Besner, 1977; Ehri, 1991; Frith, 1980; Morton, 1969, 1979a). In writing, the ortographic route involves meaning activation in the semantic system and direct access to the ortographic representation from the mental lexicon. This route allows writing familiar and well-known words with arbitrary spellings (Templeton and Bear, 1992).

Phonological awareness (PA) refers generically to the ability to abstract and manipulate segments of spoken language, that is, the children’s awareness of sounds (Morais, Alegría and Content, 1987; Wagner and Torgesen, 1987); the phonological recoding in reading involves transforming spellings of words into pronunciations via the application of grapheme to phoneme correspondence rules (G-P-C-R) and then, searching the lexicon of spoken words to find a meaningful word that matches the pronunciation just generated (Coltheart, 1978, 1980). In writing, this ability involves the application of P-G-C-R in order to obtain the orthographic form of the word. This route allows the spelling of pseudowords and unknown words with regular spellings (Brady and Shankweiler, 1991). PA and its correspondence to a graphemic representational system are pointed to be unequivocal predictors of reading and spelling ability (Bryant, Nunes and Bindman, 2000; Cain, Oakhill and Bryant, 2000; Ellis and Large, 1988; Goswami and Bryant, 1990; Hoien, Lundberg, Stanovich and Bjaalid, 1995; Lundberg, Frost, and Petersen, 1988; Lundberg y Hoien, 1991). Deficits in PA have been identified as the critical factor underlying the severe word decoding problems displayed by reading disabled individuals (Bruck, 1990, 1992; Galaburda, 1988; Hoien, Lundberg, Larsen and Tonnessen, 1989; Olson, Wise, Conners and Rack, 1990; Siegel and Ryan, 1988).

There are at least three ways of breaking up a word into its constituent sounds and thus, there are at least three possible forms of phonological awareness: syllables (break word up into its syllables), phonemes (a phoneme is the smallest unit of sound in a word; alphabetic letters can typically change the meaning of a word), and intrasyllabic units (onset and rime). The perhaps most obvious type of phonological awareness, at least in Spanish, consists of breaking a word up into its constituent syllables; however, we need to use smaller units than the syllable to read unknown words, being the phoneme the smallest unit of sound. The importance for a child to learn how to use the relationships between single letters and single phonemes, or *grapheme-phoneme* correspondences, as these relationships are often called, has been widely recognised. Words may also be divided into units larger than the single phoneme, units which themselves consist of two or more phonemes, but smaller than the syllable. Obviously, someone who can explicitly report the sounds in any word is phonologically *aware*. But, researchers have begun to extend the use of the term *awareness* by introducing the subject of rhyme. As Goswami and Bryant (1990) argue, a child who recognises that two words rhyme and therefore have a sound in common must posses a degree of phonological awareness, even if it is not certain that this child can say exactly what is the sound that these words share.

About the nature of reciprocal relationship by which early reading and spelling skills are acquired, Goswami and Bryant (1990) have found that there are three causal factors in learning to read: rhyme and alliteration or the phonological abilities that preschool children have; access to phonemes knowledge and its relation to graphemes as an instruction result; and the reciprocal influence between reading and spelling. Reading experience has an influence on spelling. In the same way, experience in spelling also influences reading. Qualitative changes are produced in this last relationship; these changes favour reading and spelling development in a child.

Phonological awareness levels vary in terms of complexity and difficulty (Yopp, 1988), emerge at different stages in a child's linguistic development (Goswami and Bryant, 1990) and may be assessed through many different tests (Denton, Hanbrouck, Weaver, and Riccio, 2000). Nevertheless, a major problem for testing people with complex communicative needs is that most existing tasks rely on the ability to speak. Changing these tests so that they do not require speech is difficult (Blischak, 1994; Vandervelden, 2003). As the different levels of PA demand different ways of information processing and place different demands on working memory capacity, this could in part explain the reading and spelling difficulties found among people with complex communicative needs that use CAA. In this sense, Dahlgren Sandberg (2001) stated that further research in this area is warranted.

The existence of phonological awareness in spite of the absence of productive speech has been an important question regarding the population with complex communicative needs. Research has provided evidence of such PA in the anarthric or severely dysarthric population, although not always intact (Baddeley and Wilson, 1985; Bishop, 1985; Bishop, Byers Brown and Robson, 1990; Bishop and Robson, 1989a, b; Dahlgren Sandberg and Hjelmquist, 1996a; Foley, 1993). Dahlgren Sandberg and Hjelmquist (1996a, b; 1997) and Dahlgren Sandberg (2001) studies have shown good phonological abilities in a group of preschoolers and school children that used CAA. However, non speaking children that used AAC had some difficulties with some of the indicators of PA, namely synthesis of phonemes and word length analysis, whereas recognition of rhyme was the easiest task (Dahlgren Sandberg and Hjelmquist, 1996b). Lower scores on all phoneme awareness measures (i.e., recognizing sounds in spoken words or manipulating sounds) were also found by Vandervelden and Siegel (1999, 2001) in a group that used AAC compared to a group of natural speakers. Another important finding was that in an within-group analysis among children using AAC, the reading children showed a better performance on all memory tests and on the sound identification and word length analysis tasks, than the non reading ones (Dahlgren Sandberg and Hjelmquist, 1997).

In spite of good phonological abilities, some studies have presented data on non vocal persons' lack of success in using their demonstrated PA on reading and writing tests (Berninger and Gans, 1986; Dahlgren Sandberg and Hjelmquist, 1996a, 1997; Foley, 1993; Smith, 1989). The low levels on literacy indicators persisted after a period of 3 to 4 years of schooling in children that used CAA compared to naturally speaking children (Dahlgren Sandberg, 2001). However, evidence was found that people who used AAC who had better skill in phoneme awareness also had better skill in word reading (Vandervelden and Siegel, 1999, 2001). As these authors remarked, although these students may have less skill, phoneme awareness was important in their word reading development, and their learning was the same as that of children who use speech (Vandervelden, 2003). Dahlgren Sandberg and Hjelmquist (1997) also stated that there were indications that reading and spelling were related to phonological skills of the children that used AAC. According to these authors elucidation of these relationships is a challenge for future research.

Working memory (WM) span is one of the more outstanding cognitive influential factors to the acquisition of reading and spelling skills (Oakhill, 1982). As many researchers recognize (Dahlgren Sandberg, 2001; Ellis and Large, 1988; Hoien and Lundberg, 1992) memory processes at work during the very rapid processes of decoding and encoding are of critical importance. Reading and writing, as cognitive tasks, require the manipulation of information which demands temporary storage. Working memory is assumed to provide the storage and to be involved in the temporary processing and storage of information so it plays a central role in linguistic abilities (Baddeley and Hitch, 1974). Gathercole and Baddeley (1990, 1993) have stressed that during reading and spelling stable phonological representations must be constructed and stored in verbal short-term memory in order to be used as a working memory system. According to Baddeley's working memory model, one of its components, the phonological loop is a specialized function for the storage of verbal material or the recoding of nonverbal information, representing the material in a phonological code that decays with time unless it is rehearsed in an articulatory process.

Deficits in phonological recoding might reflect impaired verbal short-term memory. In this sense, Ellis and Miles (1981) remarked that one of the most striking features of dyslexic children is their impaired digit span. Most studies have shown that individuals with poor reading ability exhibit shorter duration short-term memory spans for verbal material (Bowey, Cain, and Ryan, 1992; Hansen and Bowey, 1994; Newman, Fields and Wright, 1993; Siegel and Ryan, 1988; Snowling, 1991) than for nonverbal material. Snowling (1987) proposed that verbal memory deficits are linked to linguistic problems and especially to problems of segmentation of the sound structure of words. Another finding was the strong relationship observed between efficiency of phonological processes and capacity of verbal memory supporting the hypothesis that reducing phonological processing requirements in verbal short-term memory increases available resources for storage (Rapala and Brady, 1990). Because of brain damage, lower memory capacity could be expected in cerebral palsied people with complex communicative needs, which might affect their reading skills negatively.

As it may be seen, previous studies have compared the phonological skills' performance of non speaking people with others with either speech or impaired speech. Unfortunately, there is little knowledge about people with complex communicative needs' performance on reading and spelling related to phonological skills and working memory capacity, as a group in its own right. So, it deserves all our attention. Only the study of Dahlgren Sandberg and Hjelmquist (1997) has compared reading and spelling skills among non speaking children. They found that their reading and non-reading subgroups differed on their results in identification of sounds and in synthesis of sounds tasks; these groups also differed on verbal memory measured by a digit span task (Wechsler, 1977) and in the amount of Bliss vocabulary and verbal comprehension.

Aim of the study

The purpose of this study is to conduct a descriptive research of the reading and spelling skills in a group of cerebral palsied people with complex communicative needs who use alternative and augmentative communication. The focus in this study is on early literacy and the acquisition of a reading and spelling vocabulary. More specifically, the aim of this study is to compare the effects of working memory (Experiment 1) and phonological skills (Experiment 2) on the differences in literacy performance of young adults with cerebral palsy. There are two hypotheses in this study. The first hypothesis holds that if working memory (WM) capacity is a variable in order to learn to read and spell in people without disabilities, then a significant higher performance in reading and spelling measures will be expected in a high WM capacity group than in a low WM capacity group of people with CCN who use AAC. According to the second hypothesis, it is expected to find statistical significant differences among high and low phonological skills (PS) groups; the higher PS group is expected to obtain higher results in their ability to recognize and read words and pseudowords and in their spelling abilities than the low PS group.

Method

Participants

Twelve participants, 7 men and 5 women, who ranged in age from 16 to 34 years (mean age=24 years) (Experiment 1) and ten participants, 7 men and 3 women, who range in age from 18 to 34 years (mean age=25.8 years) (Experiment 2) were randomly selected from a pool of 24 persons with cerebral palsy and speech impairments. The inclusion criteria for participating in the study were: a) a cerebral palsy's medical diagnostic; b) the presence of complex communication needs, and c) the use of augmentative and alternative strategies. A restrictive criterion was that participants also had to know both the letter names for the whole alphabet and its sounds, so they must had well established letter-sound correspondence rules.

Participants in this study were older than other participants quoted in the literature (Dahlgren Sandberg and Hjelmquist, 1996a, b, 1997, 2001). According to memory research, those who defend structural developmental changes in working memory argue that by the age of sixteen there are no more modifications in working memory span (Pascual-Leone, 1980; Kail, 1986; Siegel, 1994). So, participants in this study are assumed to have a stable working memory span. With aging, there are changes in functional storage capacity and tasks are performed more rapidly and strategically (Case, 1985); therefore, it is assumed participants have acquired memory strategies. Six participants in this study had a high working memory capacity and the remaining six had a low working memory capacity, according to their results in the Digit Span subtest of the WAIS (Wechsler, 1999).

Participants' descriptive characteristics are the following: 7 participants had no speech and depended mainly on AAC techniques to communicate; the other 3 participants could produce some speech sounds and their dysarthria ranged in severity from moderate to severe. For the expression of *yes* and *no* responses nearly all of the participants used head gestures, 2 of them added sounds and vocalisations to their nodding, and only 1 person could clearly communicate *yes* and *no* through vocalisations.

The receptive language skills profiles, tested with the Peabody Picture Vocabulary Test (Dunn, Padilla, Lugo, and Dunn, 1986) were heterogeneous. 5 participants' receptive vocabulary was moderately high, 2 participants' receptive vocabulary was moderately low, and it was restricted in 5 participants as tested by the Peabody test. Participants' grammar receptive skills, assessed with the Test for Reception of Grammar (Bishop, 1989), were varied as well. All parents, teachers and familiar partners informed of good comprehension of language in predictable sequences of everyday activities and routines. Nevertheless, these skills were considered to be adequate only in 5 participants, but were poor and extremely poor in the remaining 7 participants as they failed to recognize most of the focused language structures in the Bishop's grammar test.

Participants also exhibited different profiles regarding their expressive language skills. 6 participants showed good expressive language skills. Regarding language form, 3 out of these 6 participants used traditional orthography: the first one, communicated through auditory partner assisted scanning of the alphabet; the second one, communicated messages linking syllables on a syllabic board and used a Canon communicator without voice output to follow her studies; and the third one, used a syllabic board with unfamiliar partners, and finger-spelling in order to communicate quickly with his familiar partners; he reached a high level of proficiency in the finger-spellings. These three participants made a transition from PCS and Bliss symbols to the use of the alphabet as a communication mean. Two out of these six participants used low tech boards that combined PCS with the traditional orthography; one of these used Winspeak as well -communication software program with digitised speech, on a desktop computer and accessed it by means of a head switch. The last participant used Minspeak icons on DeltaTalker with speech output that he accessed with a switch activated by a movement of his knee. These 6 participants communicated with long and well structured sentences from a grammatical and syntactical point of view. Regarding the content of their language, they communicated a variety of topics. For example, they talked about the last book they read, the last film the saw, about their short and long run plans, about their families, and so. They all had experience with different language functions. They used language not only to report on past and present experiences but also to imagine, to predict, to elicit information, to solve problems, to social closeness, and so.

Expressive language skills were limited in the remaining 6 participants. Two of these participants used about 150 PCS, one with partner assisted scanning, the other one with direct selection with his index finger. Although they had that amount of symbols, they didn't use all of them. Their utterances' mean length was 1.5. They used the symbols in a responsive mode with few initiations. Another participant used Bliss symbols; although she had a board with 350 Bliss symbols, she only used about 30 symbols to answer questions and for the expression of wants and needs. Her utterances' mean length was 1 symbol. Another two participants used traditional orthography; one used an alphabetic board with a head stick and the other one communicated messages linking syllables on a low tech communicator. They both used head and body movements to gain somebody's attention, and then they were given their communication devices. They didn't always have the communication devices available to them, so they were used to using eye-pointing for the expression of wants and needs. The mean length of their utterances was 1.5. They had no need to finish their sentences because as they began spelling, the partners predicted the rest of the word or sentence. Finally, one participant only used unaided strategies. He used his body movements to signal his desire of communicating wants and needs; then, his communication partner initiated auditory scanning of questions and he used head movements for *yes* or *no*. He also gazed to objects or persons as a communication mean. The restricted range of communication functions fulfilled was clearly influenced by the limited modes of communication available to him.

All participants but one were introduced AAC early in their lives. Six participants came from a collaborative home and school environment that provided a broad range of life experiences and broad opportunities to learn and to participate, and that supported communication in different contexts. In spite of teacher's high expectations, motivation and support to communication, knowledge and attitude barriers were identified in the families of the 6 remaining participants. For example, low parental expectations and physical disease prevented one young woman participant from attending school regularly and therefore learning the use of alternative and augmentative strategies soon in her life. Another participant had to drop the use of an AlphaTalker due to his mother's negative beliefs and attitudes about technology and her preference of unaided communication means. Four participants didn't use their communications boards outside their occupational or educational environment due to lack of familiar support.

Three participants attended integrated settings, two of them following the regular curriculum with specific adaptive instruction and the support of an educational assistant; the third one had a significant curricular adaptation. One attended university. The remaining participants came from special settings for people with motor impairments or from occupational centres; one was preparing the university access, one had finished elementary school, one had finished secondary education, four had not finished their elementary studies and one participant gave up secondary education. All the participants were tested after years of formal school attendance so they all had enough years of literacy instruction.

Table 1 provides information relating to sex, age, kind of cerebral palsy, type of speech impairment, AAC techniques and educational characteristics for each participant; it also summarises information relating to fine motor abilities of participants.

Table 1
Participants characteristics

Participant	Sex	Age	Cerebral Palsy	Speech Impairment	Fine motor Abilities	AAC techniques	Educational level
1. E	M	30	Spastic	Anarthria	Unaided pointing with index finger.	Syllabic board, fingerspelling, some gestures and head noddings.	University. Integrated settings.
2. J	M	18	Spastic	Anarthria	No hand function.	Alphabet auditory partner assisted scanning, head noddings.	High school finished. Occupational centre.
3. Ch	F	33	Spastic	Dysarthria	Unaided pointing with thumb.	Syllabic board, canon communicator without speech output, head noddings, unintelligible sounds	Preparing university access. Special setting
4. P*	F	16	Athetoid	Anarthria	Impaired hand fuction due to athetosis.	SPC board with partner assisted scanning, head noddings, eye blinks, head gestures and eye pointing.	Adaptive instruction. Integrated setting.
5. R	M	23	Spastic	Dysarthria	No hand function.	Alphabetic board, some unintelligible sounds, head noddings and eye pointing.	Unfinished high school. Occupational centre.
6. C	M	33	Spastic	Dysarthria	Unaided pointing with index finger.	SPC board with direct selection, some intelligible words as “yes” “no”.	Unfinished elementary school. Special setting.
7. F	M	19	Spastic	Anarthria	No hand function.	SPC board with the alphabet and partner-assisted scanning, Winspeak communication program, head noddings, facial expression.	Elementary school. Occupational centre.
8. MJ	F	25	Spastic	Anarthria	No hand function.	Syllabic low technology communicator, eye pointing, head movements and eye blinks.	Unfinished elementary school. Special setting.
9. L*	F	17	Spastic	Anarthria	No hand function.	SPC board with alphanumeric encoding, eye pointing, head noddings and facial expression.	Adaptive instruction. Integrated setting.
10. P	M	34	Spastic	Anarthria	No hand function.	DeltaTalker, head noddings, smiles and facial expression.	Unfinished elementary school. Occupational centre.
11. V	F	26	Spastic	Anarthria	Unaided pointing with index finger.	Bliss board, head noddings, facial expression.	Unfinished elementary school. Occupational centre.
12. O	M	17	Spastic	Anarthria	No hand function.	Unaided strategies as body movements, head noddings and “yes” and “no” gestures in response to auditory scanning.	Adaptive instruction, significant curricular adaptation. Integrated setting.

As in many other investigations (Dahlgren Sandberg and Hjelmquist, 1992, 1996b), the limited number of participants in this exploratory study was due to the small number of people that satisfied the initial criterion of use of augmentative and alternative communication due to a cerebral palsy condition. Another reason was the difficulty to gather enough number of participants, with the same characteristics, to fit in the different experimental situations (Bedrosian, 1999).

Materials

The main criterion for the selection and preparation of test materials was that assessment materials had to be suitable to the motor abilities of participants.

When standardised tests were used, an effort was made to find instruments that demanded as few procedural adaptations as possible, thereby eliminating the risk of introducing entirely new task requirements (Blishack, 1994).

Phonological skill tasks

Selected phonological skill tasks tapped into different levels of phonological processing skills - phoneme, syllable, and word levels- as they are widely acknowledged (Denton and cols., 2000; Hoien and cols., 1995). These tasks demanded different types and amounts of processing (Yopp, 1988) and also placed different loads on working memory. Though in Spanish there are no standardised phonological tests adapted to people who use AAC, our materials were based on standardised instruments by Calero, Pérez, Maldonado and Sebastián (1999). Pictures in phonological test items were taken from the *Registro Fonológico Inducido* by Monfort (1982). Table 2 shows phonological test items.

Memory capacity

The Digit Forward part of the Digit Span subtest of the WAIS (Wechsler, 1999), which tests short term auditory memory, was used as a measure of memory span. Participants were required to point to numbers in the same order as said by the examiner. Responses could be given in any augmented way. There were two trials of each sequence of numbers in case the participant did not succeed on the first trial.

Table 2
Phonological Test Items And Reading Tests

Phonological tests:
Oddity task. A set of 12 series of 3 pictures was introduced. Two of the pictures were a pair of rhyming names; the third picture's name was odd (e.g., *perro*- botón- ratón). Participants' task was to indicate the target picture with a no rhyming name in any augmented way (e.g., eye-pointing to the picture, unaided pointing with a finger). In order to avoid any biased responses, the position of pictures with an *odd name* within a series was changed through presentations.
Syllable counting. 12 pictures depicting well known objects with easy names were presented. Number of syllables varied from 1 to 4 in every pictures' names. Pictures were randomly distributed across the test. Participants' task was to count the number of syllables in pictures' names and give the number in any augmented answer (e.g., leg or hand strokes for each syllable, pointing numbers in a computer board). For example, the word *ventana* has 3 syllables; participants should give 3 strokes or point to number 3 in a keyboard.
Phoneme counting. 12 easily recognizable and unambiguous pictures were presented. Number of phonemes in pictures' names varied from 3 to 9. Pictures were randomly ordered across the test. Participants had to count the number of phonemes in pictures' names and give this number in any augmented answer (e.g. leg or hand strokes or point to a number in a computer's keyboard). For example, the word *ojo* has 3 phonemes; participants should point to number 3 in their communication devices or in a keyboard.
Phoneme identification. 36 pictures depicting well known objects were presented. Pictures' names comprised all Spanish sounds. Participants had to decide whether a particular phoneme pronounced by the examiner was present or not in a picture's name. Participants' *yes* or *no* responses were given in any augmented way (e.g., blinking once or twice, thumb up or down for *yes* or *no* respectively, head noddings). Target phonemes' location was changed across the words (e.g., initial, middle or final position)
Phoneme blending. 12 pictures depicting well known and recognizable objects were presented in two boards with 6 items each. The examiner pronounced its names, phoneme by phoneme, with an interval of ½ second between successive sounds. Participants' task was to select the picture that matched the pronounced word. The length of the words varied from 3 to 8 phonemes.
Reading tests:
Ortographic knowledge test. A set of 30 words was presented: 15 words with orthographic conventional spellings and 15 non words. Participants were asked to read them and to decide whether they were real words or not, through any *yes* or *no* augmented responses.
Word reading test. 30 words were presented. Participants had to read one word at a time. Then they were shown a chart with 4 PCS. Participants' task was to look for the matching picture from an array of four. Augmented responses were given by direct selection with a finger or eye pointing.
Pseudoword reading test. Participants in this lexical decisions task had to read 40 words and 20 pseudowords, presented one at a time, and they had to decide, after their reading, whether they were real words or not. *Yes* and *No* were given by means of any augmented response.

Reading tasks

Three tests from the *Batería para la Evaluación de los Procesos Lectores PROLEC* (Cuetos, Rodríguez and Ruano, 2000) were used to assess lexical access. An orthographic knowledge test was used. Cuetos et alt. (2000) have stressed that, by the age of 8 years old, Spanish children have the orthographic rules knowledge. A word reading test was used to assess word recognition and thereof, the use of lexical route in reading. Finally, a pseudoword reading test was used to evaluate the use of phonological route in reading. Table 2 (above) shows reading test items.

Spelling Tasks
Three spelling tasks were used; spelling of 6 single words (e.g., *sol* [sun], *lavadora* [washing machine]), spelling of 6 non-words (e.g., *ols*, *valarado*), and spelling of 6 pictures' names (e.g. PCS of *teléfono* [telephone]). Participants were required to spell only 6 items in every spelling task in order to eliminate fatigue and to increase motivation. Words in the first two tasks were presented orally. Pseudoword spelling task was introduced to check whether participants managed spelling without the aid of an orthographic representation or not. The spelling of pictures' names was introduced to determine how participants managed spelling when they had to produce phonological representations on their own.

Participants' task was to write down the words or pseudowords they heard, or the names of the pictures pointing to the letters on the adaptive technology. The examiner wrote the letters down so that each person would be able to see the results of the spelling task.

Design
EXPERIMENT 1
One simple small-group design for independent groups was applied to working memory (WM) measures in order to test the first hypotheses. The statistic used was the difference between means and this was carried out using a standard non-parametric test, the t-Student test.

Working memory capacity independent variable had two levels, high and low, after the application of the median as statistical criterion to the Digit Span task's scores (Md=3.50). A score above 3 in the Digit Span test was considered high working memory capacity. Scores under 3 were considered as low working memory span. Assignments to high (WM_1) and low (WM_2) working memory groups were made post testing according to the working memory capacity of the 12 participants. There were two groups of 6 participants each. The two following studies were considered in the assignation, the Elosúa, Gutiérrez, García, Luque and Gárate (1996) study, and the Desmette, Hupet, van der Linden and Schelstraete (1995) study, which propose an integrate model to categorize subjects according to their working memory span, less restrictive than Daneman and Carpenter (1980) one. See Table 3 for digit span test scores.

There were 3 reading dependent variables: the number of words correctly identified at the orthographic knowledge test; the number of words correctly read at the word reading test, and the number of pseudowords correctly identified at the pseudoword reading test. There were 12 spelling dependent measures: number of lexical elements correctly spelled (words, pseudowords and pictures' names), total number of letters in words, pseudowords and pictures' names; and first and last letters in words, pseudowords and pictures' names.

EXPERIMENT 2
Materials were the same as those used in Experiment 1, but only ten people participated in Experiment 2 (those marked with * in Table 1).

One simple small-group design for independent groups was applied to phonological skills (PS) measures in order to test the second hypotheses. The statistic used was the difference between means and this was carried out using a standard non-parametric test, the t-Student test.

Phonological skills independent variable was a variable made up of all participant's scores at all PS tasks; the sum of all scores showed a participant's performance profile in phonological skills. After the application of the median as statistical criterion to these scores (Md=53), this variable had two levels. Scores above and under 53 were considered low and high phonological skills, respectively. Assignments to high (PS_1) and low (PS_2) phonological skills groups were made post testing according to the phonological skills level of the 12 participants. Subjects 4 and 9 were discarded due to the proximity of their scores (52 and 54 respectively) to the median. Thus, there were two groups of phonological skills with 5 participants each. See Table 3 for phonological skills tasks scores.
In Experiment 2 the reading dependent variables were the same as the ones used in Experiment 1

Table 3:
Participants' scores at memory and phonological skills tests

Participants	Working Memory	Phonological Awareness
E	4	84
J	5	79
Ch	4	74
P*	4	52
R	4	45
C	4	39
F	3	57
M^{a}J	3	57
L*	3	54
P	3	49
V	3	39
O	2	31
Median	3,5	53

Procedure
Procedure was the same for Experiment 1 and 2. Tasks were presented in as many sessions as needed over several days in order to minimize the influence of fatigue on performance. Great care was taken to ensure that all participants attended to the different tasks across all trials. There was no time restriction for any test.

Before proper testing, instruction was given. The examiner modelled task execution so that participants knew tasks' expectations and how to carry out the tests. Two practice items were presented as well.

Tasks were presented in the same order for all participants. The test session began with phonological skill tasks, followed by the Digit Span test, the reading tests, and finally the spelling tests. In order to control any order effect, tasks presentation order was counterbalanced within phonological skills, reading and spelling tasks.

Phonological skills tasks' stimuli were applied in a visual modality. The examiner, instead of pronouncing the name of the stimuli, presented well-known pictures depicting them. There was no validation of the test items to compare use of pictures and symbols instead of words, but this confounding variable was controlled through the use of familiar words selected from Calero et alt. (1999), and Cuetos et alt. (2000), and familiar pictures. These pictures and words were then contrasted with information provided by parents, teachers and caregivers and through the examiner's own observation.

Accuracy data were collected for every task. Every response was codified as it follows. In the Digit Span test, one point was computed for every numerical series repeated in the right order. Maximum score was the highest number of numbers repeated in the same order as the examiner presented.

In the phonological skill tasks, one point was computed for every correct response at every task. In the oddity task, one point was given for every odd word identified; final score was total number of correct odd words identified. In the counting syllable task, one point was computed for every word whose syllables were correctly counted; final score was the number of words with correctly counted syllables. In the counting phoneme task, one point was given for every word whose phonemes were correctly counted. In the phoneme identification task, one point was computed for every sound correctly identified in a word; final score was the highest number of correctly identified sounds. Finally, in the phoneme blending task, one point was computed for every picture matched to the sequence of phonemes that the participant correctly blended. All participants' scores at the phonological skill tasks were added in order to obtain a global phonological skill performance profile.

In the orthographic knowledge test every participant was given one point for every word and non word correctly sorted out in the lexical decision task; maximum score was 30. In the word reading test one point was computed for every word correctly read and then matched with its corresponding pictographic symbol; maximum score was 30. In the pseudoword reading test participants scored one point for every pseudoword they read; maximum score was 20.

In the word spelling task, the number of correct spelled words, the number of total spelled letters and the number of first and final letters in words was calculated. Maximum score was 6 spelled words, 36 spelled letters, 6 first letters spelled and 6 final letters spelled. In the pseudoword and pictures' names spelling tasks the number of correct spelled pseudowords and pictures' names, the number of total spelled letters in pseudowords and in pictures' names, and the number of first and final letters in pseudowords and in pictures' names were also computed. Same scores were given in the pseudoword and pictures' name spelling tasks as in the word spelling task.

Results
Data have been processed with SPSS 11.0 (under permission of Siain, University of A Coruña).

Experiment 1
Reading and spelling descriptive data for working memory groups are showed in Table 4. Statistical analyses were made from percentages' scores.

Table 4:
Reading and spelling descriptive data in working memory capacity groups

		Working memory capacity					
		Low WM_1			High WM_2		
	N	Mean	Sd	%	Mean	Sd	%
Recognized patterns	6	14.67	7.94	48.9	24.00	7.51	80
Read words	6	17.83	4.75	59.4	22.83	9.23	76.1
Read p seudowords	6	9.00	8.39	45	16.17	3.92	80.8
Nº of spelled words	6	1.50	1.87	25	3.83	2.63	63.8
Nº of spelled pseudowords	6	1.33	1.21	22.1	3.33	2.80	55.5
Nº of spelled pictures' names	6	.83	1.60	13.8	4.00	2.75	66.6
Nº letters spelled in words	6	17.33	11.5	48.1	27.17	13.43	75.4
Nº letters spelled in pseudowords	6	15.00	11.45	41.6	25.17	15.13	69.9
Nº letters spelled in pictures' names	6	16.50	10.50	45.8	26.50	15.12	73.6
Nº first letters in words	6	3.00	2.53	50	4.83	1.94	80.5
Nº first letters in pseudowords.	6	2.83	2.56	47.1	4.50	2.51	75
Nº first letters in pictures' names	6	2.67	2.16	44.5	4.50	2.07	75
Nº last letters in words	6	2.83	2.13	47.1	4.33	2.58	72.1
Nº last letters in pseudowords	6	2.83	2.48	47.1	4.17	2.56	69.5
Nº last letters in pictures' names	6	2.83	2.31	47.1	4.50	2.51	75

There were differences between high (WM_2) and low (WM_1) working memory capacity groups in descriptive reading and spelling data. WM_2 performed better than WM_1 in all the reading and spelling tasks (see Table 4 and Figures 1 and 2).

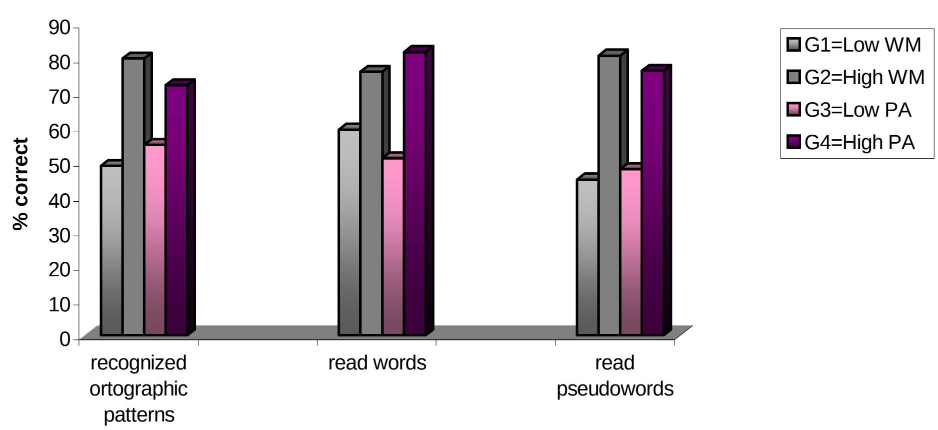

Figure 1.
Reading percentages in working memory and phonological skills groups

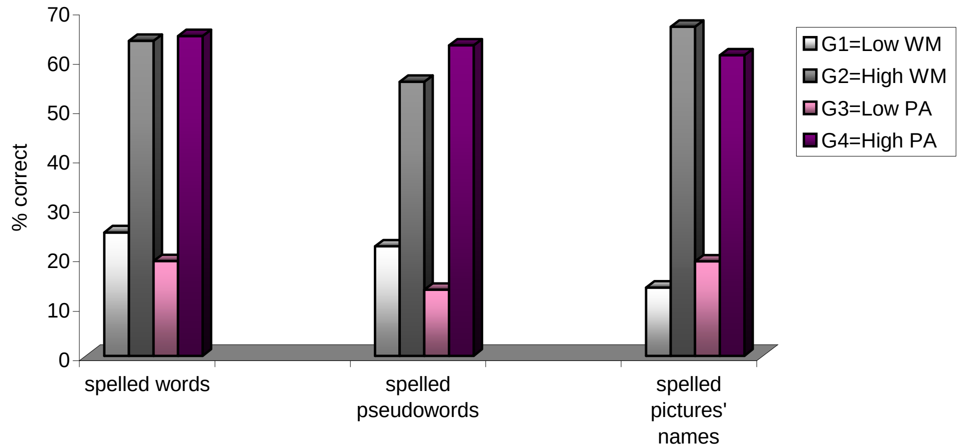

Figure 2.
Spelling of lexical elements' percentages in working memory and phonological skills groups

t-Student analysis showed statistical differences between working memory capacity groups in the number of orthographic patterns recognized (t = 3.17; p<.001), in the number of sight words read (t = 6.43; p<.001), and in the number of pictures' names spelled (t = 2.43; p<.05) (see Table 6).

Table 5:
Reading and spelling descriptive statistical data in phonological skills groups

		Phonological skills					
		Low PS_1			High PS_2		
	N	Mean	Sd	%	Mean	Sd	%
Recognized patterns	4	15.88	6.02	55.1	21.87	10.3	72.3
Read words	4	13.99	5.94	51.2	25.09	5.06	81.9
Read p seudowords	4	8.09	6.01	48.1	15.02	7.22	76.5
Nº of spelled words	4	.98	1.09	19.2	3.98	2.02	64.8
Nº of spelled pseudowords	4	.80	1.03	13.4	3.09	2.01	62.9
Nº of spelled pictures' names	4	1.09	2.09	19.1	3.07	2.08	60.9
Nº letters spelled in words	4	13.22	11.99	38.1	30.01	7.16	84.8
Nº letters spelled in pseudowords	4	10.09	11.87	28.8	29.03	6.96	81.3
Nº letters spelled in pictures' names	4	14.12	12.83	39.1	27.83	9.05	79
Nº first letters in words	4	2.06	2.09	41.1	4.93	.91	87.8
Nº first letters in pseudowords.	4	1.09	2.12	35.8	5.07	1.58	84.1
Nº first letters in pictures' names	4	2.09	2.07	35.5	4.33	1.06	83.1
Nº last letters in words	4	1.01	2.01	32.3	5.09	1.11	85.8
Nº last letters in pseudowords	4	1.62	1.98	26.8	5.11	1.09	87.8
Nº last letters in pictures' names	4	1.98	2.01	35.3	5.06	1.33	85.8

Experiment 2
Reading and spelling descriptive data for phonological skills groups are showed in Table 5. Statistical analyses were made from percentages' scores.

As it is showed in Table 5 and Figures 1 and 2, high phonological skills group performed better than low phonological skills group. There were differences between PS_2 and PS_1 in all descriptive reading and spelling measures. However, t-Student analysis only showed statistical significant differences between groups in reading, specifically, in the number of sight words read (t = 3.43; p<.001). In spelling, there were statistical differences in the spelling of pseudowords (t = 2.83; p<.05), and in the spelling of pictures' names (t =-2.72; p<.05). (See Table 7) There were also significant differences in the total number of spelled letters in words (t = 2.49; p<.05). Differences between groups were also significant in the number of first letters spelled in pseudowords (t = 2.35; p<.05) and last letters spelled in pseudowords (t = 3.33; p<.05).

Table 6:
t-Student results for working memory groups

	Working memory	
	t	p
Recognized orthographic patterns	3.8991	.001789*
Read words	4.8766	.001345*
Read pseudowords	2.6755	.119877
Spelled words	1.9887	.184553
Spelled pseudowords	1.7655	.126890
Spelled pictures' names	2.1233	.03122*
Letters spelled in words	-.12344	.143455
Letters spelled in pseudowords	-1.0999	.18999
Letters spelled in pictures' names	-1.2345	.14866
First letters spelled in words	.98763	.15922
First letters spelled in pseudowords	-1.2548	.11228
First letters spelled in pictures' names	-.34558	.10611
Last letters spelled in words	-.67777	.31337
Last letters spelled in pseudowords	-.87542	.34331
Last letters spelled in pictures' names	-1.6999	.25323

*p<.05; **p<.001

Table 7:
t-Student results for phonological skills groups

	Phonological skills	
	t	p
Recognized orthographic patterns	1.12357	.35434
Read words	3.43855	.002115**
Read pseudowords	1.09931	.287611
Spelled words	1.54603	.868761
Spelled pseudowords	2.83226	.023476*
Spelled pictures' names	-2.72210	.021118*
Letters spelled in words	2.49341	.032111*
Letters spelled in pseudowords	1.21184	.043214
Letters spelled in pictures' names	1.98235	.071134
First letters spelled in words	2.08110	.070988
First letters spelled in pseudowords	2.35228	.043444*
First letters spelled in pictures' names	-2.13119	.066108
Last letters spelled in words	-1.21141	.222179
Last letters spelled in pseudowords	3.33333	.014333*
Last letters spelled in pictures' names	2.172343	.060133

*p<.05; **p<.001

Discussion

Participants in this study exhibited different ability and skill profiles. The Cerebral Palsied population is a heterogeneous group with different physical and sensory impairments, different profiles in language and cognitive abilities, and varied educational experiences. Higginbotham and Bedrosian (1995) have stated the possession of some sort of communication disability and use of a communication technology may be their only commonalities. Therefore, there are difficulties in the implementation of group designs given the low incidence of the AAC population and the variability within this population (Bedrosian, 1999; Light, 1999; Sevcik, Romski and Adamson, 1999). However, despite this variety of personal circumstances, an effort was made to gather a sample as similar and numerous as possible. Though, we are conscious of the small sample in this study. Therefore, any generalization of our findings across persons that use AAC systems and our conclusions should be taken with caution.

In this study we assumed that working memory capacity and phonological skills would have an effect on reading and spelling performance in a group of people with CCN. A finding of this study was that, although the high working memory group scored higher in all literacy tasks than low working memory group, differences were only significant for the knowledge of orthographic patterns, for the reading of words, and for the spelling of pictures' names. The second finding of this study was that differences on phonological skills were related to differences in the spelling of pseudowords and pictures' names, to differences in the number of letters spelled in words, and to differences in the spelling of the first and last letter in pseudowords; nevertheless, differences on phonological skills had no effect on all reading measures but in the reading of words.

As it is known, working memory is important for reading (Baddeley, 1982; Daneman and Carpenter, 1980). Memory is involved in learning the spelling conventions, too. In fact, for an expert reader, reading involves the recognition of words and their specific spellings. In Spanish, there is an important number of words that have specific spellings. In order to recognize these words and to read them for accessing their meanings, a person has to know the orthographic rules (i.e., words with same sounds [*b-v*, *j-g*, *c-q-k*, *ll-y*, *h-no h*] but conventional spellings). As our results show, it seems that, once orthographic knowledge is learned and a visual sight vocabulary is acquired, working memory has a role in reading performance. In our study, it was significantly easier for high working memory capacity participants to recognize written orthographic conventions and to read words than for low working memory capacity ones; in fact, the higher number of correctly recognized and read words for the former group, seems to suggest so. Obviously, their high cognitive capacity has allowed participants to significantly learn much more orthographic conventions and to succeed in recognizing a greater amount of orthographic patterns. In this sense, low working memory capacity participants have acquired a very restricted visual written vocabulary, and therefore they have stored in memory a fewer amount of visual representations of words; they have read significantly less visual words, and they have made a high number of mismatches between read words and pictures. These significant differences might be interpreted as an evident lack of success of low working memory participants in using the visual route in reading. Furthermore, though in this study we have not taken into account on-line reading measures, we have informally appreciated that it took longer for them to read the words**.** This fact could also be interpreted as an evidence of the use of the indirect route in reading, and as a failure in the application of the GPCR when using the phonological route in reading familiar words. Low working memory group read at a very basic level, they could not even read the fiftieth percent of the tested words; those words constitute a very basic visual vocabulary that was chosen from a reading test that typically applies to children from 6 to 9 years old in Spanish.

When looking at phonological skills groups' results in reading, significant differences were found in the reading of words but not in pseudoword reading. It was surprising because it was expected that high phonological skills group would outperform in this latter task. Participants were assigned to high phonological skills condition, precisely, because of their high capacity to solve phonological tasks. Phonological skills are basic in order to grasp the alphabetic principle (Gough, Ehri y Treiman 1992; Byrne and Fielding-Barnsley, 1990). Besides, in order to read pseudowords, for which there are not any representations in the lexicon, phonological skills are necessary as grapheme to phoneme correspondence rules must be applied (Morton, 1979b). Our results, though different to the expected ones, are similar to those reported in literature. Research has showed this same lack of ability of cerebral palsied preschool children in applying their demonstrated phonological skills in reading (Dahlgren Sandberg and Hjelmquist, 1996a, b). Expert readers characterize by their ability to indistinctly use the direct and the phonological routes in reading (Coltheart, 1978; Grainger and Ferrand, 1996). In this study, the high phonological skilled group behaved as a novice reading group, in that they could not rely on their phonological abilities in order to solve the pseudoword reading problem; nevertheless, they could solve the word reading problem significantly better than low PS group. This means their reliance on a well-known visual vocabulary but their difficulty to read new words using the indirect route. Looking for an explanation of the lack of significant differences between phonological skills groups, performance within groups was analyzed. It was noticed that some of the participants within the high phonological skills group did nearly perfect in the reading of pseudowords, meanwhile some other participants did not read half of the pseudowords. Maybe variability within groups has masked the real potential of phonological skills in reading. As a positive outcome, we should emphasize that all participants, regardless their high or low phonological skills condition, were able to decode pseudowords to a certain extent. However, when GPCR are incorrectly applied, there is no progress in reading and this might be the real situation for the low phonological skill group.

As it has been suggested, children may use, from the very first moment of systematic reading acquisition, the direct route in lexical access; supporting evidence comes from studies that show that frequent words are much better read than infrequent ones, and from studies were children read words more easily than pseudowords, showing the lexical category effect (Defior, Justicia and Martos, 1998; Domínguez and Cuetos, 1992). This is our participants' situation. Words in Cuetos et al.'s reading test were very frequent Spanish words which may explain the significant better results in reading them with a whole-word strategy. This might be interpreted as Defior et al. (1998) suggested, as an indication of the advantage of using the visual or direct route as an aid in word reading. Moreover, the worse performance in both PA groups in pseudoword reading compared to word reading performance may be another indication of participants' poor reading skills. This poor reading skills linked to the unsuccessful use of the phonological route turned participants into novice readers. It has also been remarked that previous automation in the use of grapheme to phoneme correspondences' rules allows the development of orthographic representations (Defior, and al., 1998). Participants in this study, although were able to apply this rules to a certain extent as shown by correct percentages, have failed to automate this rules as they have not differed in orthographic patterns knowledge and in pseudoword reading. This is in line with literature's reported findings about the difficulty of non speaking children to attain mastery of the grapheme-phoneme relationships necessary for successful word recognition and word identification (Dahlgren Sandberg and Hjelmquist, 1996b). Also, our results bring into line with Dahlgren Sandberg and Hjelmquist (1997) and Foley (1993). They stated that the *normal* model for development of literacy skills did not fit their results since the phonological skills of the participants in their study were not accompanied by the expected reading and writing level; so our participants were. However, Dahlgren Sandberg and Hjelmquist (1997) noticed that within the non speaking group, there was indication that reading and spelling were related to phonological skills. In our study this was evidenced by high PA group's word reading significant results.

From a lexical processing point of view, it has been pointed out that a competent reader is that one who can efficiently use both, the visual and phonological routes to lexical access. It is accepted that both routes are potential and alternatively used, and that lexical and phonological processing interact (Coltheart, 1985). So, if a reader depends solely on one or the other route this could be interpreted as a symptom of difficulty or of poor reading skills (Rueda, 1995). In the case of our participants, the significant word reading differences found between phonological groups may be indicating a preferred visual word strategy, and conversely, absence of significant differences in pseudoword reading may indicate a failure in the application of correspondence's rules. Goswami and Bryant (1990) have found that meanwhile phonemic awareness is of fundamental importance for spelling among young naturally speaking children, for early reading a whole-word strategy is at work, where the role of phonology is minimal. According to this statement, it could be said that high phonological skills participants used the visual reading strategy and as a group they could be labeled as *early readers*.

Regarding spelling results, it is important to note that, although there were no differences in the spelling of orally presented words and pseudowords between working memory capacity groups, both groups differed in the spelling of pictures' names. It seems as if the verbal aid would have helped all participants to do the task. Words and pseudowords were spoken aloud by the examiner on an ongoing basis so that all participants could spell the items. Voiced presentations of words and pseudowords have played the role of an overt articulatory rehearsal of the phonological representations of the lexical items to the working memory. Taking into account both, the time that many participants spent selecting the letters and that this selection was made letter by letter, hearing aloud the words and pseudowords was an important clue. When low working memory capacity participants had to spell pictures' names on their own, without any verbal assistance, they failed. Pictures' names may be spelled either by generating a phonological representation, storing it, and then applying phonological skills or conversely, one may directly recuperate a visual orthographic pattern from the lexicon, which it is also a memory store. Significant high working memory results suggest that a bigger span or capacity allows a greater temporary store of such phonological information and more resources allocated to its processing. Another interpretation is that a higher memory capacity involves a greater amount of visual orthographic representations stored in it. Whatever route in spelling low working memory participants used, they failed to use it strategically. Taken together, the significant recognition of orthographic patterns in reading, the significant number of words read and this spelling result, we might speculate once again that high working memory group used the direct route in reading and spelling.

Lack of significance between working memory groups in the remaining spelling measures –total number of letters, first and last letters in all lexical items- is somewhat difficult to interpret. When individual performance profiles were examined it was found again a nearly perfect performance in some high working memory capacity participants, and very poor spelling results in some others. In fact, some high working memory capacity participants didn't fail the spelling of any last letter neither in words, pseudowords or pictures' names or they reached 100% correct in the spelling of total number of letters in words and in pictures' name; on the contrary, some other high working memory participants couldn't spell any last letter, and still there was one participant that couldn't hardly spell 5% of the total amount of letters. Low working memory participants also had varied spelling performance profiles, from one participant that could spell all last letters and all first letters, and nearly all letters, to some other participants that were not able to spell either any first or last letter in any of the lexical elements.

Thus, the high variability within memory groups might be involved in the lack of significance between working memory groups.

No significant differences were found between phonological skills groups in the spelling of words. As it is known, phonological skills may not be necessary in order to spell words, because words may be visually spelled or recuperated (Seidenberg, 1985; Taylor and Taylor, 1983). This fact might explain the absence of differences between high and low phonological skills groups. Phonological skills were not used for spelling the proposed words; participants needed not these skills for spelling because the lexical items were well known words, and they were spelled using the visual route –they were visual-graphemic recuperated according to Morton's model (1979b). Therefore, neither high nor low participants used their phonological abilities for spelling, relying on the visual route for performing this task. On the contrary, phonological skills are absolutely necessary in order to spell pseudowords. In this sense, those persons with high phonological skills should succeed in this kind of spelling task; and this is another important finding in this study, namely, that phonological skill groups significantly differed in the spelling of pseudowords. This finding also indicates that phonological rules were not spontaneously but systematically applied; if low phonological skills participants had used them, differences would have been found in the spelling of pseudowords.

Phonological skill groups also differed in the spelling of pictures' names. This significantly better result has to be jointly interpreted with words and pseudowords spelling results. High phonological skill group used the application of the PGCR for recuperating pictures' names and spelling them; that is the reason why high phonological skill group outperform this task compared to low capacity group. When participants have a visual representation for the word, they may recuperate it as a whole; therefore, differences between phonological groups in the first task were not found, phonological skills were not needed for doing the task. When high phonological skill participants have not the visual representation either of the pseudoword or of the word depicted by the picture, they resort to the phoneme to grapheme correspondence rules in order to spell pseudowords and pictures' names.

It has been argued that spelling depends on retrieval and reproduction of phoneme-grapheme relationships (Snowling and Stackhouse, 1983) and that phonemic awareness is of critical importance for spelling (Goswami and Bryant, 1990). The role of phonology was an important one in literacy performance in this study. High phonological group behaved as a skilled group in that they used a visual and also a phonological strategy for spelling, in contrast to reading. In this sense they were more expert in spelling compared to low phonological skill group. As Vandervelden (2003) has stressed phoneme awareness develops gradually as part of a developing skill in using the alphabetic principle in learning to read and write. The ability to use language sounds is a strongly associated ability to reading and spelling learning (Vandervelden and Siegel, 1995, 1996, 1997). Significant spelling results for high phonological skill group in the spelling of the first and last letters in pseudowords show an effect of phonological skills on spelling performance. As it was said before, for spelling pseudowords it is absolutely necessary to apply PGCR. Their higher level of phonemic awareness has allowed them to significantly spell a greater number of pseudowords. Lack of significance between phonological skill groups in the spelling of first and last letter in words and in picture's names indicate that all subjects were able to use an early skill in spelling. These results coincide with Vandervelden and Siegel (1999, 2001) findings. Vandervelden and Siegel (1999, 2001) showed different amount of ability in the AAC students group in a spelling dictation task; their students exhibited a beginning level skill as they could spell the initial letter in a pseudoword; our participants showed a more advanced skill as they spelled the first and last letters in pseudowords, and finally, advanced skills were found as they could spell whole pseudowords. Our high PA group seems to show advanced skills compared to low phonological awareness ability group.

Concluding Remarks

This study, though descriptive, has thrown some light on the advantage that participants with high level of working memory capacity and participants with high level of phonological skills take on reading and spelling skills. Though significant, we wish to emphasize once again that our results should be taken with caution. First, we should say that this study was descriptive by nature and we can not make any inference about causal relationships among variables. Second, participants sample's size was small and their learning histories, social environments, and language and abilities profiles were varied. What has been called the extrinsic variables in language and literacy learning (Smith and Blischak, (1997) might have had an influence in the results our participants reached. Another factor to be considered is that our study has involved Spanish language and as it is known this is a transparent language as opposed to opaque English language.

As a major conclusion it could be said that participants with a high level of working memory, as a group, have read and spelled basically using the visual route. A second major conclusion is that high phonological skills participants behaved in reading as novices, they read using the visual route; but for spelling they behaved as experts, they strategically used the phonological route for spelling pseudowords. These lexical elements can only be read using the indirect route, and in this task they outperformed compared to low phonological skills participants.

Educational and clinical implications are straightforward. When attending people with complex and special communication needs, working memory span should be trained, and phonological skills should also be programmed in the intervention or educational programs. As it has been found, memory has been involved in the recognition of a much greater amount of orthographic patterns and in the reading of a greater amount of visual vocabulary. Besides, as it has been stressed, conventional orthography allows communication without any restriction. If we want people with CCN to communicate using AAC devices based on traditional orthography, we should plan the practice of phonological skills in order to teach spelling skills later. We base this conclusion on the finding that literacy skills in the high phonological skills group were very much alike to those of expert writers of typical development. In this sense, Foley and Pollatsek (1999) have pointed out that many studies have demonstrated that when children who are weak in phonological awareness receive appropriate instruction, they improve much more rapidly in reading and spelling than do control groups, especially when this instruction is linked with letter-sound and word learning, and these gains are maintained for at least 2 to 4 years (Blachman, 1991, 1994; Blachman, Ball, Black and Tangel, 1994; Bradley, 1988; Lundberd and allies, 1988). That is also the case for children with complex communicative needs (Dahlgren Sandberg, 2001).

Further research is needed to elucidate whether the descriptive relations shown in this study have a causal nature or not. It would be necessary to carry out an experimental design to answer this question.

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