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Universidad Complutense de Madrid
España

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An Exploratory Study of Phonological Awareness and Working Memory Differences and Literacy Performance of People that Use AAC

María Luisa Gómez Taibo¹, Pilar Vieiro Iglesias¹, María del Salvador González Raposo², and María Sotillo Méndez³

¹Universidad de La Coruña (Spain)
²Universidad Los Andes (Venezuela)
³Universidad Autónoma de Madrid (Spain)

Twelve cerebral palsied adolescents and young adults with complex communicative needs who used augmentative and alternative communication were studied. They were classified according to their working memory capacity (high vs. low) into two groups of 6 participants. They were also divided into two groups of 6 participants according to their high vs. low phonological skills. These groups were compared on their performance in reading tests –orthographic knowledge, 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 factors for the participants that used AAC in our study. Implications of the results are discussed.

Keywords: working memory, phonological skills, cerebral palsy, complex communicative needs, reading, spelling, performance.
Literacy is used as an umbrella term, encompassing both reading and writing (Koppenhaver & Yoder, 1993). It is a well known fact the enormous effort that people with complex communication needs face in developing even basic reading and spelling skills (Berninger & Gans, 1986; Blischak, 1994; Dahlgren Sandberg, 2001; Dahlgren Sandberg, & Hjelmquist, 1996a, b; 1997; Foley, 1993; Foley & Pollatsek, 1999; McNaughton, 1998; Vandervelden & Siegel, 1999).

The poor literacy skills showed by people who use Augmentative and Alternative Communication (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 & Blischak, 1997; Sturm, 1998). The most frequent quoted intrinsic factors are individual conditions, problems in memory capacity, perceptual difficulties (e.g., visual, auditory), importance of self as a reader, and deficits in speech and language abilities (Dahlgren & Sandberg, 1998; Dahlgren Sandberg, & Hjelmquist, 1996b, 1997; Smith, 1989, 1992a, 1992b). Regarding language development, significant difficulties across language domains, including vocabulary delays, a predominance of one- to two-word utterances, poor syntax, morphological difficulties, impaired pragmatic skills, and restricted speech acts have been reported among people with complex communication needs (Smith, 2009; Sturm, 2005; Sturm & Clendon, 2004). Home and school learning and literacy experiences are the most studied extrinsic factors. Research on home literacy experiences in disabled children seem to show reduced opportunities to use printed materials (Light & Kelford Smith, 1993), restricted access to literacy events, less active participation in story reading process with passivity in interactive patterns and limited use of language (Dahlgren Sandberg, 1998; Light, Binger & Kelford Smith, 1994; Pierce & McWilliam, 1993), and low priorities and expectancies for literacy development (Light & 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 & Yoder, 1992), and they spend more time in non literacy activities than any single literacy activity during their literacy instructional time (Koppenhaver, 1991).

A useful point of departure for the investigation of literacy development in people that use AAC (Smith & 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, as well as the store of sight words; a rich semantic memory, and a broad working memory capacity.

According to dual-route cognitive models of reading and writing (Coltheart, 1985; Patterson, Marshall & 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, & Besner, 1977; Ehri, 1991; Frith, 1980; Morton, 1969, 1979a). In writing, the orthographic route involves meaning activation in the semantic system and direct access to the orthographic representation from the mental lexicon. This route allows writing familiar and well-known words with arbitrary spellings (Templeton & Bear, 1992).

Phonological awareness (PA) refers generically to the ability to abstract and manipulate segments of spoken language, that is, the children awareness of sounds (Morais, Alegria, & Content, 1987; Wagner & Torgesen, 1987); for it, they must transform 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 & Shankweiler, 1991). PA and its correspondence to a graphemic representational system are pointed to be unequivocal predictors of reading and spelling ability (Bryant, Nunes, & Bindman, 2000; Cain, Oakhill & Bryant, 2000; Ellis & Large, 1988; Goswami & Bryant, 1990; Hoien, Lundberg, Stanovich, & Bjaalid, 1995; Lundberg, Frost, & Petersen, 1988; Lundberg & 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, & Tonnesen, 1989; Olson, Wise, Conners, & Rack, 1990; Siegel & 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 first and perhaps the most obvious kind of phonological awareness is to break words up into its syllables; however, we need to use smaller units than the syllable to read unknown words. The importance for the 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. A third and intermediate kind of phonological awareness: words can also be divided into units that are larger than the single phoneme—units which themselves consist of two or more phonemes—but that are smaller than the syllable. It is usually possible to divide a syllable into two parts, an opening unit called “the onset” and the ending unit or “rime”. The word “spelling”, for example, has a clear beginning in its first three letters “spe”, and an equally clear end section which contains the vowel and the last two consonants “ing”.

About the nature of reciprocal relationship by which early reading and spelling skills are acquired, Goswami & Bryant (1990) have found that there are three causal factors in learning to read: a) rhyme and alliteration or the phonological abilities that preschool children have: a child who recognises that two words rhyme and therefore have a sound in common must possess 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. An important part of this argument is that children make analogies and inferences about the speech units in order to read and write new words; b) access to phonemes knowledge and its relation to graphemes as an instruction result; c) 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.

These levels of phonological awareness vary in terms of complexity and difficulty (Ehri et al, 2001; Foy & Mann, 2009; Puffpaff, 2009; Swan & Goswami, 1997; Yopp, 1988), emerge at different stages in a child’s linguistic development (Goswami & Bryant, 1990) and may be assessed through many different tests (Denton, Hambrock, Weaver, & 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 these different levels of PA demand different ways of information processing. For example, identification of rhyme and alliteration tasks are easier to perform than oddity task in rhyme and alliteration; rhyme and alliteration tasks are easier to carry out than segmentation tasks; and rhyme tasks are easier than alliteration tasks. These all performances place different demands on working memory capacity. There, this could in part explain the reading and spelling difficulties found among people with complex communicative needs that use AAC.

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 & Wilson, 1985; Bishop, 1985; Bishop, Byers Brown, & Robson, 1990; Bishop & Robson, 1989a, b; Dahlgren, Sandberg, & 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 AAC. 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, & 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, & 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 & Gans, 1986; Dahlgren Sandberg, & Hjelmquist, 1996a, 1997; Foley, 1993; Hart, Scherz, Kenn, & Hodson, 2007; Smith, 1989). The low levels on literacy indicators persisted after a period of 3 to 4 years of schooling in children that used AAC compared to naturally speaking children (Dahlgren Sandberg, 2001). However, it was found that people who used AAC and had better skill in phoneme awareness also had better skill in word reading (Vandervelden & 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 & Large, 1988; Hoiien & 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 & 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 & 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, & Ryan, 1992; Hansen & Bowey, 1994; Newman, Fields, & Wright, 1993; Siegel & 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 & Brady, 1990). In many instances, severe speech impairments are associated with underlying brain damage (Smith, 2003).

The majority of studies report disproportionate difficulties with phonological processing, particularly among individuals with congenital speech impairments (Smith, 2001). Cerebral palsied individuals are the largest group using AAC due to the severe congenital physical and speech impairments (von Tetzchner & Martinsen, 2000). This population have impairments in specific cognitive abilities as attention and memory (Parker, 1987). Phonological working memory seems to be emerging as being specially vulnerable to constraints arising from lack of availability of subvocal rehearsal (Smith, 2003) which may create challenges in learning to read and write.

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 performance on reading and spelling related to phonological skills and working memory capacity of people with complex communicative needs, as a group in its own right. So, it deserves all our attention. Only the study of Dahlgren Sandberg and Hjelmquist (1997) had 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.

The purpose of the present exploratory 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 used 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 and phonological skills on the differences in literacy performance of young adults with cerebral palsy. There are two hypotheses in this study. The first hypothesis holds Method that if (WM) capacity was a factor in order to learn to read and spell in people without disabilities, then a significant higher performance in reading and spelling measures was expected in a high WM capacity group than in a low WM capacity group of people with Communicative Needs that 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 should 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

Twenty four AAC users were initially recruited to the study from different schools, high schools, day care centres and vocational sites of the north-west of Spain. 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.

Four of the initial participants were excluded due to their extreme scores in span working memory. In this way, a sample of 12 participants were finally selected and made up the final sample: 7 men and 5 women, ranging in age from 16 to 34 years (mean age=24 years).

Participants in this study were older than other participants quoted in the literature (Dahlgren Sandberg & 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 age, 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).

The range of skill and experience and educational levels of the participants are huge. This is due to the fact that in this study all the identified AAC users from the north-west region of Spain that met the criteria set participated.

Participants’ descriptive characteristics are the following: 9 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, these 3 participants relied on simple unaided strategies for their communication as pointing or eye-pointing as a compliment to their sounds. 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.

Native receptive and expressive language for all participants was Spanish. Participants’ receptive language skills profiles were heterogeneous. 5 participants’ receptive vocabulary was moderately high, 2 participants’ receptive vocabulary was moderately low, and it was restricted in 5 participants according to the descriptive category results in the Peabody Picture Vocabulary Test (Dunn, Padilla, Lugo, & Dunn, 1986). Participants’ grammar receptive skills were varied too. All parents, teachers and familiar partners informed of good comprehension of language in everyday activities and routines. Nevertheless, these skills were assessed with the Test for Reception of Grammar (Bishop, 1989). Grammatical knowledge was considered to be adequate in 5 participants, but it was poor and extremely poor in the remaining 7 participants. As there are not Spanish standardised scores of this test, results were taken as merely informative.

Participants also exhibited different profiles regarding their expressive language skills (see Table 1). Six 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 (subject 2 in Table 1); the second one (subject 3 in Table 1), 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 (subject 1 in Table 1). 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 (subject 9); 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 (subject 7). The last participant used Minspeak icons on DeltaTalker with speech output that he accessed with a switch activated by a movement of his knee (subject 10). 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 (subject 4 in Table 1), the other one with direct selection with his index finger (subject 6 in Table 1). 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 (subject 11); 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 (subject 5) and the other one communicated messages linking syllables on a low tech communicator (subject 8 in Table 1). 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 (subject 12). 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 Alpha Talker 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 familial 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, type of cerebral palsy and of speech impairment, AAC techniques and educational characteristics for each participant; it also summarises information relating to fine motor abilities of participants.

As in many other investigations (Dahlgren Sandberg & 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. 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 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 for Spanish people there are no standardised phonological tests adapted to people who use AAC, our materials were based on standardised instruments by Calero, Pérez, Maldonado, & Sebastián (1999). Pictures in phonological test items were taken from the Registro Fonológico Inducido by Monfort (1982). Table 2 shows phonological test items and ranges of scores.

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.

Reading tasks

Three tests from the Bateria para la Evaluación de los Procesos Lectores, Battery for the Assessment of Reading Processes PROLEC (Cuetos, Rodríguez, & Ruano, 2000) were used to assess lexical access: a) An orthographic knowledge test was used. Cuetos et al. (2000) have stressed that, by the age of 8 years old, Spanish children have the orthographic rules knowledge; b) a word reading test was used to assess word recognition and thereof, the use of lexical route in reading; c) a pseudoword reading test was used to evaluate the use of phonological route in reading. Table 2 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. Syllabic structure in words and pseudowords was similar for experimental control.

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.
Table 1

Participants characteristics

<table>
<thead>
<tr>
<th>Participants</th>
<th>Sex</th>
<th>Age</th>
<th>Cerebral Palsy</th>
<th>Speech Impairment</th>
<th>Fine motor Abilities</th>
<th>AAC techniques</th>
<th>Educational level</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>F</td>
<td>33</td>
<td>Spastic</td>
<td>Dysarthria</td>
<td>Unaided pointing with thumb.</td>
<td>Syllabic board, canon communicator without speech output, head nods, unintelligible sounds</td>
<td>Preparing university access. Special setting</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>16</td>
<td>Athetoid</td>
<td>Anarthria</td>
<td>Impaired hand function due to atheosis.</td>
<td>SPC board with partner assisted scanning, head nods, eye blinks, head gestures and eye pointing.</td>
<td>Adaptive instruction. Integrated setting.</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>33</td>
<td>Spastic</td>
<td>Dysarthria</td>
<td>Unaided pointing with index finger.</td>
<td>SPC board with direct selection, some intelligible words as “yes” “no”.</td>
<td>Unfinished elementary school. Special setting.</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>19</td>
<td>Spastic</td>
<td>Anarthria</td>
<td>No hand function.</td>
<td>SPC board with the alphabet and partner-assisted scanning, Winspeak communication program, head nods, facial expression.</td>
<td>Elementary school. Occupational centre.</td>
</tr>
<tr>
<td>8</td>
<td>F</td>
<td>25</td>
<td>Spastic</td>
<td>Anarthria</td>
<td>No hand function.</td>
<td>Syllabic low technology communicator, eye pointing, head movements, eye blinks.</td>
<td>Unfinished elementary school. Special setting.</td>
</tr>
<tr>
<td>9</td>
<td>F</td>
<td>17</td>
<td>Spastic</td>
<td>Anarthria</td>
<td>No hand function.</td>
<td>SPC board with alphanumeric encoding, eye pointing, head nods and facial expression.</td>
<td>Adaptive instruction. Integrated setting.</td>
</tr>
<tr>
<td>12</td>
<td>M</td>
<td>17</td>
<td>Spastic</td>
<td>Anarthria</td>
<td>No hand function.</td>
<td>Unaided strategies as body movements, head nods and “yes” and “no” gestures in response to auditory scanning.</td>
<td>Adaptive instruction, significant curricular adaptation. Integrated setting.</td>
</tr>
</tbody>
</table>
PHONOLOGICAL AWARENESS AND WORKING MEMORY

According to the working memory capacity of the 12 participants, they were assigned to two groups, the group of low working memory capacity (WM_L) and the group of high working memory capacity (WM_H), with 6 participants each. As for that the assigned we considered the following studies: Elosúa, Gutiérrez, García, Luque, and Gárate (1996); Desmette, Hupet, van der Linden, and Schelstraete (1995), which propose an integrative model to classify subjects according to their working memory span, less restrictive than Daneman and Carpenter (1980). 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.

According to the phonological skills abilities of the 12 participants they were also assigned to two groups, the low phonological skills group (PS_L) and the high phonological skills group (PS_H), each one with 6 participants.

Table 2
Phonologic tests 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 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 give 3 strokes or 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:

Orthographic 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.

Procedure

Two simple small-group designs for independent groups were applied in order to test the two hypotheses. For this design, the statistic used was the difference between means and this was carried out using a standard non-parametric test, the t-Student test. The first design was applied to WM measures; the second one was applied to phonological measures.

Assignments to groups were made post testing. According to the working memory capacity of the 12 participants, they were assigned to two groups, the group of low working memory capacity (WM_L) and the group of high working memory capacity (WM_H), with 6 participants each. As for that the assigned we considered the following...
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. A score above 53 was considered as a high phonological skill. Scores under 53 were considered low phonological skills. See Table 3 for digit span test and phonological skills tasks’ 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.

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. Total testing time for the AAC users participating in this study ranged from 4 to 6 hours.

Before proper testing, instruction was given. The examiner, who was not blind to the trials, modelled task execution so that participants knew tasks expectations and how to carry out the tests. Two practice items were presented as well.

Table 3
Participants’ scores at memory and phonological skills tests

<table>
<thead>
<tr>
<th>Participants</th>
<th>WorkingMemory</th>
<th>Phonological Awareness</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>3</td>
<td>49</td>
</tr>
<tr>
<td>11</td>
<td>3</td>
<td>39</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
<td>31</td>
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<tr>
<td>7</td>
<td>3</td>
<td>57</td>
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<td>8</td>
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<td>9</td>
<td>3</td>
<td>54</td>
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<td>10</td>
<td>4</td>
<td>52</td>
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<td>45</td>
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<td>79</td>
</tr>
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<td>3</td>
<td>4</td>
<td>74</td>
</tr>
<tr>
<td>Median</td>
<td>3,5</td>
<td>53</td>
</tr>
</tbody>
</table>
Results

Reading and spelling descriptive data for working memory and phonological skills groups are showed in Table 4. Statistical analyses were made from percentages’ scores.

Working memory groups’ results

There were differences between high (WM₂) and low (WM₁) working memory capacity groups in descriptive reading and spelling data. WM₂ performed better than WM₁ in all the reading and spelling tasks (see Table 4 and Figures 1 and 2).

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 5).

Phonological skills groups’ results

As it is showed in Table 4 and Figures 1 and 2, high phonological skills group performed better than low phonological skills group. There were differences between PS₂ and PS₁ in all descriptive reading and spelling measures.
Nevertheless, in reading, t-Student analysis only showed statistical significant differences between groups in the number of sight words read (t = 3.54; p < .001). In spelling, there were statistical differences in the spelling of pseudowords (t = 2.81; p < .05) and in the spelling of pictures’ names (t = -2.79; p < .05). (see Table 5). There were also significant differences in the total number of spelled letters in words (t = 2.49; p < .05). Table 5 shows that differences nearly reached signification in the total number of letters spelled in pseudowords. Differences between groups were also significant in the number of first letters spelled (t = 2.35; p < .05) and last letters spelled (t = 3.33; p < .05) in pseudowords.

**Table 5**

t-Student results for working memory and phonological skills groups

<table>
<thead>
<tr>
<th></th>
<th>Working memory</th>
<th>Phonological skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognized orthographic patterns</td>
<td>3.17092</td>
<td>-</td>
</tr>
<tr>
<td>Read words</td>
<td>6.43827</td>
<td>3.54855</td>
</tr>
<tr>
<td>Read pseudowords</td>
<td>1.38675</td>
<td>1.1101</td>
</tr>
<tr>
<td>Spelled words</td>
<td>1.76664</td>
<td>1.6903</td>
</tr>
<tr>
<td>Spelled pseudowords</td>
<td>1.60357</td>
<td>2.81386</td>
</tr>
<tr>
<td>Spelled pictures’ names</td>
<td>2.4327</td>
<td>-2.79410</td>
</tr>
<tr>
<td>Letters spelled in words</td>
<td>-1.40841</td>
<td>2.49901</td>
</tr>
<tr>
<td>Letters spelled in pseudowords</td>
<td>-1.13813</td>
<td>.05324</td>
</tr>
<tr>
<td>Letters spelled in pictures’ names</td>
<td>-1.49969</td>
<td>.082734</td>
</tr>
<tr>
<td>First letters spelled in words</td>
<td>.12564</td>
<td>2.0870</td>
</tr>
<tr>
<td>First letters spelled in pseudowords</td>
<td>-1.34568</td>
<td>.46139*</td>
</tr>
<tr>
<td>First letters spelled in pictures’ names</td>
<td>- .4346</td>
<td>.0650608</td>
</tr>
<tr>
<td>Last letters spelled in words</td>
<td>-.915258</td>
<td>-.129641</td>
</tr>
<tr>
<td>Last letters spelled in pseudowords</td>
<td>-.91634</td>
<td>.230979</td>
</tr>
<tr>
<td>Last letters spelled in pictures’ names</td>
<td>-1.19523</td>
<td>.0612022</td>
</tr>
</tbody>
</table>

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

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

Discussion

Participants in this study exhibited different ability profiles. 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, & Adamson, 1999). 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, the generalization of our findings across persons that use AAC systems is difficult 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. As it may be observed in Tables 4 and 5, 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 (see Figure 1). 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 (see Figure 1).

As it is known, working memory is important for reading (Baddeley, 1982; Daneman & 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 amount 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 evidence of 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. It could be said that low working memory group read at a very basic level, if it is taken into account that they could not read even the fiftieth of the words; these words constitute a very basic visual vocabulary and it was chosen from a reading test that typically applies to children from 6 to 9 years old.

When looking at phonological skills groups’ results in reading (see Table 5), 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, & Treiman 1992; Byrne & 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 haven’t confirmed our hypothesis 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 & 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 (see Tables 4 and 5). 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. In fact, some subjects had received phonick instruction during their school years while some others hadn’t. This could explain differences found in phonological skills which are absolutely necessary to perform in word reading tasks but not in pseudoword lexical decision task. 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 where children read words more easily than pseudowords, showing the lexical category effect (Defior, Justicia, & Martos, 1998; Dominguez & 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, et 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 & Hjelmquist, 1996b). Also, our results bring into line with Dahlgren Sandberg & 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 & 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 the 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 on the contrary, the 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 at best 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 (see Table 5), 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 that the verbal aid has helped all participants to do the task. Voiced presentations of words and pseudowords have played the role of a public articulatory rehearsal of the lexical items' phonological representations to the working memory, as words and pseudowords were spoken aloud on an ongoing basis by the examiner to all participants, so that, they could spell these elements. Taking into account the time that many participants wasted in selecting the letters, and that this selection was made one to one, 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 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 bigger 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.

The lack of significance between working memory groups in the remaining spelling measures –total number of letters and first and last letters spelled in all lexical items- is difficult to interpret (see Table 5). But when individual performance profiles were examined, it was found, again, a nearly perfect performance in some high working memory capacity participants, while some others
had very poor spelling results. 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 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 (see Table 5). 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 & 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; these skills were not necessary for spelling the words because these 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 these 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 or successfully used, if low phonological skills participants had used them differences would have been found in the spelling of words.

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 globally recuperate it; 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 & Stackhouse, 1983) and that phonemic awareness is of critical importance for spelling (Goswami & 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 an ability strongly associated to reading and spelling learning (Vandervelden & 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; these students exhibited a beginning level skill when they could spell the initial letter in a pseudoword; they showed a more advanced skill when they spelled the first and last letters in pseudowords, and finally, advanced skills were found when they could spell the 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 a high level of working memory capacity and participants with a 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. As a first reason we should say that this study was descriptive by nature and we can not make any inference about causal relationships among variables. In the second place, the size of the participants sample was small and they all had different learning histories, different social environments, and diverse language and abilities profiles. What has been called the extrinsic variables in language and literacy learning (Smith & Blischak, 1997) might have had an influence in the results our participants got. Another factor to be considered is that our study 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 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 & 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, & Tangel, 1994; Bradley, 1988; Lundberd & Hoen, 1991). 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. In this sense, it would be necessary to carry out an experimental design for answering this posed question.

References


PHONOLOGICAL AWARENESS AND WORKING MEMORY


