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# General Visual Ability as a Moderator in the Relationship RAN – Fluency in a Regular Orthography

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**Abstract**: Visual skills play a controversial role in the literacy process. The predictive part of RAN on fluency is known, especially in transparent spelling.
In this research, we wanted to explore the influence of visual abilities on literacy for primary school students; for this purpose, we evaluated 209 students. We tested both the Reading and decoding efficiency, rapid naming, and visual abilities. The interaction of rapid naming (RAN) and visual ability (VA) significantly determined fluency.
This association is discussed concerning other findings that have demonstrated the visuospatial abilities influence literacy.

**Keywords:** *rapid naming, visual ability, reading efficiency, literacy.*

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## Introduction

Reading it seems to be an effortless thing; we do it automatically. However, at first, it took a lot of effort to learn the process, and unfortunately, some have difficulties all their lives. A special concern of scientists is to find a targeted intervention to help people with dyslexia. Dyslexia is characterized by severe reading problems, which are not due to a lack of general intelligence, poor education, uncorrected sensory issues, or neurological impairment (American Psychiatric Association, 2013).

## Literature Review

One of the most appreciated theories in literacy is Ehri's theory of automation (2005). According to this, in the pre-literacy stage, people do not know literacy principles, and they use visual cues to identify words (Ehri, 2005).

In the partially alphabetical fase, children learn the letters, focusing on letter recognition (Ehri, 2005). Most children manage to comprehend the correspondence between letters and phonemes in a year of training (Law et al., 2018). People with dyslexia are as fast as those with normal development in individual letter recognition (Lachmann & van Leeuwen, 2007). In languages with orthographic consistency, the same phonemes correspond to the same graphemes (Antzaka et al., 2018), so children can easily switch to decoding. Decoding indicate the ability to quickly and correctly decipher the relationship between letters and sounds of words or sentences (Arnesen et al., 2017). The basic process is identical to recognizing any other object, and people with dyslexia have no problems at this stage of visual processing (Stein, 2018). When a child reads, he moves the gaze from one letter to another, and then he must learn where to focus his gaze on comprehending the whole word (Stein, 2018).

Children read easily, fluently, fluently in the stage of consolidated literacy because they remembered in memory patterns of a letter combination (word recognition; Ehri, 2005). Moreover, the pre-existing functions (visual skills and basic auditing, phonological processing, speech perception, oculomotor control, short and long-term memory, attentional and executory functions, etc.) are coordinated to undergo specific reading procedures. They are automated by intensive training (Lachmann, 2018; Nicolson & Fawcett, 2018). The automation process is accompanied by structural and functional changes in the brain, creating a particular network of Reading (Hung et al., 2018; Wimmer & Ludersdorfer, 2018).

Studies show that in languages with transparent orthography in the first or second year of schooling, there is a transition from decoding to fluent reading, which involves correct reading and appropriate prosody (Kuhn & Stahl, 2000; Wimmer & Schurz, 2010).

### *Rapid naming (RAN) as a Predictor for Reading Fluency*

RAN is the ability to pronounce the names of familiar symbols quickly (e.g., objects, colors, letters, digits) presented in series (Kirby et al., 2010). It measures the ability to access and retrieve phonological representations from long-term memory (Torgesen et al., 1997). Even though the name of the objects is learned faster, letters and digits are better automated by students (Norton & Wolf, 2012).

RAN is a process that predicts a young child's ability to automatize letter sequences and words and to connect them with their linguistic information (Norton & Wolf, 2012).

RAN involves attentional and visual cognitive processes (Norton & Wolf, 2012). RAN is a universal predictor for fluency, regardless of the degree of orthographic transparency of the language (Landerl et al., 2019). This role is maintained irrespective of the type of the stimulus (alphanumeric or non-alphanumeric), indicating that other processes are involved in rapid naming than the reading of the letters (Araújo & Faisca, 2019). RAN has an independent contribution to literacy development (Wolf & Bowers, 1999).

### *Visual Processing*

Three parallel channels transmit information from the retina to the cortex: the parvocellular (parvocellular) and the coniocellular (koniocellular) magnocellular pathway. Magnocellular pathway disorders appear to exist in people with dyslexia (Vidyasagar & Pammer, 1999). A child with normal development has a visual span that includes all the letters in parallel. Their processing is optimal when the child stares at a central-slightly left point of the string (Aghababian & Nazir, 2000).

Visual-spatial control is mediated by several biological (hemispheric dominance), biomechanical (manual dominance), and cultural (reading habits) factors (Rinaldi et al., 2020). Spatial perception disorder is considered either a cause or a consequence of dyslexia (Gilger et al., 2016), while empirical evidence is mixed. Great emphasis was placed on explanations of reduced visual processing, which would explain the reading and writing problems associated with dyslexia. The most important theory in this direction is magnocellular deficit theory (Stein & Walsh, 1997). Studies supported this theory report low-performance perception of movement and

low spatial-visual frequency, and high temporal frequency (Borsting et al., 1996; Stein, 2001). Also, some research suggests that people with dyslexia have reduced visual attention (Bosse et al., 2007) and difficulties orienting spatial attention (Facoetti & Molteni, 2001; Facoetti et al., 2003). A recent review shows that magnocellular and attention dysfunction would be due to a reduced reading experience rather than a dorsal canal development abnormality (Joo et al., 2017).

In contrast, some researchers argue that people with dyslexia have special visual-spatial abilities (Craggs et al., 2006). Only the results of visuospatial subfactors would be high (Von Karolyi et al., 2003). These results support Gershwind-Galaburda's theory, which argues that the predominant pathology of the left hemisphere, specific to dyslexia, leads to a higher functioning of the right hemisphere (Galaburda et al., 1987). This theory was later hard-fought (McManus & Bryden, 1992). Bacon and Handley (2010) found that dyslexic people develop visual rather than verbal reasoning, with visual memory having a compensatory role.

Besides, von Karolyi et al. (2003) found that people with dyslexia are faster in identifying existing objects from a series of figures, implying the existence of a superior visual integration ability. Winner et al. (2001) and Duranovic et al. (2015) conducted extensive studies on groups of people with and without dyslexia. They found that those with dyslexia performed lower than those with normal development in all samples, including mental imaging and visual memory. However, they argue that these people may present superior results at certain tests, which involve solving everyday visual problems.

According to the Meta-analysis of Tafti et al. (2014) students with dyslexia performed poorly than normal development in visual-spatial tests. Moreover, given the complex nature of the disorder, it cannot be stated that a single efficacy would cause dyslexia (Tafti et al., 2014). The meta-analysis of Chamberlain et al. (2018) shows that those with RD have lower performance in visuospatial ability tests and greater variability in performance. In a systematic review of Gilger et al. (2016), the group of those with RD had poorer visual results than those in the control group in 17% of the studies, and 11% of the studies had superior results. The biggest disadvantage of the RD group occurs in the spatial rotation test, which measures visual processing by the impossible figure test. The heterogeneity of the results is due to both the diversity of participants and the tests administered. For example, Goswami (2015) argues that the visual-spatial deficit is more pronounced in older school years after the poor reading experience leaves its mark on the functioning of the dorsal and attentional

canal. Many theories describes dyslexia and its effects. We consider that Pennington's theory (2006) claims that dyslexia has multifactorial causes and best covers reality. One of the etiological factors may be visual in children with dyslexia.

The present study supports the understanding of literacy (word reading accuracy and fluency) of children in primary school (from first to fourth grade) by highlighting the interactions between RAN, VA, and word reading efficiency in skills development reading in the Romanian language. The study highlights the way general visual abilities interact with predictors in developing reading abilities. To our knowledge, there are no researches to show the relationship between RAN, VA, and WRE. Some studies expose the relationship between RAN -fluence, respectively VA -WRE, but not how they are interrelated. This information is all the more important for Romanian literature, as there is very little research in the field.

H1: *We expected to* find a positive relationship between rapid naming (RAN) and phonological awareness (B1, B2, C1) and word reading fluency (WRE) for all the primary grades (Landerl & Wimmer, 2008).

H2: Phonological awareness (B1, B2, and C1) is a predictor for reading fluency from grade 1 to, but with a lower association effect than RAN (Landerl et al., 2019).

H3: VA has a moderator effect between RAN and reading fluency; specifically, children with better general visual abilities outperforms in RAN and WRE tests, those who have low VA.

## Methodology

### *Participants*

In this study, 209 primary school students (117 boys and 92 girls) participated voluntarily, and we obtained informed consent from their parents. We recruited students from schools in the North-East part of the Romanian county from 3 schools in urban areas. There had been tested: 64 first graders (31 girls, age $M$ = 90.30, $SD$=4.27), 41 second grade students (15 girls, $M$ = 110.26, $SD$ = 6.01), 55 third graders (23 girls, $M$ =114.80, $SD$=3.87) and 45 fourth grade students (23 girls, $M$ =133, $SD$= 2.53). The children have the Romanian language as their native language, have no impaired hearing or sight problems. They were not diagnosed with ADHD, epilepsy, or behavioral problems. They come from various social environments. Initially, we tested 215 children, and then we eliminated those with speech sound disorders from the final data analysis.

### *Procedure and measure*

We applied the tests at the beginning of the school year, in the second half of October 2019. The author and a trained assistant individually evaluated each child. We used for testing The Battery for Assessment of Dyslexia and Evolutive Dysorthography (Sartori et al., 1995; adapted for the Romanian population by David & Roşan, 2017). We presented a fixed sequence of tests (familiar words, nonwords, RAN, VA). We tested every child individually. We started a stopwatch when we showed the list to the child and stopped when he attempted the last item. If a task blocked a child, he or she was encouraged to move on and complete the list.

The DDE 2 test (David & Roşan, 2017) generally evaluates the Reading and word reading accuracy competencies for first to fourth-grade children. The Battery includes tests that can establish the initial level of the competencies and understand whether their characteristics are suited. The tests were administered one at a time for each of the main variables of the study as follows:

*Reading* accuracy and reading fluency – We used Test 2 from the DDE-2 test, which measures the correctness of reading the word list. We asked them to read the columns one by one. We recorded the number *of correctly read words for reading accuracy (percentage of correctly read terms) and time for reading fluency* (time/ nr. item word list).

Sample 3 for nonword reading accuracy and fluency: We asked them to read the columns one by one. We recorded: number of nonwords read correctly and reading time. Nonword reading accuracy: nonword correctly read percentage, nonword reading fluency: the time necessary to read one nonword (time/ nr. items nonword list).

For Rapid naming (RAN) - Digit Naming was administered. We presented to the children a 30-digit matrix: 2, 4,5, 7,9 randomly arranged (Tong et al., 2017). The task was to name digits rapidly on a horizontal row. We measured the time for calling the numbers.

Visual abilities (VA). We used TVAS, the Test of Visual Analysis Skills of Rosner (1993). The children had to copy a figure composed of different lines. This task provides information about visual analysis.

### *Ethical agreement*

Before testing, we obtained the accord of the Ethical Commission of the Faculty of Psychology and Educational Sciences of Iasi. Moreover, we informed the County School Inspectorate and the management of the schools. We presented to the children's parents the purpose of the study and asked them to sign the consent if they agreed to test.

## Results

We find out that the correlation between PA, RAN, and reading and decoding were significant Table 1.

**Table 1.** Zero-order intercorrelation between main variables

| | RAN | B1 | B2 | C1 | VA | WRE | PWRE |
|---|---|---|---|---|---|---|---|
| RAN | 1 | | | | | | |
| B1 | -.635** | 1 | | | | | |
| B2 | -.654** | .963** | 1 | | | | |
| C1 | -.626** | .948** | .961** | 1 | | | |
| VA | -.395** | .430** | .436** | .445** | 1 | | . |
| WRE | -.744** | .546** | .552** | .533** | .492** | 1 | |
| PWRE | -.706** | .532** | .542** | .518** | .433** | .905** | 1 |

*p < .05, **p < .001

We used IBM SPSS Statistics version 21 and the Process macro v.3.1. Table 2 shows the partial correlation that we analyzed. The second-order correlation showed that the direction and magnitude of our associations of WRE with RAN are significant and negative and positive and significant with VA.

**Table 2.** Partial correlation among measures accounting for parent's level of education and grade of the child and descriptive data

| Partial correlation | | M | SD | RAN | VA |
|---|---|---|---|---|---|
| par & grade | RAN | 18.41 | 7.20 | | |
| | VA | 10.54 | 4.57 | -.12* | |
| | WRE | 39.47 | 15.84 | -.49** | .20* |

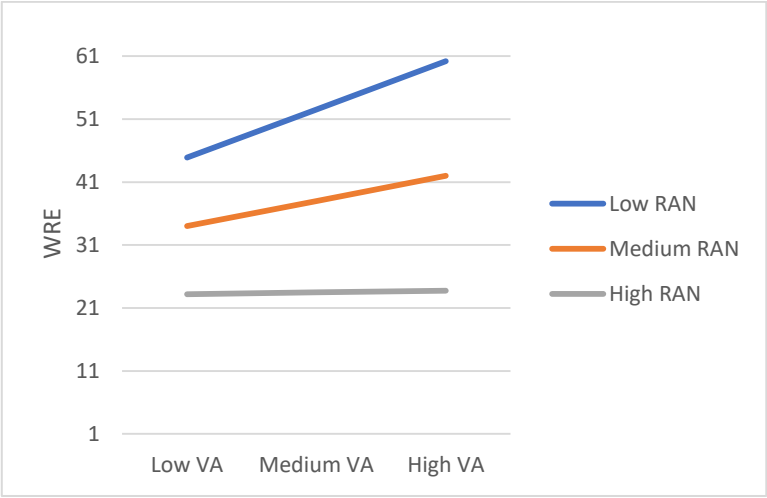
*p < .05, **p < .001

To determine whether VA impacts the relation between RAN and WRE, we tested VA as a moderator using Process macro v.3.1. to explore the interaction effect. We mean-centered the main independent variables and used the mean and of the moderator and one standard deviation above and

below mean to analyze the results conditioned by the levels of the moderator. We present the results in Table 2 below.

**Table 2.** Moderation effects

| | B (SD) | t | p |
|---|---|---|---|
| Model 1 | | | |
| Constant | 17.91 (5.32) | 3.36 | .009 |
| RAN | -2.01 (.23) | -8.68 | <.001 |
| VA | .87 (.27) | 3.13 | .002 |
| RAN X VA | -.11 (.03) | -3.02 | .002 |
| Parents level of education | 5.28 (1.44) | 3.66 | .003 |
| Grade of the child | 5.52 (2.43) | 2.31 | .02 |




First, VA was included in the analysis as an explanatory factor for WRE. Parents education level and grade of the child were accounted as covariates in this model. All the variables accounted for a significant amount of variance in WRE ($R^2$ = .80, $F$ (5, 200) = 73.70, $p$ < .001). The interaction term also accounted for a significant proportion of the variance in WRE ($R^2$ = .10, $F$ (1, 200) = 9.13, $p$ < .002). The conditional effect of the focal predictor at the value of the moderator revealed an enhanced significant effect on the upper level (b = -2.52, se = .34 $p$ < .001), on the average level ($b$ = -2.01, $se$ = .23, $p$ < .001) and on the lower level ($b$ = -1.50, $se$ = .22, $p$ < .001). The results are also showed in the graphic below (Figure 1).

## Discussion

Many studies aim to identify the cognitive processes that underlie the literacy process (Rothe et al., 2015). As we expected, the results showed that children with reading disorders also have difficulties in rapid naming and phonological processing deficit (H1, Carroll et al., 2016; Carroll & Snowling, 2004, Dandache et al., 2014; Paulesu et al., 2001). Furthermore, the association RAN -reading fluency is stronger than the association PA- WRE (H3, Eklund et al., 2013; Landerl et al., 2019; Tiron & Gherguţ, 2019).

We wanted to find out what other cognitive processes contribute to literacy. Reading is based on visual processing, which is why visual skills play an essential role. Children with better phonological skills (phonological awareness) have better visual-spatial ability (Sze et al., 2018). The current study offers a fair picture of how RAN and VA correlate. We wanted to identify the role of visual literacy skills. We assumed that children with better fluency performed better on rapid naming and the visual task.

Visual-spatial abilities play an essential role in reading because they involve multi-faceted sensory processing (Giovagnoli et al., 2016). Some researchers say that people with dyslexia have superior visual-spatial skills (Bacon & Hendley, 2010). Meanwhile, others show that several visual traits are consistently associated with dyslexia (Taft et al., 2014). Adults with dyslexia perform worse than their peers on visuospatial tasks (excluding memory processes) (Czaplewska et al., 2009; Winner et al., 2001). We found an association between VA and WRE, respectively VA-PWRE only for children in the fourth grade. This result is in accord with Giovagnoli et al. (2016) who concluded that visual-spatial deficits were age-dependent and varied across different educational stages.

Furthermore, we found out that VA is a moderator in the relation RAN -WRE. To our knowledge, this result brings a novelty in the field, highlighting the relationship of visual skills and phonological processing skills with reading fluency. When having an intervention for dyslexia, we recommend testing not only RAN, PA but VA too, so we can more effectively customize our therapy to combat dyslexia.

**Limits***:* we tested children only from Suceava County. It would be helpful to extend to other schools from Romania. Our study is a cross-sectional one, so our results need to be verified in a longitudinal study.

## Ethical approval

This article does not include any tests performed on animals by any of the authors.

Following the Romanian research law, before testing, ethical approval was received from the Ethical Commission of the Faculty of Psychology and Educational Sciences of Iasi. We obtain a written agreement from Suceava County School Inspectorate and from the school principals was obtained.

We informed the parents regarding the purpose of the study, and we asked for their acceptance by signing the informed consent. Children had given their verbal consent before the test began. We informed them that they could withdraw, with no other consequences on their status.

## Compliance with Ethical Standards

This manuscript is not submitted to another journal. The submitted work is original, wasn`t published elsewhere or in other language. It was not split into parts. Our results are presented honestly, with no data manipulation.

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Katalin Tiron and Alois Gherguţ designed the methods for the study. Katalin Tiron collected data for the study. Cristina Maria Bostan analyzed the data. All the authors equally contributed to writing this manuscript.

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