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COGNITIVE SCIENCE & NEUROSCIENCE | RESEARCH ARTICLE

Effect of age and gender on children's reading performance: The possible neural underpinnings

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Abstract: The present study aimed to assess the effect of age and gender on second-grade children's reading performance. Two hundred and eighty-seven children aged 7.1–8.2 years were divided into two age subgroups (the younger, 85–91 months and the older, 92–98 months) and were examined in reading accuracy, fluency, and comprehension tasks. Results showed a significant effect of age in reading performance, with the older children having better scores than younger ones for reading fluency, reading comprehension, and the total reading performance. Gender was not found to play an important role in reading performance. The findings are discussed on the ground of functional brain development and the different rates of cerebral maturation.

Subjects: Child Development; Cognitive Neuroscience of Language; School Psychology

Keywords: age; gender; reading; brain

1. Introduction

Learning to read is one of the most important goals of the first school years (Moats, 2000). Reading is the process of understanding speech written down (Ziegler & Goswami, 2005). In other words, the beginning reader must associate written words to their known lexicon of spoken words, must know that each word is composed of letters, and must understand that each letter represents individual sounds utilized within speech (Vellutino, Fletcher, Snowling, & Scanlon, 2004). To become a competent reader, a child has to acquire word reading competence as well as reading comprehension skills (Gough, Hoover, & Peterson, 1996; Vellutino & Scanlon, 1991).



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PUBLIC INTEREST STATEMENT

Scholastic attainment varies with the month of birth, such that in any age cohort the older pupils tend to outperform the younger. Gender is another factor that is often reported to affect reading development. This paper sought to explore the effect of age and gender on second-grade children's reading performance and discuss them in a neurobiological point of view. We found that older children have better reading scores than younger, but gender does not affect second-grade children's reading performance. These findings highlight the necessity of comprehensive intervention during kindergarten and first grade to ensure that all students are on the right track for learning through the school years. Teachers should give special importance to reading instruction during the first school years. Their efforts should aim to counterbalance possible performance differences due to age factor as well as to prevent reading problems the subsequent scholastic years.

Research suggests that children reading skills progress through developmental stages (Ehri, 1995; McCoach, O'Connell, Reis, & Levitt, 2006). In a recent research report, Kennedy et al. (2012) concluded that "a comprehensive model of early literacy development during the preschool and early school years strongly supports the view that a range of language and print related skills emerge in a mutually supportive fashion with development in one area promoting and supporting development in others" (p. 317). Moreover, several studies have confirmed that specific skills that are developed during preschool years could predict the reading performance at the primary school years (Caravolas et al., 2012; Papadimitriou & Vlachos, 2014). Additionally, given that children are active users of technology in their everyday lives across a range of media, Korat (2010) suggested that well-designed technology tools carefully chosen by parents and teachers can provide young children with an additional efficient and enjoyable learning experience for reading development.

There is also evidence that age is a factor that often affects educational attainment and reading performance. More specifically, a large body of empirical evidence attests a "birth-date effect" in education. That is, scholastic attainment varies with the month of birth (Bell & Daniels, 1990; Gledhill, Ford, & Goodman, 2002; Russell & Startup, 1986), such that in any age cohort the older pupils tend to outperform the younger. Using chronological age as a criterion for entrance into first grade means that the age difference between some pupils in the same class can be almost one year. There is continuing controversy about the optimal or appropriate age at which children should start school. The efficacy of delaying school entry beyond the age that a student can legally enroll in public school has been debated in the research literature. Many researchers (Crosser, 1991; La Paro & Pianta, 2000; Milling Kinard & Reinherz, 1986) presented evidence that older children fare better academically than their younger age appropriate peers. Additionally, Uphoff and Gilmore (1985) using research evidence about the relationship between age and achievement argued that the older and/or more mature students in a class fare better than younger classmates.

In contrast, some studies (Demeis & Stearns, 1992; Dietz & Wilson, 1985) found no significant relationship between age and achievement, while other (Langer, Kalk, & Searls, 1984) found significantly higher achievement of the oldest as compared to the youngest students at age nine but this difference disappeared by age seventeen. As a whole, while some studies (Dietz & Wilson, 1985; Gredler, 1980) found no age effect on academic performance of first graders most, of the relevant studies pointed out that younger pupils seemed to be less ready for school tasks than their older peers and that the younger classmates were shown to be lower achievers in reading, arithmetic, and language skills (Davis, Trimble, & Vincent, 1980; DiPasquale, Moule, & Flewelling, 1980; Donofrio, 1977). As for the relationship between school entrance age and reading performance, Teltsch and Breznitz (1988) found that the oldest first graders surpassed their younger peers in all of the academic parameters examined; i.e. reading comprehension, reading time, and reading decoding skills. Additionally, Trapp (1995) indicated that late starters scored significantly better than early starters in reading tasks.

The last decade research into maturational changes in the brain during the years in which reading expertise develops provided important insights into how these changes affects learning and influence individual differences in the capacity to acquire reading skill (Schlaggar & McCandliss, 2007). Functional and structural neuroimaging studies have shown that brain maturation during childhood affects functional specialization in cortical regions and the development of specific cognitive functions which are associated with the development of reading ability (Bach et al., 2010; Nagy, Westerberg, & Klingberg, 2004).

Gender is another factor that is often reported to affect reading development. Girls are generally thought to perform better than boys in verbal and linguistic functions (Halpern, 1986; Maccoby & Jacklin, 1974; McCormack & Knighton, 1996). Further, statistics from the US Department of Education indicated that the reading skills of girls are slightly more advanced than those of boys. More specifically, at school entry, 70% of girls could name letters, as compared to 62% of boys, and 32% of girls could associate letters with sounds, as compared to 26% of boys (Nancollis, Lawrie, & Dodd, 2005).

Borg and Falzon (1995), in a study of Maltese primary children in grades 3–5, found that girls outperformed boys in English, Maltese, and math at each of the three grade levels investigated.

Other studies investigating the role of pupil's gender in scholastic attainment generally indicate that before age 11 there are no clear-cut gender differences in verbal abilities such as reading and spelling (e.g. Ross & Simpson, 1971; Thompson, 1971), or in arithmetic skills and mathematical ability (e.g. Kellmer, Butler, & Davie, 1966); that is, the genders are very similar in verbal and mathematical abilities. Clear and consistent gender differences tend to emerge after age 11 (Shackleton & Fletcher, 1984), with girls becoming superior in verbal abilities and boys in mathematical abilities (Maccoby & Jacklin, 1974).

Additionally, a significant body of research claims that more boys than girls experience reading problems (Badian, 1999; Wheldall & Limbrick, 2010). Many studies suggest that there are more boys than girls with reading disabilities, although the degree varies considerably and some studies have identified considerably high gender ratios of 3:1 or higher (Miles, Haslum, & Wheeler, 1998). However, despite available evidence, some researchers have reported little or no significant gender differences. For example, Shaywitz, Shaywitz, Fletcher, and Escobar (1990) found no significant gender differences when samples were research identified as opposed to school identified, indicating that the greater prevalence of boys with reading disabilities was due to referral bias. More specifically, they indicated that since boys are generally more active and impulsive, they are more likely to be identified through traditional school-identification procedures, whereas girls—who are generally quiet and who may struggle to read—often go unnoticed. A longitudinal study by Siegel and Smythe (2005) also reported no significant gender differences in reading disabilities. As Wheldall and Limbrick (2010) maintain these findings are consistent with Hyde's (2005) hypothesis of gender similarities, which suggests that boys and girls are more alike than different on most psychological variables, including reading, based on a review of 46 meta-analyses covering a variety of cognitive abilities and psychological traits.

Taking into account the above findings, the aim of the present study was to assess the effect of age and gender on second-grade children's reading performance. Based on the aforementioned studies as well as on recent neurobiological evidence of functional brain development (Bach et al., 2010; Beaulieu et al., 2005; Schlaggar & Church, 2009), it was predicted that significant differences will be observed between younger and older second-grade children's reading skills (Hypothesis 1) and that girls would precede boys in reading performance (Hypothesis 2).

2. Method

2.1. Participants

Participants were 287 second-grade students [(146 boys and 141 girls) (chronological age $M = 92.9$ months, $SD = 2.94$ for boys and $M = 92.8$ months, $SD = 3.09$ for girls)] selected from 15 Greek elementary schools. The reason we choose the second-grade students as participants is that in languages with more transparent orthography, such as Greek, high levels of reading accuracy are reached by the end of the first grade (Seymour, Aro, & Erskine, 2003; Zoccolotti, De Luca, Di Filippo, Judica, & Martelli, 2009). The participants were randomly selected from the school population of Karditsa, Greece, after permission of the Greek Ministry of Education and parents' consent had been given. School selection followed a stratified randomized approach in an effort to represent urban (four), rural (seven), and semi-urban (three) schools. Pupils were grouped into two age cohorts. As presented in Table 1, the first (younger) cohort was from 85 months to 91 months (mean age for boys $M = 88.5$ months, $SD = 1.52$ and $M = 88.5$ months, $SD = 1.42$ for girls) and the second (older) was from 92 months to 98 months (mean age for boys $M = 94.1$ months, $SD = 1.84$ and $M = 94.3$ months, $SD = 1.67$ for girls). All children were fluent speakers of the Greek language, were in mainstream school placement, and did not have a history of major medical psychiatric illness, development disorder, or significant visual or auditory impairments according to the medical reports of their schools.

Table 1. The number of participants by age and gender

Age (months)	Gender		x ²
	Boys	Girls	
	N	N	
85-91	32	38	NS
92-98	114	103	NS
Total	146	141	NS

2.2. Materials and procedure

All children were tested individually in two 10-min sessions with the following tasks:

Word and pseudo-word reading accuracy, reading fluency, and text comprehension.

Reading accuracy: Subtests 5 and 6, of the Test of Reading Performance (TORP; Padeliadu & Sideridis, 2000) were administered to assess word and pseudo-word reading accuracy. Pseudo-word reading accuracy tasks are used as indicator of students' mastery of sublexical processes as these processes are mainly utilized in pseudo-word decoding. TORP subtests 5 and 6 included lists of 40 words and 19 pseudo-words, respectively, in order of ascending difficulty. Administration of both subtests was discontinued when students scored 0 on 6 consecutive items.

Reading fluency: Reading fluency was assessed by measuring word and pseudo-word reading efficiency (Protopapas, Sideridis, Mouzaki, & Simos, 2007). These tests were designed to assess efficiency of automatic recognition of high-frequency words and speeded pseudo-word decoding. Words were selected on the basis of their frequency of appearance and pseudo-words were constructed to match phonological and/or morphological characteristics of respective high-frequency words. Each student was instructed to name each word as fast as possible without making errors in 45 s.

Reading comprehension: The TORP subtest 13 (Padeliadu & Sideridis, 2000) used to evaluate students' text comprehension skills. It included six passages of ascending length and text complexity that were followed by 2-4 multiple choice questions. Administration was discontinued if the student had failed to answer correctly all the questions following a passage or had severe difficulties with word reading.

3. Results

SPSS 19 was used for all statistical analyses. Since the subsequent analysis relied on raw scores, the reliability of all raw score measures was calculated. The reliability of the measures was computed for the total sample. The Cronbach's α scores varied, with the majority of coefficients hovering between 70 and 79. The majority of reliability coefficients are within an acceptable range (0.70) for basic research (Nunnally & Bernstein, 1994).

Table 2 presents the mean and standard deviations in total reading performance scores and its components (accuracy, fluency, and comprehension scores) for the two ages groups of the participants. Reading scores were evaluated by 2×2 [(age (older and younger students) \times gender (boys and girls)] mixed effects model ANOVA in an attempt to verify group differences in total reading performance and its components (accuracy, fluency, and comprehension). Results of the ANOVAs revealed a significant main effect of age for total reading performance [$F(1,285) = 9.457, p < 0.01$] with lower performance for the younger age group ($M = 217.72, \pm 48.52$) than for the older age group ($M = 236.27, \pm 41.73$). The main effect of reading fluency was also significant [$F(1,285) = 11,289, p < 0.001$] with lower performance for the younger age group ($M = 61.94, \pm 26.89$) than for the older age group ($M = 74.45, \pm 28.93$). Finally, the main effect of reading comprehension was also significant

Table 2. Reading performance (mean and standard deviations) scores by age group

Tasks	Age				η^2	Power
	85–91 months		92–98 months			
	M	SD	M	SD		
Reading accuracy	93.50	18.23	96.40	13.52	0.01	0.34
Reading fluency	61.94**	26.89	74.45**	28.93	0.04	0.93
Reading comprehension	6.80*	2.80	7.47*	2.63	0.01	0.46
Total reading performance	217.72**	48.52	236.27**	41.42	0.03	0.87

* $p < 0.05$.

** $p < 0.01$.

Table 3. Reading performance (mean and standard deviations) scores by gender

Tasks	Gender				η^2	Power
	Boys		Girls			
	M	SD	M	SD		
Reading accuracy	95.97	13.61	95.40	13.52	0.00	0.06
Reading fluency	74.54	30.58	68.14	28.93	0.01	0.39
Reading comprehension	7.03	2.53	7.58	2.63	0.01	0.43
Total reading performance	234.93	46.50	228.44	41.42	0.05	0.24

[$F(1,285) = 4,064, p < 0.05$] with lower performance for the younger age group ($M = 6.80, \pm 2.80$) than for the older age group ($M = 7.47, \pm 2.63$). The main effect of reading accuracy was not significant [$F(1,285) = 2,583, p = 0.109$], with the younger age group having similar performance scores ($M = 93.50, \pm 18.23$) with the older age group ($M = 96.40, \pm 13.52$). However, the effect size for age and total reading performance was relatively small ($\eta^2 = 0.03$), as well as the effect size for reading fluency ($\eta^2 = 0.04$) and reading comprehension ($\eta^2 = 0.01$). That is, even though there is a statistically significant relationship between ages and reading performance tasks, age accounts for little of the variance in reading performance.

Table 3 presents the mean scores and standard deviations for the total reading performance and its components accuracy, fluency, and comprehension scores of the second-grade boys and girls. Results of the ANOVAs revealed no significant differences according to gender in total reading performance ($F < 1$) or in its components tested separately with accuracy ($F < 1$), fluency [$F(1,285) = 1.009, p = 0.316$], and comprehension [$F(1,285) = 3.770, p = 0.053$], which mean that the two genders did not differ in their reading performance. Additionally, the interaction between the effects of age and gender was not significant in total reading performance ($F < 1$) or in its components tested separately with accuracy ($F < 1$), fluency ($F < 1$), and comprehension [$F(1,285) = 1.617, p = 0.205$], indicating that the effect of age did no differ for boys and girls.

4. Discussion

The present study aimed to examine the reading performance of second-grade school children. More specifically, we attempted to investigate possible age and gender differences in reading performance (accuracy, fluency, and text comprehension). Our results revealed a significant effect of age in reading performance, with older children having better scores than younger ones in reading fluency, reading comprehension, and the total reading performance. However, the effect size of the variable age on total reading performance was relatively small, as well as the effect size on reading fluency and reading comprehension. That is, even though there is a statistically significant relationship between ages and reading performance tasks, age accounts for little of the variance in reading performance. This finding could be attributed to the relatively large samples involved in the analyses

which enhanced the power of the tests and allowed for statistically significant differences to be detected, however small these might be. Nevertheless, it could still be suggested that teachers should be aware that the younger pupils in their class might require additional support in their reading compared to their older classmates and take appropriate action to effectively meet their needs. The absence of significant differences in reading accuracy could be attributed to the well-documented statement that in languages with more transparent orthography, such as Greek, high levels of reading accuracy are reached quite rapidly (Seymour et al., 2003; Zoccolotti et al., 2009).

Our findings are in accordance with several studies which found out that older children have better scores than younger ones in reading performance (Bell & Daniels, 1990; Borg & Falzon, 1995; Crosser, 1991; Russell & Startup, 1986; Trapp, 1995). Additionally, they reflect a continuation of the trend reported by other researchers (Davis et al., 1980; DiPasquale et al., 1980; Donofrio, 1977) that younger pupils seemed to be less ready for school tasks than their older peers verifying our first hypothesis.

However, our results are in disagreement with those reported by Dietz and Wilson (1985) and Gredler (1980) who reported no age effect on academic performance. It has been argued (Borg & Falzon, 1995) that the age-position effect lends support to the concept of readiness or maturation, that is, the notion that a pupil will cope with concepts or tasks only when she or he has reached a particular stage of cognitive development (Bell & Daniels, 1990). Hence older pupils will be more receptive than younger ones.

The age differences reported in this study could be attributed to the continuous maturation of the visual and auditory temporal processing—capacities necessary for a successful reading—during school age years (Dawes & Bishop, 2008). From a neurobiological point of view, the differences in reading performance we found in this study between younger and older second-grade students could be attributed to differences in brain maturation and hemispheric lateralization for language processing between these two groups. In a very recent functional magnetic resonance imaging study, young beginning readers (aged 8.3 years) with age-appropriate reading skills displayed a left hemispheric dominance characteristic for language processing already by grade two, while their poor readers peers displayed a more bilateral activation pattern, which points to an increased effort and the emergence for compensatory strategies for reading and the phonological processing just 1.5 years after the start of formal reading instruction (Bach et al., 2010).

The possible differences in brain maturation between younger and older second graders could be explained by the finding reported in a diffusion tensor magnetic resonance imaging study, which highlights the structural integrity of the brain wiring. This research (Beaulieu et al., 2005) showed that regional brain connectivity in the left temporo-parietal white matter correlates with a wide range of reading ability in children as young as 8–12 years old, suggesting that the maturation of the white matter may play a key role in the development of cognitive processes such as reading. As suggested recently by Schlaggar and Church (2009), the dynamic nature of the reading brain as the child matures is a demonstration of both the inherent flexibility and the increasing efficiency of brain processing over development.

The second hypothesis, which essentially investigated gender's effect on reading performance, was not supported from our results. Gender was not found to play an important role, since we did not obtain statistically significant differences in reading performance between the two genders. Our results are generally in line with previous research (Nancollis et al., 2005; Trapp, 1995), which found no female superiority in reading. This finding reflects a continuation of the trend reported by Borg and Falzon (1995) that during the primary years there are no consistent gender differences on the scholastic attainment.

However, there is evidence suggesting that differences in cerebral laterality between boys and girls (Clements et al., 2006; Jaeger et al., 1998) as well as genetic and environmental factors (Olson, 2002) can contribute to gender differences in reading. Girls are generally found to perform better

than boys in many tasks related to reading (Guthrie & Greaney, 1991; Joseph, 2000) and more boys than girls experience reading problems (Wheldall & Limbrick, 2010). A likely explanation for these conflicting results is that the effect sizes for the gender difference vary across different reading tests. Males and females perform equally on some reading tests but not on others. As Freeman (2004) reports the National Assessment of Education Progress results for fourth, eighth and tenth grades in schools in the USA showed that girls outperformed boys in reading.

Males and females are different by their biology but they also differ from each other in cognitive functions (Kimura, 1999). Neurophysiological studies on children (Hanlon, Thatcher, & Cline, 1999) suggest that gender differences occur in many brain regions early in prenatal development and continue throughout the life cycle. Neuroimaging studies examining gender differences in cerebral activation patterns associated with language-based tasks, such as phonological processing and auditory comprehension tasks have shown differences in cerebral laterality (Kansaku, Yamaura, & Kitazawa, 2000; Pugh et al., 1996). More specifically, during phonological processing tasks, results indicate that men have a significantly greater left lateralization in frontal regions. Kansaku et al. (2000) obtained similar results when looking at posterior brain regions utilizing auditory comprehension tasks, whereby men demonstrate greater left lateralization in middle and superior temporal gyri than women whose patterns of activation are more bilateral. The aforementioned results suggest that women are more likely to have a bilateral representation for language and that both hemispheres have sufficient capacity to handle language tasks. However, there are neuroimaging studies in which no gender differences were found (i.e. Frost et al., 1999). Clements et al. (2006) attributed these contradictory results to the small samples employed and differences among the types of tasks used in the language domain as well as to the way that tasks have been measured (auditory vs. visual). Our results support the conclusions of a recent electrophysiological study of school-aged children (Spironelli, Penolazzi, & Angrilli, 2010), that neurophysiological gender differences are not accompanied by a difference in linguistic competence and performance; therefore, linguistic networks recruited in boys' and girls' brain are equally efficient for reading but start from neuroanatomical and functional distinct hemispherical asymmetries. In sum, although the two genders develop brain areas known to be lateralized for specific verbal functions in a somewhat different order, time, and rate across the left and right hemispheres, our results may have an implication that this variety of maturity doesn't affect the reading performance in second grade.

Taken together, the findings of our study may imply that second graders' age variability could be one factor, among many others, for explaining significant differences in their reading performance. However, it remains to be confirmed whether the differences observed in the current study apply across different socioeconomic groups and literacy environments. Reading is a learned skill, and both biological and environmental factors intervene and affect school children's reading performance (Olson et al., 2011). Reading development is shaped through the interaction of child's maturation and environmental experiences, and thus a fuller understanding of this developmental process should take into account both factors. In this view, literacy work at home could diminish the differences in reading performance observed in our study between older and younger children attending the same grade. However, given the multitude of biological and environmental factors which might affect reading development during childhood, but also that biological age is a stable factor, it is vital to provide opportunities for practice especially for younger children to improve their reading skills.

The first school years represents a critical stage of reading development, since the learning experiences accumulated could affect the scholastic attainment in subsequent years (Shonkoff & Phillips, 2000). As suggested by Bentin, Hammer, and Cahan (1991) the impact of education during this period is four times larger than the impact of age. Reading literature confirms that the process of learning to read begins early, even before the beginning of formal instruction in schools, and highlights as well the importance of early experiences for young children's reading preparation.

Given that reading is a learned skill and not a biological awakening, our findings might have important educational implications. Firstly, they remind us of the crucial role parents play in promoting children's reading development prior to starting school. In other words, parents could provide young children with relevant early home experiences, in order to diminish possible age handicap on reading skills. More specifically, they could encourage the young child to tell what he or she thinks or feels, to build a rich vocabulary by reading and talking about new words, to play sound games, to talk about letters and sounds, to learn the sounds of language and language patterns, etc. Given that a plethora of studies have shown that the literacy environment at home and in school makes the difference (Davidson & Snow, 1995; La Paro & Pianta, 2000), and that the speed of learning to read often depends on children's phonological awareness at the beginning of kindergarten, teachers and parents could adopt strategies to promote phonological awareness helping them to recognize syllables and individual sounds in words, to combine or blend sounds into words, to manipulate syllables in words, and to link sound and letter information. Additionally, elementary school teachers have to make learning meaningful, taking into account the age, interests, and needs of children, to provide a rich and varied literacy environment, to integrate reading into other activities, to show that it is an essential, everyday skill with practical value, to use assessment data to determine the current strengths and needs of children, to continually adapt their teaching strategies to match a child's growth, to pay attention to the needs of children who are at risk of reading failure, and to seek timely intervention and support.

In conclusion, our findings highlight the necessity of comprehensive intervention during kindergarten and first grade to ensure that all students are on the right track for learning through the school years. Given that children arrive at the doorsteps of formal education exhibiting meaningful differences both in the neural systems and the social experiences on which educational practices must build. Teachers should give special importance to reading instruction during the first school years. Their efforts should aim to counterbalance possible performance differences due to age factor as well as to prevent reading problems the subsequent scholastic years.

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