Journal of Education and Human Development
December 2015, Vol. 4, No. 4, pp. 58-62
ISSN: 2334-296X (Print), 2334-2978 (Online)

Published by American Research Institute for Policy Development
DOI: 10.15640/jehd.v4n4a8
URL: http://dx.doi.org/10.15640/jehd.v4n4a8

Executive Function and Academic Skills in First Grade: Evidence for a Male Advantage in Patterning

Ally Patterson[1], Allison Bock[2] & Robert Pasnak[3]

Abstract

Children's abilities to recognize and manipulate patterns have been linked to executive function and reading skills. The literature on sex differences related to these skills is inconsistent, with some studies demonstrating an advantage for young females in inhibition, working memory, and reading comprehension. The present study sought to identify any sex differences in patterning, as well as any sex differences in the relationships between patterning, executive function skills, and reading ability. The present study found evidence for a male advantage in patterning, but did not find support for any sex differences in executive function or reading skills. Additionally, the present study found support for a relationship between cognitive flexibility and patterning that did not differ by sex. Overall, the present study contributes to a growing body of work on patterning, but is the first to identify a male advantage in this skill. In light of these findings, teachers and parents may choose to emphasize patterning instruction for female students in order to bridge the gap between boys' and girls' performance.

Keywords: patterning, executive function, mathematics, sex differences

1. Introduction

Despite popular stereotypes of female academic inferiority, some empirical evidence suggests that sex differences in mathematics are nonexistent prior to third grade (Fryer & Levitt, 2010). Other evidence suggests that girls' performance in mathematics remains equal to boys throughout the school years (Else-Quest, Hyde, & Linn, 2010). It could be expected, then, that young boys and girls will have similar performance on mathematics exercises in the early-elementary years.

Patterning is an academic skill that has been covered in early-elementary mathematics curricula for many years (Clements & Sarama, 2007a). Patterning instruction is a ubiquitous feature of United States kindergartens, and is part of the Common Core of U. S. education (National Governors Association Center for Best Practices, 2010). Successful patterning requires that the child recognize or manipulate a pattern in a group of items. This skill involves more than simple size, color, or shape recognition. Instead, patterning requires that children use generalization and abstraction skills to identify a rule within the set of units, and then complete the sequence. These skills have been shown to relate to executive functions such as working memory and cognitive flexibility (Lee, Ng, Bull, Pe, & Ho, 2011; Miller, Rittle-Johnson, Loehr, & Fyfe, in press). Though research has not been published on sex differences in children's patterning skills, some tasks assessing executive function have been shown to differ by sex (Boelema et al., 2014; Mileva-Seitz et al., 2015). Because patterning is associated with mathematics and related to executive functions, it is unclear from the literature if a particular sex should demonstrate better performance in patterning.

[1] George Mason University, Department of Psychology, 4400 University Drive, 3F5, Fairfax, VA 22030 USA. apatte17@gmu.edu, Telephone: 1-251-767-5501, Fax: 1-703-993-8279
[2] George Mason University, Department of Psychology, 4400 University Drive, 3F5, Fairfax, VA 22030 USA. Current address: University of Minnesota, 1954 Buford Ave, 425Z, St Paul, MN 55108
[3] George Mason University, Department of Psychology, 4400 University Drive, 3F5, Fairfax, VA 22030 USA.

Female children often have an advantage on measures of general intelligence, possibly related to earlier maturation of the female brain (Palejwala & Fine, 2015). Additionally, girls show early advantages in reading comprehension (Logan & Johnston, 2009), an ability that has been linked to executive function skills (Cartwright, 2012). Sex differences on executive function tasks are less consistent, but often do favor girls. Mileva-Seitz et al. (2015) found that 4-year-old girls outperform boys on tests of inhibitory control as measured by the Go/No Go task. Additionally, Boelema et al. (2014) performed a longitudinal investigation of adolescents' executive function skills and concluded that females show evidence of mature inhibitory control by the beginning of adolescence, while males do not. However, Macdonald, Beauchamp, Crigan, and Anderson (2014) did not find any sex differences in accuracy of inhibitory control in their sample of 5-to 8-year-olds.

Some researchers have found sex differences in working memory as well. Lynn and Irwing (2012) reported an advantage on the Wechsler digit span test of working memory for female children and adolescents, but a male advantage for adults. Additionally, Lynn and Irwing described a trend whereby this advantage is greater for girls who are five years old than for girls aged 6 to 16, suggesting that males may make compensatory gains during middle childhood and adolescence. However, in a study assessing cognitive flexibility in 3- to 5-year-olds, Deak and Wisehard (2015) found no differences between boys and girls on card sort and induction tasks. Overall, what sex differences exist in executive functions during the middle childhood years remains unclear.

The present study sought to identify sex differences among first graders' executive function and reading skills, and to determine the contribution of these skills to patterning. This connection between executive function and patterning is expected because previous research has established relationships between patterning, executive function skills, reading achievement, and mathematics achievement (Bock et al., 2015; Miller et al., in press). Within these relationships, however, variations due to sex differences remain unknown.

In keeping with the literature, we expected a female advantage for inhibition, working memory, and reading tasks, but equal performance by males and females for a cognitive flexibility task. Further, we expected that executive function and reading performance would be related to patterning for both males and females. Finally, we hypothesized a female advantage in patterning, stemming from a female advantage in executive function and reading skills.

2. Method

2.1. Participants

Eighty-four children from 11 first-grade classrooms in a Mid-Atlantic area were recruited for participation. The sample included an approximately equal number of boys (N = 40) and girls (N = 44) who were either six or seven years old.

2.2. Procedure and Materials

Participants completed an assessment of reading ability, the Gray Oral Reading Test 4 (GORT), a patterning assessment previously used by Bock et al. (2015), and three measures of executive function skills. For the GORT, children read five passages aloud and then answered comprehension questions. For the 24-item patterning measure, children filled in blank sections of pattern sequences using one of four alternatives. The patterns were series of numbers, pictures of objects, or letters that increased or decreased in value, size, or position of the alphabet, or were symmetrical. They were presented via a flip chart in a counterbalanced order.

Working memory was assessed with the digit span section of the Wechsler Intelligence Scale for Children. To measure memory capacity, children were first asked to repeat several series of numbers in the sequence they were given. Afterwards, children were asked to repeat several series of numbers backwards as a measure of working memory. Inhibition was assessed with the Day/Night task, which asks children to say "day" when they see a picture of the moon and "night" when they see a picture of the sun (Gerstadt, Hong, & Diamond, 1994). Cognitive flexibility was assessed with the Multiple Classification Card Sorting Test in a procedure similar to the one used by Cartwright (2002). During this task, children sorted four sets of 12 cards based on the color and type of image on each card.

3. Results

Descriptive statistics were computed for all variables. With the exception of inhibition, all variables were normally distributed. The inhibition variable had high negative skewness and positive kurtosis values, indicating a ceiling effect. A t-test revealed that boys (M = 8.83, SD = 3.48) performed more accurately on patterning than girls (M = 7.14, SD = 3.37), $t(82) = 2.26$, $p < .05$. The effect size (d = .49) is considered a medium effect (Cohen, 1992).

Boys and girls performed equally accurately on all measures of executive function and reading ability, $p > .05$. A simple regression revealed that working memory (as measured by Wechsler digit span backwards) contributed significantly to total reading comprehension on the GORT for boys only, B = .35, $t(38) = 2.09$, $p < .05$. Working memory performance did not contribute to reading comprehension for girls, B = .17, $t(42) = 1.04$, $p > .05$. Additionally, for boys only, there was a medium correlation between working memory and average reading comprehension on the GORT, $r(38) = .37$, $p < .05$, as well as a medium correlation between working memory and reading fluency on the GORT, $r(38) = .45$, $p < .01$. For girls, there were no significant relationships between working memory and average reading comprehension $r(42) = .17$, $p > .05$ or working memory and reading fluency $r(42) = .06$, $p > .05$.

As reported in Bock (2015), simple correlational analyses were performed to determine correlations between the variables. Patterning was correlated only with cognitive flexibility $r(82) = .31$, $p < .01$. Cognitive flexibility was significantly correlated with inhibition, $r(82) = .23$, $p < .05$, and working memory, $r(82) = .34$, $p < .01$, though inhibition and working memory were not significantly correlated with each other. These correlations have medium effect sizes (Cohen, 1992). Additionally, reading comprehension was marginally correlated with inhibition, $r(82) = .23$, $p < .10$, and significantly correlated with working memory, $r(82) = .27$, $p < .05$. Only working memory was significantly related to reading fluency, $r(82) = .30$, $p < .01$.

4. Discussion

The primary goal of this study was to determine whether there were sex differences in pattern identification among first-grade children. A secondary goal of the study was to determine sex differences in executive function and reading skills, which have been previously linked to patterning. The results revealed a male advantage in patterning, but no sex differences in inhibition, cognitive flexibility, working memory, or reading comprehension and fluency. Additionally, the results revealed that working memory contributed to variance in reading comprehension for boys only, and correlated with reading fluency for boys only. The results replicated Bock et al.'s (2015) finding that cognitive flexibility is related to patterning. Finally, results demonstrated that cognitive flexibility is related to both inhibition and working memory; reading comprehension is related to inhibition and working memory; and reading fluency is related to working memory.

This study is the first to identify sex differences in patterning, a skill frequently taught in elementary school math curricula. This finding was unexpected because patterning is thought to contribute to early mathematics (Clements & Sarama, 2007a,b; National Association for the Education of Young Children/National Council of Teachers of Mathematics Education, 2002/2010; National Council of Teachers of Mathematics, 1993) and is part of the Common Core of U. S. education for that reason (National Governors Association Center for Best Practices, 2010), and previously published results showed similar male and female achievement in early-elementary school math (Fryer & Levitt, 2010). Additionally, this finding is unexpected because of the relationship of patterning to some executive function skills (Lee et al., 2011; Miller et al., in press), which often favor female children (Boelema et al., 2014; Mileva-Seitz et al., 2015). These results are also unexpected because patterning has been linked to reading skills (Hendricks, Trueblood, & Pasnak, 2006; Kidd et al., 2014), which girls often develop before boys (Logan & Johnston, 2009). The present study did not demonstrate any sex differences in accuracy on any task except for patterning.

This study adds to an inconsistent body of literature on sex differences in executive function skills. While some studies have found sex differences in some or all of these skills (Boelema et al., 2014; Gur et al., 2012; Lynn & Irwing, 2008; Mileva-Seitz et al., 2015), other results indicate that boys and girls perform equally well on such measures (Deák & Wiseheart, 2015), which is what was found here. Additionally, this study demonstrates relationships between working memory and reading comprehension; and working memory and reading fluency, but for boys only.

This finding stands in contrast to research suggesting relationships between reading and working memory for all children. Further research is needed to identify and explain these differences and similarities, especially as they relate to the male patterning advantage apparent in our sample.

Limitations of this study include lack of variance in the inhibition variable, caused by a ceiling effect. A different inhibition task should be used in the future for school-aged children. Additionally, this study did not examine mathematics performance, which has been shown to differ by sex in some studies of older age groups (Fryer, & Levitt 2010). Future patterning studies should consider including a math assessment, as patterning is grouped with mathematics in school curricula.

Overall, the present study contributes to a growing body of work on patterning, but is the first to identify a male advantage in this skill. Future research could look beyond explanations related to executive function or reading skills to help explain these findings. The results could be useful to teachers who might consider the influence of executive function skills when working with struggling readers. Additionally, other researchers have demonstrated that boys generally receive more attention from their teachers during instruction, and that this discrepancy is especially apparent during mathematics lessons (Eccles, MacIver, & Lange, 1986). In light of these findings, teachers and parents may choose to emphasize patterning instruction for female students in order to bridge the gap between boys' and girls' performance.

References

Bock, A. M. (2015). *The cognitive components of patterning: The relation between executive function and patterning* (Unpublished doctoral dissertation). Retrieved from ProQuest Dissertations & Theses Global. (3707241)

Bock, A., Cartwright, K. B., Gonzalez, C., O'Brien, S., Robinson, M. F., Schmerold, K., Shriver, A., & Pasnak, R. (2015, March). *The role of cognitive flexibility in patterning.* Paper presented at Eastern Psychological Association, Philadelphia, PA.

Boelema, S. R., Harakeh, Z., Ormel, J., Hartman, C. A., Vollebergh, W. A., & van Zandvoort, M. J. (2014). Executive functioning shows differential maturation from early to late adolescence: Longitudinal findings from a TRAILS study. *Neuropsychology*, *28*(2), 177.doi:10.1037/neu0000049

Cartwright, K. B. (2002). Cognitive development and reading: The relation of reading-specific multiple classification skill to reading comprehension in elementary school children. *Journal of Educational Psychology, 94,* 56-63.

Clements, D. H., & Sarama, J. (2007a). Mathematics. In R. S. New & M. Cochran (Eds.), *Early Childhood Education: An international encyclopedia* (Vol. 2, pp. 502-509). Westport, CN: Praeger.

Clements, D. H., & Sarama, J. (2007b). Early childhood mathematics learning. In F. K. Lester, Jr. (Ed.), *Second handbook of research on mathematics teaching and learning* (pp.461-555). Charlotte, NC: Information Age.

Cohen, J. (1992). A power primer. *Psychological Bulletin, 112*, 155-159.

Deák, G. O., &Wiseheart, M. (2015). Cognitive flexibility in young children: General or task-specific capacity?. *Journal of Experimental Child Psychology*, *138*, 31-53.

Eccles, J., MacIver, D., & Lange, L. (1986, April). *Classroom practices and motivation to study math*. Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Else-Quest, N. M., Hyde, J. S., & Linn, M. C. (2010). Cross-national patterns of gender differences in mathematics: a meta-analysis. *Psychological bulletin*, *136*(1), 103.

Fryer, R. G., & Levitt, S. D. (2010). An empirical analysis of the gender gap in mathematics. *American Economic Journal: Applied Economics*, 2, 210 –240. doi:10.1257/app.2.2.210

Gerstadt, C.L., Hong, Y.J., & Diamond, A. (1994). The relationship between cognition and action: Performance of children 3.5–7 years old on a Stroop-like day-night test. *Cognition*, 53, 129–153.

Gur, R. C., Richard, J., Calkins, M. E., Chiavacci, R., Hansen, J. A., Bilker, W. B., … Gur, R. E. (2012). Age group and sex differences in performance on a computerized neurocognitive battery in children age 8–21. *Neuropsychology*, *26*(2), 251–265. doi:10.1037/a0026712

Hendricks, C., Trueblood, L., & Pasnak, R. (2006). Effects of teaching patterning to first graders. *Journal of Research in Childhood Education, 21*, 77-87.

Kidd, J. K., Pasnak, R., Gadzichowski, K. M., Gallington, D. A., McKnight, P., Boyer, C. E., & Carlson, A. (2014). Instructing first-grade children on patterning improves reading and mathematics, *Early Education and Development, 25*, 134-151.

Lee, K., Ng, S. F., Pe, M. L., & Ho, R. M. H. (2011). Are patterns important? An investigation of the relationships between proficiencies in patterns, computation, executive functioning, and algebraic word problems. *Journal of Educational Psychology, 103,* 269-281.

Logan, S., & Johnston, R. (2009). Gender differences in reading ability and attitudes: Examining where these differences lie. *Journal of Research in Reading*, *32*(2), doi:199-214.10.1111/j.1467-9817.2008.01389.x

Lynn, R., & Irwing, P. (2008). Sex differences in mental arithmetic, digit span, and g defined as working memory capacity. *Intelligence*, *36*(3), 226-235.

Macdonald, J. A., Beauchamp, M. H., Crigan, J. A., & Anderson, P. J. (2014). Age-related differences in inhibitory control in the early school years. *Child Neuropsychology*, *20*(5), 509-526. doi:10.1080/09297049.2013.822060

Mileva-Seitz, V. R., Ghassabian, A., Bakermans-Kranenburg, M. J., van den Brink, J. D., Linting, M., Jaddoe, V. W., ... & van IJzendoorn, M. H. (2015). Are boys more sensitive to sensitivity? Parenting and executive function in preschoolers. *Journal of experimental child psychology*, *130*, 193-208.

Miller, M., Rittle-Johnson, B., Loehr, A. M., & Fyfe, E. R. (in press). The influence of relational knowledge and executive function on preschoolers' repeating pattern knowledge. *Journal of Cognition and Development*. doi:10.1080/15248372.1023307

National Association for the Education of Young Children/National Council of Teachers of Mathematics Education (2002/2010*) Early childhood mathematics education: Promoting good beginnings*. Washington, DC: NYAEC.

National Governors Association Center for Best Practices (2010) *Common core state standards*. Council of Chief State School Officers, Washington D.C.

National Council of Teachers of Mathematics. (1993). *Curriculum and evaluation standards for school mathematics addenda series, grades K-6.* Reston, VA: NCTM.

Palejwala, M. H., & Fine, J. G. (2015). Gender differences in latent cognitive abilities in children aged 2 to 7. *Intelligence*, *48*, 96-108. doi:10.1016/j.intell.2014.11.004