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Math Learning in Grade-4 and 5: What Can We Learn Form The Opportunity-Propensity Model?

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Abstract

Several factors seem important to understand the nature of mathematical learning. Byrnes and Miller combined these factors into the Opportunity-Propensity model. In this study the model was used to predict the number-processing factor and the arithmetic fluency in grade 4 (*n* = 195) and grade 5 (*n* = 213). Gender, intelligence and affect (positive affect for arithmetic fluency and negative affect for calculation accuracy) predicted math learning, and pointed to the importance of the propensity factors. We have to be careful not to interpret gender differences, since this is a social construct, our analyses pointed to the relevance of including antecedent factors in the model as well . The Implications of the study for math learning will be discussed below.

Keywords:

Mathematics, Gender, Intelligence, Propensities, Opportunities, Affect, Motivation

Introduction

Mathematics Learning

Mathematics is important in our society. Mathematics is as essential as being able to read and write (Ojose, 2011). In a longitudinal study in the United Kingdom 1700 participants were interviewed at the age of 37 about/concerning/regarding their current job satisfaction. The study revealed that people with low math skills often got low-paid jobs. About 50% of the men with low math skills had a low income, whereas this was only the case in 26% of the men with good math skills (Parsons & Bynner, 1997). Geary (2011a) confirmed the relation between poor math skills and unemployment, low chances to get promotion and low SES. Another study (*N* = 21260) revealed that children with math problems had less chance to end their secondary school with a diploma and to enter higher education (Duncan & Magnuson, 2011).

Mathematics depends on heterogeneous interrelated subskills (Fias & Henik, 2021; Kadosh & Dowker, 2015). We can distinguish calculation accuracy and arithmetic fluency. In addition, regarding mathematics, children differ as far as their motivation and affect are concerned. In a Turkish study (*N* = 789, age: 9-12year Mathematics is considered) as one of the most feared topics in education (Şahin et al., 2014).

The Opportunity-Propensity Model

Several studies explored mathematics achievement in the past, focusing on cognitive abilities as predictors (e.g., Geary et al., 2011 a&b; Landerl et al., 2021). Other studies focused on non-cognitive abilities, such as motivation (e.g., Giofrè et al., 2017) or on contextual predictors (e.g., Kaskens et al., 2020; Perera & John, 2020) of mathematics. However, by focusing on single predictors, the importance and unique explained variance of these predictors might have been overestimated.

Byrnes and Miller (2007) developed the Opportunity-Propensity (O-P) framework, aiming to differentiate between opportunity and propensity factors in an effort to explain variance and individual differences in development. They defined Propensity factors (P) as the variables that make people able (e.g., intelligence) and/or willing (e.g., motivation and affect) to learn. Opportunity factors (O) are defined as contexts and variables that expose children to learning content (e.g., home environment, classroom instruction). Antecedent (A) are defined as variables that are present early in a child's life (e.g., birth weight, birth order and gender) and explain why some people are exposed to richer opportunity contexts and have stronger propensities for learning than others (Byrnes & Miller, 2007, 2016; Wang & Byrnes, 2013).

The O-P model has been tested by the use of secondary datasets. In the first longitudinal study, researchers explained about 80% of variance through antecedent, opportunity and propensity factors in secondary school children in the United States (Byrnes & Miller, 2007). A second study with data from kindergarten up until primary school revealed additional evidence for the O-P-model with propensity factors as the strongest predictors (Byrnes & Wasik, 2009). Finally, Wang and colleagues (2013) found evidence for this model in lower-income pre-kindergarten children. A visual representation of the model can be found in Figure 1.

Antecedent Factors

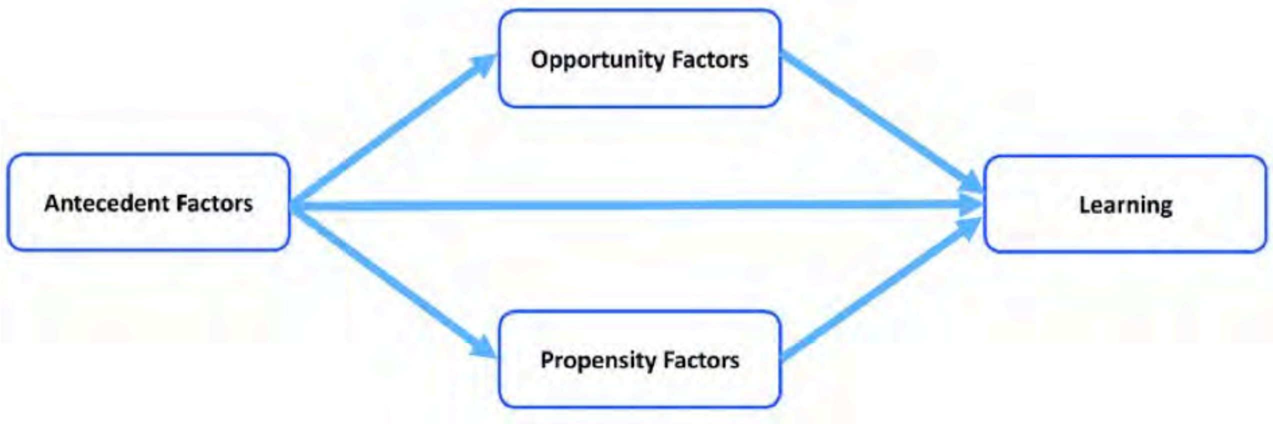
Most studies reveal that lower birth weight is related to lower levels of math performance at school-age level, with especially strong effects for extremely low birth weight (<1500 g; Chatterji et al., 2014; De Rodrigues et al., 2006; Klein et al., 1989).

Birth order seems to predict learning as well. In some studies, children who were born first, perform better in academic contexts (Belmont & Marolla, 1973; Cheng et al., 2012; Zajonc & Markus, 1975), although this was not the case in all samples (e.g., Desoete, 2008). The advantage of firstborn children has been explained by the dilution hypothesis in which the first born child takes advantage of more parental resources (at least for the time the child is only child), compared to later born children who had to share these resources (Hotz & Pantano, 2015).

Finally also gender, as a social construct might also be involved as antecedent predictor for learning. Reminding us that group differences should never be used as proof of group's superiority (Caplan & Caplan, 1997; 1999), some studies revealed that boys had better math skills than girls (Else-Quest et al., 2010; Freudenthaler et al., 2008; Lu, 2007; Lupart et al., 2004; Stoet & Geary, 2018; Zambrana et al., 2012). However other studies such as Spinath and colleagues (2010) did not find big gender differences and Byrnes and Miller (2007) and Byrnes (2020) concluded that gender could not explain much variance when other antecedent, opportunity or propensity factors that were taken into account.

Figure 1

Het Opportunity-Propensity model. Note. Adapted from "The relative importance of predictors of math and science achievement: An opportunity–propensity analysis." door J.P. Byrnes & D.C. Miller, 2007, Contemporary Educational Psychology, 32(4), p.599-629, (https://doi.org/10.1016/j.cedpsych.2006.09.002)



Opportunity Factors

There are several opportunity factors that explain variance in math learning. Teacher experience is one of this factors (Boonen et al., 2013; Byrnes, 2020; Byrnes & Miller, 2007; Clotfelter et al., 2010; Depaepe et al., 2013, Hattie, 2003). A recent study revealed that the alignment between different teachers (opportunity factor) and autonomous motivation in children (propensity factor) were the two most important predictors for the outcome variables to predict the home-learning experiences of 779 Belgian children with developmental disorders and 1443 of their typically developing peers (5-19 years) throughout the first remote learning period during the COVID-19 pandemic (Baten et al., 2022). In addition Boyd et al. (2007) and Hanushek et al. (2005) however showed that starting teachers were not always less effective compared to teachers that had more experience.

Another factor that explains variance in math learning is the exposure to the number of hours math instruction that is given (Cattaneo et al., 2016; Keith & Cool, 1992). However, in some studies the number of hours of math in class was not predictive (Aksoy & Link, 2000) or the impact differed between poor, moderate en high achieving pupils (Huebener et al., 2016).

Propensity Factors

Although some single study found no significant effect of intelligence (e.g. Jones & Byrnes), most studies demonstrated a significant relationship between intelligence (Floyd et al., 2003; Kucian & von Aster, 2015; Primi et al., 2010; Roth et al., 2015; Taub et al., 2008) and academic performance. Finally, some researchers focused on non-cognitive predictors (Schoenfeld, 1983) such as motivation (Deci & Ryan, 2008a&b; Froiland & Worrell, 2016; Ryan & Deci, 2000) and well-being or positive and negative affect (Awang-Hashim et al., 2015; Diener, 1984; Diener et al., 2005; McLeod, 1990; McLeod & Adams, 1989; Peixoto et al., 2016; Pekrun et al., 2006). In a meta-analysis, Taylor and colleagues (2014) highlighted a positive relationship between autonomous motivation (where the force to fulfill a task is internal, e.g., passion) and general school achievement, in addition to a negative relationship between controlled motivation (where the force to fulfill a task is external, e.g., reward-related) and academic achievement. This relationship was confirmed by several studies (Nurmi & Aunola, 2005; Pantziara & Philippou, 2014; Schneider & Bös, 1985; Steinmayr & Spinath, 2009). In addition also well-being can be considered a propensity factor, since it makes people willing and able to learn. Positive and bidirectional relations between subjective well-being and academic performance were found. Students with higher levels of subjective well-being (and more positive emotions than negative emotions) had better academic performance and vice versa. Furthermore, higher perceptions of own academic competence were predictive of better academic achievement and vice versa (Arefi et al., 2014) which confirmed the reciprocal-effects model between academic self-concept and academic achievement (Seaton et al., 2015).

Current Study

Although there is plenty of evidence for this model (Byrnes & Miller, 2016, 2007; Byrnes & Wasik, 2009; Wang & Byrnes, 2013) from secondary datasets, the model remains unknown and there is little research from primary data simultaneously tapping the antecedents, opportunities and propensities empirically in children explaining their mathematical achievement. Recently a PhD study was set up at Ghent University to explore how mathematics learning is related to factors described in the opportunity-propensity model using primary datasets. This resulted in a cross-sectional study combining antecedent, opportunity, and propensity factors in 114 numbchildren (Baten & Desoete, 2018) and in 30 adults (Baten & Desoete, 2021) as well as in an intervention study (Baten et al., 2020). The current study is an attempt to replicate the usefulness of the model on a larger sample of children (*n* = 408). It might seem unimportant to include antecedent factors as predictors, since these are clearly factors over which educators have no control. However including antecedent factors is essential not to overestimate the predictive value of opportunity and propensity factors in the model. As such, this study contributes to theory-building about mathematical learning. The study has two research questions (RQ).

Rq1: What Factors are Related to Proficient Mathematics in Grade 4 and 5 in Flanders?

The study investigated antecedents factors related to mathematics in grade 4 and 5. We studied the influence of gender (Freudenthaler et al., 2008; Lu, 2007; Lupart et al., 2004; Zambrana et al., 2012), birth order (Belmont & Marolla, 1973; Cheng et al., 2012; Hotz et al., 2015; Zajonc & Markus, 1975) and birth weight (Breslau et al., 2004; Chatterji et al., 2014; De Rodrigues et al., 2006; Klein et al., 1989).

In addition the study included opportunity factors related to mathematics in grade 4 and 5. We studied if the number of years of experience in teaching (Boonen et al., 2013; Clotfelter et al., 2010) and the instruction time (Aksoy & Link, 2000; Keith & Cool, 1992) predicted math proficiency in Flanders.

The study also included propensity factors, such as intelligence (Floyd et al., 2003; Kucian & von Aster, 2015; Primi et al., 2010; Roth et al., 2015; Taub et al., 2008), positive and negative affect related to mathematics (Peixoto et al., 2016; Pekrun, 2006) and motivation

(Nurmi & Aunola, 2005; Pantziara & Philippou, 2014; Steinmayr & Spinath, 2009).

Finally, in line with previous studies (Baten & Desoete, 2018; Fias & Henik, 2021) the impact of these factors on calculation accuracy and on fact retrieval fluency was studied.

Rq2: Are there Gender Differences as far as Mathematics and the Antecedent, Opportunity and Propensity Factors are Concerned?

We studied in line Else-Quest et al. (2010), Lu (2007), Zambrana et al. (2012) if there were gender differences in this sample, and expected in line with Bakhiet et al. (2015) no gender differences on intelligence, but higher intrinsic motivation (Skaalvik & Skaalvik, 2004) and more positive affect (Rubinsten et al., 2012) related to mathematics in boys.

Method

Participants

408 children in total participated in this cross-sectional study. The sample included 195 children (79 boys, 116 girls) from grade 4 and 213 children (84 boys, 129 girls) from grade 5. The age of the children differed from 9 till 12 years. The sample included 15 children with dyscalculia (3.68%), 27 children with dyslexia (6.62%) and 17 multilingual children (4.17%).

Procedure

After parents agreed to the participation of their children, an appointment for the actual research was made. Sessions lasted about 90 minutes while tests and questionnaires were administered individually to each child. Testing happened in a location chosen by the parents. The researcher gave standardized instructions and was available to answer questions.

Instruments

Antecedent and opportunity factors were measured through questionnaires. More specifically, for the O factors, teachers were asked how many years of experience they had in teaching mathematics and how many hours of mathematical instructions the children received per week (teaching hours).

To measure A factors, parents were asked about their aspirations regarding the mathematical abilities of their children. They had to reflect on the score they wanted their child to have at the end of the current school year (in percentage). Additionally, information on birth order and birth weight of the child was collected.

With regards to the P factors the following instruments were used.

Intelligence was measured using an abridged Dutch version of the Wechsler-Intelligence-Scale for Children-III (WISC-III-NL; Kort et al., 2005). The total intelligence quotient or IQ (M = 100; SD = 15) was obtained by combining the separate scores on the following subtests: Vocabulary, Similarities, Picture Concepts, and Block Design. The reliability of this short form was .92 and the distribution of total IQ-scores calculated with the short form did not significantly differ from the distribution of the scores on the full intelligence test (Grégoire, 2000). Cronbach's α of the total IQ in the current sample was .795.

Motivation for mathematics was measured with the Dutch version of the Academic Self-Regulation Scale (Vansteenkiste et al., 2009) which consists of 24 questions which allow the calculation of the level of autonomous and controlled academic motivation. As suggested by the authors, the introduction for the questions was changed from 'I am motivated to study because…', to 'I am motivated to study mathematics because …' in order to measure motivation with regards to mathematics specifically. The child had to respond on a 5-point Likert scale to statements such as 'because I find this an important goal in my life' as an index of autonomous motivation and 'because other people (e.g. parents, friends, teachers) oblige me to do so' to measure controlled motivation. The score for each scale was calculated by averaging the score on the items belonging to that scale. Cronbach's α for this sample was .86 for autonomous and .72 for controlled motivation.

Subjective well-being was determined through the Dutch version of the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988; translated by Engelen et al., 2006). Children indicated on a 5-point Likert scale how many negative (e.g. guilt and sadness) and positive (e.g. success and interest) emotions they experienced on a regular school day. Scores were calculated for the level of positive affect and the level of negative affect by averaging the score on 10 items. Cronbach's α for this sample was .85 for positive affect and .77 for negative affect.

Arithmetic fluency (fact retrieval speed) and calculation accuracy investigated as outcome measures.

To measure the arithmetical fluency, the Arithmetic Number Fact Test (de Vos, 2002) was used. Children had to solve as many additions (e.g. '7+2'), subtractions (e.g. '6-5'), multiplications (e.g. '5x8'), divisions (e.g. '27:9') or a mix of these exercises as possible within five minutes. The number of correct answers was used as outcome measure. This test has been standardized for Flanders on a sample of 10059 children. The psychometric value of the test has been demonstrated with a Cronbach's alpha of .900 (Desoete and Roeyers, 2005). For this sample Cronbachs α was .92.

To measure the calculation accuracy of the child, the Kortrijkse Rekentest Revisie (KRT-R; Baudonck et al., 2006) was administered. This test evaluates the conceptual understanding and the proficiency or accuracy needed to solve 90 exercises in a number-problem or word-problem format (e.g., '283 times more than -71 is …'; '27681:90 = …'; 'Wim has 4.8kg of flour. Jan has a double amount of flour. How many flour do Jan and Wim have together?') without a time limit. The number of correct answers was calculated as outcome measure. The internal consistency for this sample was Cronbach's α = .84.

Statistical Analyses

Statistical Package for the Social Sciences (SPSS), version 27 was used to analyse the data. First Spearman correlations were calculated.

To answer the first research question, multivariate hierarchic regression analyses were conducted. The multivariate hierarchic version was used. For fluency's sake rough data were used. For calculation accuracy z-scores were calculated since the test for grades 4 and 5 had other items. All analyses were conducted if/whenever the conditions to conduct parametric tests were fulfilled (Field, 2009).

For the second research question the condition of multivariate normality was not fulfilled, so independent samples t-tests were used. Bias-corrected and accelerated (BCa) lower and upper confidence intervals were computed using bootstrapping as computer-intensive resampling techniques that involved 1000 bootstrap samples based on the original observations in this study, as robust hypothesis testing of differences. The 1000 bootstrapped means were put in order, from lowest to highest, and the central 95% of values were used to form the confidence interval, using SPSS 27.

Results

Descriptive Statistics

Table 1 gives an overview of all correlations and the descriptive statistics that are given. Both math components (arithmetic fluency and calculation accuracy) correlated significantly (r = .43, p < .01). In addition fluency correlated with intelligence (r = .20, p < .01), positive affect (r = .32, p < .01) negative affect (r = -.19, p < .01) and autonomous motivation (r = .30, p < .01). For calculation accuracy similar results were found. Intelligence (r = .49, p < .01), positive affect (r = .33, p < .01), negative affect (r = -.31, p < .01) and autonomous motivation (r = .33, p < .01) correlated significantly with calculation accuracy. In addition birth weight correlated significantly with positive affect (r = -.14, p < .01) and there was a significant correlation between birth order and birth weight (r = .18, p < .05). The propensity factors also correlated significantly with each other.

Research question 1: What antecedent-, opportunity- and propensity factors are related on math in grade 4 and 5?

To answer this multiple question, in line with Field (2009, p 212) hierarchic regressions were conducted.

Table 1
Correlations between the variables and descriptive statistics

		M(SD)	1	2	3	4	5	6	7	8	9	10	11
1	Fluency	105.33 (20.96)											
2	Calculation	.00 (.99)	.43**										
3	Gender	-	-.16**	-.25**									
4	Birth weight	3342.36 (515.53)	.03	.07	-.15**								
5	Birth order	1.89 (1.07)	.05	-.00	-.06	.18*							
6	Experience T	17.28 (10.87)	.05	.04	-.01	.07	.05						
7	Hour math	6.15 (.90)	-.01	.04	.02	.04	-.03	.12					
8	Intelligence	0.00 (1.00)	.20**	.49**	-.05	.08	.00	.07	-.02				
9	PA	3.31 (0.72)	.32**	.33**	-.14**	-.02	-.06	.04	.00	.13**			
10	NA	1.71 (0.54)	-.19**	-.31**	-.02	-.03	-.01	-.03	.06	-.27**	-.42**		
11	Aut. mot.	3.48 (.88)	.30**	.33**	-.11*	-.03	-.03	.04	-.04	.17**	.74**	-.42**	
12	Cont. mot.	2.61 (.78)	.01	-.09	-.05	.30	.06	-.06	.02	-.17**	-.13**	.32**	-.17**

*Note: ** p < .01, * p < .05, Gender coded as 0 = male and 1 = female, Birth weight = birth weight in gram, , Experience T = experience teacher measured in number of years teaching, Hours math = number of hours per week a teacher teaches math, Intelligence = z-score on the Raven, PA = positive affect, NA = negative affect, Aut. mot. = total autonomous motivation, Cont. mot. = total controlled motivation*

In step 1 all antecedent factors were added. In step 2 all opportunity factors were added. Finally the opportunity factors were added..

Arithmetic Fluency

The antecedent factors in step 1 predicted a significant percentage of variance in arithmetic fluency (F(3, 310) = 3.37, p = .019). Especially gender was important. Boys were better in arithmetic fluency compared to girls. Adding the opportunity factors to the model (in step 2) did not improve the model (F(5, 308) = 2.07, p = .068). The teacher experience and the number of hours of instruction were no significant predictors for arithmetic fluency. Adding propensity factors (in step 3) improved the model, with 13% more explained variance (F(10, 303) = 5.97, p < .001). There was an explained variance of 14% with intelligence and positive affect that predicted arithmetic fluency. For more information, see Table 2.

Calculation Accuracy

In step 1 the antecedent factors explained 5% of the variance (F(3, 311) = 6.09, p < .001) in calculation accuracy. Gender was no significant predictor.

Adding opportunity factors (in step 2) made the model significant (F(5, 309) = 3.88, p = .002). However the experience of the teacher and the number of hours mathematics instruction were no significant predictors of calculation accuracy skills of children.

Adding propensity factors improved the model with 33% explained variance (F(10; 304) = 19.36, p < .001). Intelligence and negative affect were significant predictors of calculation accuracy. For more information, see Table 3

To conclude, the included opportunity factors were no significant predictors, whereas propensity variables explained 13% of the variance of arithmetic fluency and 33% of the variance of calculation accuracy. Intelligence was a significant predictor for fluency and accuracy, whereas positive affect only influenced arithmetic fluency.

Research question 2: Are there gender differences on mathematics and on the antecedent, opportunity and propensity factors?

Independent sample t-tests were used to look for gender differences, see Table 4.

Boys were better in mathematics compared to girls. They also experienced more positive affect. There were no significant gender related differences on opportunity factors. Boys in this sample had a higher birth weight compared to girls.

Table 2

Results of hierarchic multiple regressions on the antecedent, opportunity- en propensity factors of arithmetic fluency

	Arithmetic fluency							
Variable	R^2	*Adj. R^2*	ΔR^2	*B*	*SE B*	β	*t*	*p*
Step 1	.03	.02	.03					
Gender				-6.96	2.37	-.17	-2.94	.003**
Birth weight				.00	.00	.03	.53	.599
Birth order				.37	1.03	.02	.36	.719
Step 2	.03	.02	.00					
Gender				-7.03	2.37	-.17	-2.96	.003**
Birth weight				.00	.00	.03	.54	.591
Birth order				.31	1.04	.02	.29	.768
Teacher experience				.03	.11	.01	.26	.797
Hours math instruction				-.64	1.23	-.03	-.52	.603
Stap 3	.16	.14	.13					
Gender				-4.81	2.28	-.11	-2.11	.036*
Birth weight				.00	.00	.01	.28	.780
Birth order				.34	.98	.02	.34	.732
Teacher experience				-.01	.10	-.01	-.11	.909
Hours math instruction				-1.16	1.16	-.05	-1.00	.320
Intelligence				3.08	1.11	.15	2.78	.006**
Positive affect				6.58	2.34	.23	2.81	.005**
Negative affect				1.23	2.39	-.03	-.51	.607
Autonomous motivation				2.26	1.94	.09	1.17	.243
Controlled motivation				1.77	1.48	.07	1.19	.235

Note. * p < .05, ** p < .01

Table 3

Results of the hierarchic multiple regression analyses of the antecedent, opportunity- en propensity factors on calculation accuracy

Calculation accuracy								
Variable	R^2	*Adj.* R^2	ΔR^2	*B*	*SE B*	β	*t*	*p*
Step 1	.05	.05	.05					
Gender				-.45	.11	-.22	-4.02	<.001**
Birth weight				.00	.00	.05	.83	.409
Birth order				-.01	.05	-.01	-.14	.888
Step 2	.06	.04	.00					
Gender				-.45	.11	-.23	-4.03	<.001**
Birth weight				.00	.00	.04	.74	.947
Birth order				-.01	.05	-.01	-.21	.397
Teacher experience				.01	.00	.06	1.09	.598
Hours math instruction				.00	.06	.00	-.01	.762
Step 3	.39	.37	.33					
Gender				-.39	.09	-.19	-4.16	<.001**
Birth weight				.00	.00	-.00	-.07	.947
Birth order				-.03	.04	-.04	-.85	.397
Teacher experience				.00	.00	.02	.53	.598
Hours math instruction				-.01	.05	-.01	-.30	.762
Intelligence				.43	.04	.45	9.53	<.001**
Positive affect				.15	.10	.11	1.54	.125
Negative affect				-.30	.10	-.16	-3.05	.002**
Automous motivation				.12	.08	.10	1.48	.141
Controlled motivation				.10	.06	.08	1.61	.109

Note. * $p < .05$, ** $p < .01$

Discussion

Mathematics is important in our society (Duncan & Magnuson, 2011; Geary, 2011a & b; Ojose, 2011). The Opportunity-Propensity (O-P) model (Byrnes, 2020; Byrnes & Miller, 2007; Wang et al., 2013) integrates predictors of learning, and helps gaining insight into how predictors are interrelated, and whether some are more important than others.

Answering the first research question and looking at the antecedent factors, in line with some previous studies (Baten & Desoete, 2018; Desoete, 2008), but in contrast with other studies on birth weight (Breslau et al., 2004; Chatterji et al., 2014; De Rodrigues et al., 2006; Klein et al., 1989) and birth order (Belmont & Marolla, 1973; Cheng et al., 2012; Hotz et al., 2015; Zajonc & Markus, 1975) these antecendent factors could not significant explain variance in fact retrieval or calculation accuracy in our sample. However gender as antecendent factor, attributed to the variance in both math components. In line with previous studies (Freudenthaler et al., 2008; Lu, 2007; Lupart et al., 2004; Zambrana et al., 2012) boys were more proficient in mathematical fluency and in calculation accuracy in grade 4 and 5.

Looking at opportunity factors, the present study could not confirm significant predictors for math proficiency. The experience of the teacher nor the number of hours of instructions were significant predictors of variability in mathematics. The fact that experience was no significant predictor is in contrast with previous studies (Baten & Desoete, 2018; Boonen et al., 2013; Clotfelter et al., 2010), but the fact that the number of hours of instruction was not significant confirmed previous findings in Flanders (Baten & Desoete, 2018). It might be that not only the quantity of instruction, but especially the quality of instruction matters. Moreover, to engage in mathematics may also have more to do with what is happening outside the classroom than in for many students. Additional studies are needed including measures such as school attendance, parental educational level etc.

Looking at propensity factors, in line with previous studies in Flanders (Baten & Desoete, 2018), motivation did not predict math proficiency in grade 4 and 5. These findings are in contrast with the findings of Steinmayr and Spinath (2009) who found that higher motivation resulted in better math results. Intelligence was a significant predictor for math fluency and calculation accuracy, confirming previous studies (Baten & Desoete, 2018; Floyd et al., 2003; Kucian & von Aster, 2015; Primi et al., 2010; Roth et al., 2015; Taub et al., 2008). In this study there was a significant effect of positive affect on math fluency and a significant effect of negative affect on calculation accuracy, where in a previous study we found the reversed picture (Baten & Desoete, 2018).

Table 4

	Boys	Girls
Arithmetic Fluency (t_{313} = 3.32, *p* = .001). M [95% CI] *SD*	109.63_a [106.21; 113.03] (22.30)	102.49_b [100.15; 104.81] (19.56)
Calculation accuracy (t_{406} = 5.08, *p* < .001) M [95% CI] *SD*	0.30_a [0.14; 0.44] (0.97)	-0.20_b [-0.32; -0.08] (0.97)
Birth weight (t_{352} = 3.08, *p* = .002), M [95% CI] *SD*	3444.95_a [3367.42; 3523.64] (489.38)	3274.44_b [3207.80; 3341.64] (522.25)
Birth order (t_{403} = 1.65, *p* = .100). *M* [95% CI] *SD*	1.99 [1.81; 2.17] (1.17)	1.82 [1.70; 1.96] (0.98)
Teacher experience (t_{382} = 0.15, *p* = .878) *M* [95% CI] *SD*	17.38 [15.67; 19.06] (11.02)	17.21 [15.88; 18.65] (10.78)
Hours math instruction (t_{376} = 0.32, *p* = .751) *M* [95% CI] *SD*	6.17 [6.02; 6.35] (1.14)	6.14 [6.04; 6.24] (0.70)
Intelligence (t_{405} =0.86, *p* = .393) *M* [95% CI] *SD*	0.05 [-.10; .20] (1.03)	-0.03 [-.16; .08] (0.98)
Positive affect (t_{405} = 2.74, *p* = .006) *M* [95% CI] *SD*	3.43_a [3.31; 3.55] (0.74)	3.23_b [3.14; 3.32] (0.70)
Negative affect (t_{405} = 0.63, *p* = .529) *M* [95% CI] *SD*	1.74 [1.66; 1.83] (0.56)	1.70 [1.64; 1.77] (0.52)
Autonomous Motivation (t_{398} = 1.88, *p* = .061) *M* [95% CI] *SD*	3.58 [3.44; 3.73] (0.93)	3.41 [3.32; 3.52] (0.85)
Controlled Motivation (t_{397} = 0.92, *p* = .357) *M* [95% CI] *SD*	2.66 [2.54; 2.78] (0.78)	2.58 [2.48; 2.68] (0.78)

Note. 95% CI = 95% Confidence Interval

When comparing antecedent, opportunity and propensity factors, propensity factors were the strongest predictors for both math components. This finding confirmed a previous study on elementary school children (Baten & Desoete, 2018).

Answering the second research question, in line with earlier studies (Else-Quest et al., 2010; Stoet & Geary, 2018) boys were more proficient on mathematics compared to girls. However, these results have to be interpreted carefully since gender is increasingly being thought of as a social construct, rather than a biological one and some researchers point to the fact that analyzing sex differences might even be potentially harmful. These finding should therefore not be seen as proof of a more powerful group's superiority, but only as one of the antecedent factors in the O-P model. In addition, boys in this study had, in line with the findings of Voldner et all (2009) a higher birth weight. In contrast with Simonton (2008), we did not find evidence for differences in birth order. As expected there were no significant gender related opportunity differences. Looking at gender related propensity predictors, boys and girls only differed on positive affect, with boys having more positive feelings about mathematics compared to girls. This finding is in contrast with earlier studies (Ghasemi & Burley, 2019) were no gender differences were found. Boys and girls did not differ in this study on intelligence or on motivation.

This study has some limitations. First, there was no gender balance in the sample. More girls participated to the study. The second limitation was the cross-sectional design of the study and the fact that not all relevant factors of the opportunity-propensity model could be included. Finally Figure 1 might be an simplified version of the O-P model, since there is also a relationship from opportunities to propensities (Wang et al., 2013). Thus opportunity and propensity factors might not be as separate as Figure 1 would presume. Additional studies should include all relationships. In addition we should conduct longitudinal studies including also other O-P predictors such as teacher quality, school attendance, language fluency, SES, parental education level etc..

However the present analyses confirmed the value of the O-P model and gave us information of a rather large sample of children (*N* = 408) and their teachers.

Conclusion

In summary, our findings suggest two general conclusions. First, gender as antecedent factor in the Opportunity Propensity model (Byrnes & Miller, 2007) remains important. Gender friendly targeted instruction and giving all students the opportunity to engage in mathematics may be a educationally important. Second, especially propensity factors, such as intelligence and positive and negative affect explain variance in mathematical proficiency.

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