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# Motivation, Temperament, Personality and Well-Being as Predicting Propensity Factors for Mathematical Abilities of Adults

**Elke Baten*** 
Ghent University, BELGIUM

**Annemie Desoete**
Ghent University/ Artevelde University of Applied Sciences, BELGIUM

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**Abstract:** The role of motivation, temperament, personality and well-being as predicting propensity factors for mathematical abilities was investigated in 30 adults. By embedding these predictors in the Opportunity-Propensity framework, this study aimed to reveal their unique contribution in math development, which is important to improve mathematics education. To our knowledge, the present study is the first to combine predictors and find evidence for the importance of some non-cognitive and socio-emotional propensity factors for mathematical performance by using primary data. Results indicated significant interrelations between the propensities, pleading to integrate them in math research. Furthermore, the relationship propensities and mathematics was dependent on the specific investigated math task, which is in line with the componential nature of mathematics. Negative Affect was the best prediction of accuracy (lower levels of subjective well-being associated with lower levels of mathematical accuracy) whereas Intrinsic Motivation was the best predictor for fact retrieval speed. Limitations and implications for future research are described.

**Keywords:** *Mathematics, motivation, temperament, personality, well-being.*

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## Introduction

Already in the beginning of the first year of formal education, individual differences exist between children in terms of reading and mathematics (Claessens et al., 2009; Janus & Offord, 2007; Stock et al., 2010). As education continues, scholastic achievement differences were found to subsist (Deary et al., 2000). In addition, how children begin school is known to affect how they will continue (Fritz et al., 2021). Thus, having good mathematical abilities seems important. However, the acquisition of these skills is a struggle for some people, since a lot of individual differences exist in math abilities. This is also reflected in the fact that 5-7% of children (Shin & Bryant, 2015) get diagnosed with a Mathematical Learning Disability (MLD) when they have severe and persistent problems with mathematical performance, resistant to instruction (MLD; Bryant et al., 2015; Grigorenko et al., 2020; Morsanyi et al., 2018).

The existence of these individual differences in math abilities (Dowker, 2019; Dowker et al., 2019), increases the need to understand the nature of typical and atypical numerical cognition. This understanding might lead to the improvement of services for math strugglers in educational contexts. The Opportunity–Propensity (O-P) model supplies us with a framework to reflect on mathematical cognition (Byrnes & Wasik, 2009). The authors of this model suggest that people are more likely to realize their potential for learning if they are provided with the right Opportunities (O) to learn and have the will and capability or Propensity (P) to benefit from the Opportunities provided to them (Wang & Byrnes, 2013). Multiple predictors are taken into account in this model. This holistic approach on learning is relatively new. Previous research on math development especially focused on isolated predictors. Working memory (De Weerdt et al., 2013; Shin & Bryant, 2015), familiarity with math language (Praet et al., 2013), seriation, classification (Stock et al., 2010) and intelligence (Desoete, 2008; Dix & van der Meer, 2015) are only some examples of factors that have been related to later math achievement. Furthermore, most of the investigated predictors in previous research are situated on the cognitive level (for instance 'intelligence') but the research with regards to non-cognitive or socio-emotional predictors is more

* **Corresponding author:**
Elke Baten, Ghent University, Department of Experimental Clinical and Health Psychology Belgium. ✉ elke.baten@ugent.be

scarce. In terms of the Opportunity-Propensity model (Byrnes & Miller, 2007; Wang & Byrnes, 2013), it might be important to not only relate mathematical achievement to cognitive or ability Propensity factors (P factors), but also to investigate the role of non-cognitive constructs as P factors. In the following paragraph, 'motivation', 'personality', 'temperament' and 'subjective well-being' as non-cognitive P factors are described and theoretical embedded.

## Literature Review

*Motivation*

In a study on 1678 children in the United Kingdom, motivation in terms of self-perceived ability and intrinsic values predicted the achievement in mathematics above general intelligence (Spinath et al., 2006) However, the incremental validity of motivation as propensity factor, beyond intelligence could not be confirmed in a study on 179 Chinese primary school pupils. Only marginal significant results were reported. Cultural differences in opportunities (Europe vs. China) were postulated (Lu et al., 2011) to explain the lack of consistency among the findings. However, research on motivation with regards to mathematics remains promising (Baten et al., 2020; Desoete et al., 2019).

The Self-Determination Theory (SDT; Deci & Ryan, 1985; Orsini et al., 2015; Ryan & Deci, 2017) is one of the leading theories in motivational psychology. According to this theory, the quality of motivation increases when underlying motives to fulfill a task are more internalized or autonomous (in contrast with external or controlled motives; Vansteenkiste et al., 2009). Studying for a test to get a new bike from your parents if you obtain good grades is an example of an external or a controlled motive (controlled motivation, CM). In contrast, autonomous motivation (AM) refers to internalized motives such as studying mathematics because of the personal relevance for a later academic career or for feelings of pleasure and passion (Gagné & Deci, 2005; Vansteenkiste et al., 2009). Taylor et al. (2014) revealed moderately strong positive relations between autonomous motivation and general school achievement in a meta-analysis on 18 studies. The different types of controlled motivation had significant negative relations with academic achievement. However, because of the small number of studies included in the meta-analysis and some methodological problems with some of them, these results need to be interpreted with caution (Taylor et al., 2014). Nevertheless some studies revealed significant positive relations between autonomous motivation and academic achievement levels (Baten et al., 2020; Grolnick et al., 1991).

*Personality*

One of the most validated theories about human personality is the Big Five Personality Theory (Costa & McCrae, 1992). According to this theory the personality of people can be described in five traits: Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism. Openness is described as being curious and open to new experiences. Conscientiousness is about the amount of control and discipline, the will to achieve. Extraversion is described as being sociable and the level to which one needs social contacts. People who score high on Agreeableness are friendly and cooperative, helpful and trusty in nature. Neuroticism is described as the level of emotional stability. High scorers on Neuroticism are more emotionally instable and for instance more likely to be anxious or fearful (Costa & McCrae, 1992; Kwantes et al., 2016).

Research on the Big Five Personality traits and academic performance was integrated by Poropat (2009) in a meta-analysis on 80 research reports. Results revealed Conscientiousness and Openness as the Big Five traits with the strongest association with academic performance, even when controlling for intelligence. In 2012, these results were replicated (Richardson et al., 2012). Conscientiousness seemed to be the most strongly associated with academic performance (Bratko et al., 2006; Trautwein et al., 2009). Some authors investigated the relationship with other predictive factors for mathematical abilities such as motivation. Richardson et al. (2012) concluded that personality might work as a predictor for mathematical performance, through motivation.

*Temperament*

Temperament, as a construct, has been related to personality in a lot of studies (e.g. Smits & Boeck, 2006; Van Beek et al., 2013). It has been seen as underlying the surface of personality, visible from birth (Mervielde et al., 2005). According to the Reward Sensitivity Theory (Gray, 1981), individual differences in reactivity and self-regulation are linked to biological mechanisms that guide human behavior (Rothbart et al., 2000). More specific, the Behavioral Inhibition System (BIS) was considered as a biological system related to behavior to avoid punishment or negative consequences, whereas the Behavioral Activation System (BAS) was seen as a biological system related to pursuing reward or positive consequences (McNaughton & Corr, 2004). Furthermore, tests of the BAS-system such as the BIS/BAS scales (Carver & White, 1994) divided BAS into three subscales, namely BAS Drive, related to active behavior conducting to achieve goals; BAS Reward Responsiveness describing behavior to achieve positive emotions related to good performances and BAS Fun Seeking related to impulsive behaviors to achieve fun (Carver & White, 1994; Pickering & Corr, 2008).

In 565 Dutch university students, both BIS and BAS were related to academic performance, trough measures of study investment. Higher BAS was associated with higher study engagement, resulting in better academic performance. Higher BIS resulted in a lower academic performance through exhaustion (Van Beek et al., 2013).

*Subjective well-being*

The concept of subjective well-being (SWB) focuses on 'feeling well' in the hedonic tradition (Keyes & Annas, 2009). Diener (1984) describes three dimensions of SWB: positive emotions, negative emotions and life satisfaction. The positive and negative emotions are combined into the affective element, where the concept of life satisfaction forms the cognitive component (Disabato et al., 2016). In addition, Pekrun et al. (2002) developed the control-value model, as elaboration of Dieners' model to understand the effects of emotions on learning and academic performances. By appraising an environment (= cognitive component), emotions arise (= affective component) that at their turn have an effect on academic achievement.

Research on the relationship between SWB and academic achievement demonstrated significant correlations among them, with higher levels of SWB being related to better academic performance. This relationship remained significant even when controlling for intelligence. However, Oishi et al. (2007) indicated curvilinear relationships between positive emotions and academic performance meaning that the academic performances were higher for those with more positive emotions up until a certain point, where the relationship turned around.

## Methodology

*Research Model*

Within the Opportunity-Propensity model (Byrnes & Miller, 2007; Wang & Byrnes, 2013), we investigated the role of motivation, subjective well-being, temperament and personality as propensity predictors for mathematics fluency and accuracy.

*Research Goal*

Understanding the development of mathematical cognition is important to improve mathematics education. Within this study, we try to go beyond the traditional cognitive propensity factors for mathematical performance, and investigate the combined role of motivation, subjective well-being, temperament and personality as non-cognitive predictors for math performance. In addition, we investigate the impact on two types of mathematical tasks since mathematics has shown to be componential in nature (Dowker et al., 2019).

More specifically, two research questions are investigated:

1. What is the combined role of motivation, personality, temperament and subjective well-being as non-cognitive propensity factors for mathematical performance?

2. Can we confirm the componential nature of mathematics? Does the type of mathematical task matter (Baten & Desoete, 2018): Is the relationship between the non-cognitive propensities and mathematics the same for fact retrieval speed and for procedural calculation (accuracy)?

*Sample and Data Collection*

Participants were recruited through an online research recruiting system of Ghent University: Experimetrix. Thirty people took part in the experiment, fifteen male and fifteen female. Participants were between 18 and 28 years old ($M$ = 22.3 years, SD = 2.59 years). Their mean intelligence was 99.1 (SD = 12.66), measured using the Raven Advanced Progressive Matrices (Raven et al., 1996). All participants completed an online survey at home and then came to the university building and took part in the research for two hours. They signed an informed consent, fulfilled the questionnaires, the mathematics measures and received a reward of 20 euro's for their participation. Predictor and criterion variables were obtained from different sources with different rating scales, limiting common method biases in behavioral research as much as possible (Podsakoff et al., 2003, 2012).

*Instruments*

Mathematics fluency and accuracy was tested. *The fact retrieval skills or fluency* ('speed') were measured with items of the Arithmetic Number Fact Test (de Vos, 2002). Participants had to solve as many number-fact problems (e.g., 5x9 = ...; 24:6 = ... ) with a mix of the different operations as possible in one minute. Cronbach's alpha was shown to be .90 (Desoete & Roeyers, 2005). *Procedural calculation accuracy skills* were assessed with items of the Cognitive Developmental skills in aRithmetics Test (CDR; Desoete & Roeyers, 2002) grade 5. This test measured accuracy to solve calculations in a number-problem or word-problem format (e.g., '283 times more than -71 is ...'; 27681:90 = ... 'Wim has 4.8 kg of flour. Jan has a double amount of flour. How many flour do Jan and Wim have together?') without a time limit. The psychometric value of the test was proven to be good (Desoete & Roeyers, 2005).

The non-cognitive propensities motivation, personality, temperament and subjective well-being were measured. *Motivation* was assessed with the Self-Regulation Academics (Deci et al., 1989; Vansteenkiste et al., 2009) questionnaire with 24 questions to measure the level of autonomous (Identified Regulation and Intrinsic Motivation) and controlled (External Regulation and Introjected Regulation) academic motivation. Respondents needed to answer questions about the reasons for studying/involving in mathematics on a 5-point Likert scale. Cronbach's α for autonomous and controlled motivation was .96 and .80 respectively. *Personality* was assessed with the NEO Five Factor Inventory (NEO-FFI-NL; Costa & McCrae, 1992; Hoekstra et al., 1996) to measure the Big five traits with a total of 60 items (12 per trait). Respondents had to answer on a 5-point Likert-scale. Scores were calculated for Neuroticism, Extraversion, Openness, Agreeableness and Conscientiousness. The psychometric value of the instrument was found to be good (De Corte et al., 2007). *Temperament* was assessed with the Behavioral Inhibition (BIS) and Behavioral Activation (BAS) Questionnaire (Carver & White, 1994; Franken, 2002) consisting of 24 items measuring Behavioral Inhibition and Behavioral Activation (including BAS Drive, BAS Fun Seeking and BAS Reward Responsiveness). Every item was scored on a 4-point Likert scale. The psychometric value of the instrument was found to be good (Beck et al., 2009; Franken et al., 2005).

*Subjective well-being* was measured, in line with previous studies (Baten & Desoete, 2018) with the Positive and Negative Affect Scale (PANAS; Engelen et al., 2006; Watson et al., 1988). There were ten questions measuring Positive Affect (such as energy and enthusiasm) and ten questions on Negative Affect (such as fear and guilt). Every item was scored on a 5-point Likert scale. Cronbach's α for the scale of Positive Affect was .70 and for the scale of Negative Affect Cronbach's α was .83.

All instruments were used in previous studies (Baten & Desoete, 2018; Baten et al., 2020) to eliminate item ambiguity and social desirability. In addition, to avoid method bias as much as possible, the predictor and criterion variables were measured from different sources and all testing was recorded and checked afterwards to control for biases if they happened.

*Analyzing of Data*

The distribution of scores for both fact retrieval speed and procedural calculation, including means (*M*), standard deviations (*SD*), minimum and maximum scores were analyzed. In addition the intercorrelations between the different propensity predictors (motivation, personality, temperament and subjective well-being) were computed.

The assumptions of analyzing techniques were investigated. The scores on fact retrieval were normally distributed, $W(29) = .98$, $p = .857$, so parametric statistics were used The scores on procedural calculation, were not normally distributed, $W(29) = 0.79$, $p < .001$, so non-parametric analyses were used.

Hierarchical linear regressions were conducted to study the combined predictions for procedural calculation and fact retrieval (was allowed since the residuals on the tests were normally distributed). Significant predictor variables were added in order of strongest to weakest association (based on the correlation table). If more than one predictor variable was significant within the same component (motivation, personality, temperament and subjective well-being) the strongest variable was included in the regression analysis.

Finally, in line with McClelland et al. (2015), a median-split analysis was done on the total of autonomous (AM) and controlled (CM) motivation. By combining the scales of AM and CM, four motivational types where created. Means and standard deviations for fact retrieval fluency and procedural calculation accuracy scores among the motivational types were computed. In addition, Analysis of Variance (ANOVA) was conducted to investigate if the scores on fact retrieval were significantly different between the motivational types.

## Findings / Results

The distribution of scores for both fact retrieval speed and procedural calculation can be found in Table 1.

*Table 1. Descriptive statistics of mathematical skills*

| | **M** | **(SD)** | **Minimum** | **Maximum** |
|---|---|---|---|---|
| Fact retrieval | *26.73* | (4.89) | 17 | 37 |
| Procedural calculation | *6.17* | (0.99) | 4 | 7 |

*Note:* M = mean, SD = standard deviation

In Table 2, there is an overview of the Pearson intercorrelations between the different propensity predictors.

*Table 2. Intercorrelations between the different propensity factors.*

| | Motivation | | | | | | Personality | | | | | Temperament | | | | | SWB | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** |
| 1 | - | | | | | | | | | | | | | | | | | |
| 2 | .30 | - | | | | | | | | | | | | | | | | |
| 3 | .85** | .76** | - | | | | | | | | | | | | | | | |
| 4 | -.49** | .26 | -.18 | - | | | | | | | | | | | | | | |
| 5 | -.56** | .11 | -.32 | .82** | - | | | | | | | | | | | | | |
| 6 | -.55** | .19 | -.27 | .95** | .96** | - | | | | | | | | | | | | |
| 7 | -.51** | -.30 | -.51** | .37* | .42* | .42* | - | | | | | | | | | | | |
| 8 | .11 | .18 | .18 | .08 | .02 | .05 | -.32 | - | | | | | | | | | | |
| 9 | .31 | .21 | .33 | -.01 | -.13 | -.08 | -.34 | .09 | - | | | | | | | | | |
| 10 | .29 | .03 | .21 | .05 | -.11 | -.03 | -.25 | .24 | .38* | - | | | | | | | | |
| 11 | .09 | .30 | .23 | .03 | -.09 | -.03 | .06 | -.49** | -.18 | -.19 | - | | | | | | | |
| 12 | .39* | .39* | .48** | -.25 | -.17 | -.22 | -.18 | .06 | .13 | .06 | .21 | - | | | | | | |
| 13 | .35 | .41* | .47** | -.25 | -.32 | -.30 | -.31 | .33 | .13 | .04 | .07 | .17 | - | | | | | |
| 14 | .11 | -.2 | .01 | .16 | -.08 | .12 | .05 | -.30 | .23 | .12 | .07 | -.02 | -.28 | - | | | | |
| 15 | .12 | .14 | .16 | .07 | .02 | .04 | .15 | .06 | .04 | .04 | .22 | .13 | .50** | -.05 | - | | | |
| 16 | .30 | .18 | .30 | .04 | -.08 | -.02 | -.02 | -.03 | .24 | .13 | .20 | .13 | .51** | .55** | .73** | - | | |
| 17 | .03 | .06 | .06 | .13 | .07 | .11 | -.15 | .60** | .44* | .25 | -.48** | .07 | .10 | -.03 | .20 | .13 | - | |
| 18 | .23 | .07 | .20 | -.13 | -.10 | -.12 | .06 | -.49 | -.23 | -.28 | .70** | .29 | -.05 | .24 | .37 | .35 | -.27 | - |

*Note:**p<.05; **p<.01 ; SWB = subjective well-being

1)External Regulation 2)Introjected Regulation 3)Total Controlled Motivation 4)Identified Regulation 5)Intrinsic Motivation 6)Total Autonomous Motivation 7)Openness 8)Conscientiousness 9)Extraversion 10)Agreeableness 11)Neuroticism 12)BIS 13)BAS Drive 14)BAS Fun Seeking 15)BAS Reward Responsiveness 16)BAS 17) Positive Affect 18)Negative Affect

Several propensity factors correlated significantly with each other.

*Relationship of Propensities with Mathematics as outcome measure*

An overview of the relationships between motivation, personality, temperament, subjective well-being and mathematics can be found in Table 3.

*Table 3. Correlations of propensities and mathematics.*

| | **Fact retrieval skills** | **Procedural calculation** |
|---|---|---|
| | **Pearson's r** | **Spearman's ρ** |
| **Motivation** | | |
| Intrinsic Motivation | .39* | .01 |
| Identified Regulation | .31° | -.03 |
| Introjected Regulation | .13 | .28 |
| External Regulation | -.38* | -.02 |
| Total Autonomous Motivation | .37* | -.01 |
| Total Controlled Motivation | -.18 | .07 |
| **Personality** | | |
| Openness | .00 | -.09 |
| Conscientiousness | .28 | .26 |
| Extraversion | -.11 | .25 |
| Agreeableness | -.31° | -.04 |
| Neuroticism | .07 | -.34° |
| **Temperament** | | |
| BIS | -.27 | -.01 |
| BAS | -.17 | -.28 |
| BAS Drive | .13 | .06 |
| BAS Fun Seeking | -.26 | -.29 |
| BAS Reward Responsiveness | -.07 | -.15 |
| **Subjective well-being** | | |
| Positive Affect | .06 | .12 |
| Negative Affect | -.11 | -.39* |

*Note:* °p<.10; *p<.05; **p<.01; ***p<.001

For *fact retrieval (speed)* there was a significant positive correlation with Intrinsic Motivation (AM) ($r(28) = .39$, $p = .031$, $R^2 = .16$) and total autonomous motivation ($r(28) = .37$, $p = .044$, $R^2 = .14$). There was a significant negative correlation between external regulation (CM) and fact retrieval, $r(28) = -.38$, $p = .040$, $R^2 = .14$. For *procedural calculation (accuracy),* there was a significant negative correlation with Negative Affect ($\rho(28) = -.39$, $p = .035$, $R^2 = .15$).

For *motivation*, there was a trend of positive association between fact retrieval and Identified Regulation (AM; $r(28) = .31$, $p = .096$, $R^2 = .10$). For *personality,* there was a trend of negative relationship between fact retrieval and Agreeableness ($r(28) = -.31$, $p = .093$, $R^2 = .10$ and between procedural calculation and Neuroticism ($\rho(27) = -.34$, $p = .066$, $R^2 = .12$). In addition, the relationships between Conscientiousness on the one hand and fact retrieval ($r(28) = .28$, $p = .129$) and procedural calculation ( $\rho(28) = .26$, $p = .164$) on the other hand, were in the positive direction, but not significant. Finally, for *temperament,* BIS data pointed to a negative but non-significant association with fact retrieval ($r(28) = -.27$, $p = .144$).

*Combined Predictions for Procedural Calculation and Fact Retrieval*

The residuals on the test of *procedural calculation* (accuracy) were normally distributed, $W(30) = 0.97$, $p = .443$, thus hierarchical linear regression were conducted with subsequently adding the propensities as predictors, in order of strongest to weakest association.

As first step the regression with Negative Affect (SWB) as a predictor for procedural calculation was significant, $F(1,28) = 7.27$, $p = .012$. In step 2, Introjected Regulation (motivation) was added, $F(2,27) = 4.60$, $p = .019$. For step 3, BAS Fun Seeking (temperament) was added, $F(3,26) = 4.00$, $p = .018$. Finally, in step 4, Neuroticism (personality) was added to the model, $F(4,25) = 3.31$, $p = .026$. Regression coefficients for the predictors of this hierarchical linear regression can be found in Table 4.

*Table 4. Summary of regression statistics for the prediction of procedural calculation.*

| Predictor Variables | B | SE | p | $R^2$ | $\Delta R^2$ |
|---|---|---|---|---|---|
| Step 1 | | | | .21 | .21* |
| Negative Affect | -.07 | .03 | .012 | | |
| Step 2 | | | | .25 | .05 |
| Negative Affect | -.07 | .03 | .009 | | |
| Introjected Regulation | .24 | .18 | .199 | | |
| Step 3 | | | | .32 | .06 |
| Negative Affect | -.06 | .03 | .024 | | |
| Introjected Regulation | .20 | .18 | .274 | | |
| BAS Fun Seeking | -.53 | .35 | .138 | | |
| Step 4 | | | | .35 | .03 |
| Negative Affect | -.04 | .04 | .364 | | |
| Introjected Regulation | .27 | .19 | .17 | | |
| BAS Fun Seeking | -.57 | .35 | .114 | | |
| Neuroticism | -.35 | .32 | .290 | | |

*Note*: B = unstandardized beta coefficient, SE B = standard error, p = significance value, $R^2$=explained variance, $\Delta R^2$= change in explained variance.* $p < .05$

From step 2 onwards the amount of extra explained variance was no longer significant, $\Delta R^2 = .05$, $p = .199$. Therefore, the first model (with Negative Affect as propensity of SWB) was the best prediction of procedural calculation.

For *fact retrieval* (speed) a similar hierarchic linear regression analysis was conducted, since the residuals were also normally distributed, $W(30) = 0.96$, $p = .384$. Again the propensities were added as predictors, in order of strongest to weakest association. In the first step, Intrinsic Motivation (AM) predicted fact retrieval, $F(1,28) = 5.16$, $p = .031$. In the second step, Agreeableness (personality) was added, $F(2,27) = 4.02$, $p = .030$. Regression coefficients for the predictors of this hierarchical linear regression can be found in Table 5.

*Table 5. Hierarchical linear regression analysis with fact retrieval abilities as outcome variable (scores on the TTR). Summary of regression statistics for the predictor variables.*

| Predictor Variables | B | SE | p | $R^2$ | $\Delta R^2$ |
|---|---|---|---|---|---|
| Step 1 | | | | .16 | .16* |
| Intrinsic Motivation | 1.65 | 0.73 | .031 | | |
| Step 2 | | | | .23 | .07 |
| Intrinsic Motivation | 1.53 | 0.71 | .041 | | |
| Agreeableness | -2.65 | 1.65 | .120 | | |

*Note*: B = unstandardized beta coefficient, SE B = standard error, p = significance value, $R^2$=explained variance, $\Delta R^2$= change in explained variance.* $p < .05$

From step 2 on, the amount of extra explained variance was no longer significant, $\Delta R^2 = .07$, $p = .120$. Therefore the first model with 'Intrinsic Motivation' as propensity was the best predictor for fact retrieval.

The median-split analysis on the total AM and the total CM, differentiated participants who scored on the median or above as high scorers from participants who scored below the median as low scorers. The median score for the scale of AM was 2.63 and for CM the median score was 3.06. In total, 15 out of 30 participants scored high on AM, whereas 15 out of 30 scored low on this scale. For CM, 15 out of 30 participants scored high and 15 participants scored low. By combining the scales of AM and CM, four motivational types where created. The first group consisted of participants scoring high on both CM and AM ($n = 7$), the participants in the second group scored low on both CM and AM ($n = 7$). Participants in the third group scored high on AM, but low on CM ($n = 8$) and participants in the last group scored low on AM but high on CM ($n = 8$). Means and standard deviations for fact retrieval scores of the different groups can be found in Table 6.

*Table 6. Means (M) and standard deviations (SD) for different motivational types on fact retrieval.*

| Motivational Type | Autonomous Motivation | Controlled Motivation | n | Mean (M) | Standard Deviation (SD) |
|---|---|---|---|---|---|
| 1 | High | High | 7 | *26.43* | (1.68) |
| 2 | Low | Low | 7 | *25.86* | (1.68) |
| 3 | High | Low | 8 | *30.50* | (1.57) |
| 4 | Low | High | 8 | *24.00* | (1.57) |

The ANOVA with motivational type (type 1 or high AM and high CM, type 2 or low AM and low CM, type 3 or high AM and low CM, type 4 or low AM and high CM) as independent factor and fact retrieval as dependent variable, yielded significant variation in fact retrieval scores among the motivational types, $F(3, 26) = 3.02$, $p = .048$. A post-hoc Bonferroni test indicated significant differences in fact retrieval scores between the group with high AM and low CM (M = 30.50, SD = 1.57) on the one hand and low AM and high CM on the other hand (M = 24.00 , SD = 1.57), $p = .043$.

## Discussion

The Opportunity–Propensity (O-P) model suggests that people are more likely to learn if they are provided with the right Opportunities (O) to learn and have the will and capability or Propensity (P) to benefit from the opportunities provided to them (Wang & Byrnes, 2013). In addition several propensities seem to be related to mathematics. However, surprisingly few studies have been conducted to explore the combined effect of P predictors. This study addresses this gap by investigating several non-cognitive propensities at once: personality, temperament, motivation and subjective well-being, to predict procedural calculation and fact retrieval speed in students.

At first, the *separate relationships* between the propensities and mathematics were investigated. In line with the meta-analysis of Poropat (2009) we found a positive relationship between Conscientiousness (personality) as propensity (P) and mathematical abilities. The relationship between Openness and mathematics however could not be confirmed in our dataset. Results for Neuroticism were although not significant, going into the expected direction of a negative association with mathematical performance (procedural calculation). Further, a trend of negative relationship was found between Fun Seeking as temperament (P) and procedural calculation. Since this is only found on the subscale of BAS and not on the BAS scale in general, this is not entirely in contrast with results from Van Beek et al. (2013), which showed positive associations with BAS in general and academic performance. The latter association was not replicated in the current study.

In addition, for the *motivation* propensities, results showed that people who are externally regulated for studying mathematics perform worse on fact retrieval tasks. These results are in line with Taylor et al. (2014) who indicated that people who were more autonomously motivated, performed better on fact retrieval. For procedural calculation, no significant associations with motivation were found. This might be due to lack of variation in the procedural calculation tests (see limitations section). Furthermore, in line with SDT, the ANOVA on the fact retrieval scores confirmed that the quality of motivation is more important than the quantity of motivation. We learned that the group with the most qualitative motivation profile (high AM and low CM) yielded significant better results on fact retrieval mathematics than the group with high CM and low AM. The quantity of motivation was high in both groups, but the quality was better in the group that also had the best results on arithmetic fact retrieval.

Finally, there was a trend of association between *subjective well-being* and mathematics. Poor procedural calculation skills or accuracy was associated with more emotional anxiety, fear and instable emotions. This is partially in line with previous research, although here only the relationship with Negative Affect was replicated, and only for procedural math or accuracy, not for fact retrieval speed.

Summarizing the above, several non-cognitive or socio-emotional propensities were in some way or another related to mathematical abilities. The strongest association with procedural calculation was Negative Affect as an indicator of SWB (negative association). For the scores on fact retrieval, the construct most associated was Intrinsic Motivation or passion (positive association), which is according to SDT (Deci & Ryan, 1985) the most qualitative form of motivation. Results also learned us that a lot of the propensities intercorrelated, which influenced the strength of the association of the separate constructs and mathematical abilities.

Additional analyses were conducted simultaneously tapping the relationship between personality, temperament, motivation and SWB. A model with Negative Affect (SWB) was the best prediction of procedural calculation (accuracy). In addition the model with 'Intrinsic Motivation' as propensity was the best predictor for fact retrieval speed. Moreover results of the hierarchical linear regressions revealed that Negative Affect explained a significant amount of variance in procedural mathematics, up until Neuroticism was added into the model. This could be explained by the strong association between Negative Affect and Neuroticism, pointing to the fact that focusing on separate propensities (for instance only investigating Negative Affect) might lead to biased conclusions related to math performance. If Neuroticism had not been measured in this study, strong conclusions could have been made about the impact of SWB in terms of Negative Affect. With the results that rose from this dataset in mind, we learn that these conclusions should be made with caution, since apparently Neuroticism had a strong impact on this regression. Another example of the importance of taking into account intercorrelations between predictors could be found in the absence of some significant associations in this study that were expected based on previous research. For instance, the lack of the highly expected positive association between Conscientiousness and mathematical abilities might be explained by the negative association between Conscientiousness and BAS Fun Seeking (Smits & Boeck, 2006).

In conclusion, although the sample in this study was very small, the results of this study not only indicate that the non-cognitive propensity constructs considered in this paper are related to mathematical abilities (Research Question 1) but that the impact of these constructs also depends on the kind of mathematical task that is investigated as an outcome factor (fact retrieval vs. procedural mathematics; Research Question 2). We cannot use the same models to explain all kinds of mathematical abilities.

## Conclusion

This study emphasized the importance of some non-cognitive and socio-emotional propensity factors such as temperament, personality, motivation and subjective well-being for mathematical performance. Negative Affect (SWB) was the best predictor of procedural calculation (accuracy). Intrinsic Motivation was the best predictor for fact retrieval speed. It is important to take home that biased conclusions can be made if several potential predictive factors are not embedded in a comprehensive model such as the O-P framework. Future research on this topic is important and can help us to develop interventions that tackle the real sources of variance for different mathematical abilities and thereby improving the services for children with MLD.

## Recommendations

The Opportunity-Propensity-model might help to look into more pieces of the math performance puzzle at once. This is important, since the results of this study indicated a lot of significant interrelationships between the different predictor variables. Investigating only one or two predictors and relate them to math performance, might overestimate the importance of predictors. Practitioners should be aware of this issue. Further, this study revealed that the investigated propensity factors relate differently to fact retrieval speed vs. procedural accuracy. Insight in this different relationship might be important to improve services and differentiate interventions across children with semantic memory MLD vs. procedural MLD. Finally, the significant relationships between some of the propensity factors investigated in this study and mathematical achievement might implicate that working only on opportunities in practice and interventions might not be enough to improve achievement. A first step in interventions might be to work on the characteristics of children that make them willing and able to take advantage of the given opportunities (= propensity factors). Important here is to not only work on the cognitive propensity factors but to go beyond and also work on the non-cognitive propensity factors.

## Limitations

All studies have limitations. The first limitation of this study is the sample size impacting the power of the study. Power-issues might be the explanation of why some expected results of previous studies could not be replicated in our sample. Additional research with a larger sample of participants seems indicated. For instance, examining the absence of an association between Conscientiousness and math abilities in the current study, learned us that the relationship was in line with the expectations but not statistically significant on the 95%-reliability level. Larger sample size might have revealed more significant results. Second, descriptive statistics showed that there might be not enough variation in the scores for the procedural calculation or 'accuracy' test. Third, the data collected for this study was only cross-sectional, so no causal interferences can be made. Longitudinal studies with good measurements on larger sample sizes seems indicated. Next, in this study only some propensity factors were included and these were all non-cognitive or socio-emotional. Cognitive factors (such as intelligence, working memory) should be added within the O-P framework in future research. In addition although validated questionnaires and tests were used as in previous studies (Baten et al., 2020) data were obtained from the same person in the same measurement context, so in future studies additional control for method biases, as suggested by Podsakoff et al. (2003) might be indicated. Finally, since mathematics is a core subject in primary school, a limitation of this study is the age of the people included in the sample. Structural Equation Modelling (SEM) and path-analyses on elementary school children with and without MLD might be indicated to help us understand the development of mathematical abilities.

### Authorship Contribution Statement

Elke Baten: Conceptualization, design, data acquisition, analyzing ad interpretation, writing. Annemie Desoete: Supervision conceptualization and design, reviewing data analyzing and interpretation of statistical analysis , writing and final approval.

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