UNIVERSITÀ DEGLI STUDI DI TRIESTE

XXXI CICLO DEL DOTTORATO DI RICERCA IN

NEUROSCIENZE E SCIENZE COGNITIVE

THE RELATIONSHIP BETWEEN MATH ANXIETY, MATH ATTITUDES AND MATH PERFORMANCE
A STUDY ON ITALIAN AND CROATIAN 3^{rd}AND 5^{th} GRADERS

Settore scientifico-disciplinare: **Psicologia dello sviluppo e psicologia dell'educazione (M-PSI/04)**

DOTTORANDA: **Renata Martinčić**

COORDINATORE: **Prof. Tiziano Agostini**

SUPERVISORE DI TESI: **Prof. Alessandra Galmonte**

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Introduction

Math anxiety (MA) is defined as an emotional reaction impairing the performance of people engaged in numbers and mathematics (Gunduz, 2015). Furthermore, MA is a “feeling of tension, apprehension or fear that interferes with math performance” (Ashcraft, 2002). Specifically, MA interferes with the individual’s performance on mathematics, manipulation of numbers, and problem-solving activity (Ingole & Pandya, 2015; Lai, Zhu, Chen, & Li, 2015). Additionally, also the students’ negative attitudes and perceptions, such as disliking math or feeling nervous and bored by it often leads to the experience of MA, which can foster poor mathematic achievements (Mullis, Martin, Foy, & Arora, 2012). Studies suggest that MA creates worries that influence the cognitive system responsible for the short-term storage and manipulation of information (Miyake & Shah, 1999). It might also influence the math performance by overloading the working memory (Ashracft et al., 1998). Studies show that parents’ attitudes and their gender stereotypes about mathematics have an important influence on children’s academic attitudes, performance, and beliefs, especially in the math domain (Eccles, 2006). Specifically, there is a positive correlation between MA and general anxiety with the Person’s coefficient about .35 (Wang et al., 2014), and a significant link between math performance and self-efficacy (Bandura, 1997; Schunk & Pajares, 2009). Math anxiety is a common global phenomenon which has a high prevalence. The sources of MA are various which makes it difficult to address. Specifically, according to previous studies in this field the possible sources of MA are students’ self-efficacy and self-concept (Bandura, 1997; Schunk & Pajares, 2009; OECD, PISA 2012), parents and teacher’s attitudes towards mathematics and their own MA (Eccles, 2006; Soni & Kumari, 2015), testing environment and previous experiences of success and failure in mathematics (Bong & Skaalvik, 2003; Fast, Lewis, Bryant, Bocian, Cardullo, Rettig, & Hammond, 2010; Wang, Eccles, & Kenny, 2013), cognitive and executive functions, especially the working memory capacity (Aschraft & Kirk, 2001; Miyake & Shah, 1999), and the important factors are student’s age and gender (Carey, Devine, Hill, & Szücs, 2017; Dowker, 2005; Ma & Kishor, 1997; Young, 2012; Wu et al., 2012), genetic predispositions of general anxiety (Wang et al., 2014), culture (Else-Quest, Hyde, & Linn, 2010; Guiso, Monte, Sapienza, & Zingales, 2008; OECD, PISA, 2012), and socio-economic status (Adimora, Nwokennab, Omejec, & Ezed, 2015; Geyik 2015). The prevalence varies quite widely and it depends on the population being sampled, especially on the criteria applied in the particular study. The Program for International Student Assessment

(PISA) which evaluates the academic achievement of 15-year-old students in the countries being part of the Organisation for Economic Co-operation and Development (OECD) have found that in the research across on average 65 countries, 33% of students reported feeling helpless when solving math problems (OECD, PISA, 2012). The problem is that MA and negative attitudes towards mathematics have the long-term consequences which might influence the real-life situations. Therefore, studies showed that consequences of high MA are avoidance of math and math-related situations (Ashcraft & Ridley, 2005). Furthermore, negative consequences also include poor performance on standardized math tests and difficulty with math-related problem solving (Hembree, 1990), low performance on courses involving numerical reasoning (Núñez-Peña, Suárez, Pellicioni, & Bono, 2013), reduced efficiency in solving simple arithmetic problems (Imbo & Vandierendonck, 2007), and difficulties in basic numerical processing (Ma & Xu, 2004).

Furthermore, math gender stereotypes or opinions that boys are better at mathematics than girls are one of important causes of significantly lower number of women in the Field of science, technology, engineering and mathematics (STEM). The phenomenon of under presentation of women in this field has been found in many research (Eccles, Jacobs, & Harold, 1990; Dasgupta, 2011). Furthermore, female students report not to be interested in undertaking science and engineering career in the future starting from the early childhood (American Society for Quality, 2009). This is the real-life problem which needs to be addressed because of many reasons. One of the reasons regards the importance of women's self-esteem related to mathematics and the importance of their positive opinions towards mathematics, whereas the other reasons are more practical. Specifically, the STEM field is considered the field of huge importance for the national economy, economic growth, and the competitiveness in the global economy (National Academy of Sciences, Committee on Science, Engineering & Public Policy, 2007; U.S. Government Accountability Office, 2006; U.S. Department of Education, 2006). Therefore, addressing the problem of the gender gap properly would attract more women in the STEM field which would bring major diversity, maximized innovation, creativity, and competitiveness (National Association of College and Employers, 2009). The STEM gender gap has already caused the life-threatening consequences such as difficulties in designing the first generation of the car airbags. The designing was conducted by the predominately male group of engineers which resulted in the car airbag design non-adapted for women and children that led to the huge number of otherwise avoidable deaths of women and children in car accidents (Margolis & Fisher, 2002).

The present research aims to study the relationship between emotional variables, math attitudes, cognitive and executive functions, and the real math performance on different time-limited math tests of calculation and reasoning. Specifically, the research includes three studies in which three main goals were addressed. In particular, Study 1 addressed the relationship between math performance and students' self-perceived MA, general anxiety, and emotional and behavioural problems estimated by their teacher/professor. Study 2 addressed the relationship between math performance and cognitive and executive functions such as the short-term memory, working memory, attention, inhibition, switching, and mental flexibility. Study 3 addressed the opinions and beliefs about mathematics such as the math self-esteem and general self-esteem, explicit math gender stereotypes, value attributed to math, self-perception of math ability and perceived math difficulty, and their relationship with math performance. Math tests combined six tests, three of them were tests of calculation and two tests were part of logical reasoning. One test was used just to introduce the topic, and it was neither part of calculation nor of reasoning tests.

The research was conducted on both Italian and Croatian students attending 3rd and 5th grade of public elementary schools. Two collective assessments and one 1-hour individual assessment was conducted on the Italian sample. A study on the Croatian sample included a collective assessment which matches with the Italian Study 3. The results showed that math performance is significantly associated with different cognitive and emotional variables assessed in this study which are math anxiety, cognitive and executive functions, and math attitudes such as math self-esteem and explicit math gender stereotypes. However, there are some differences regarding the findings of this study in relation with the children's age and nationality.

In summary, the results of the present study have confirmed the findings of previous studies in this field about the relationship between MA, gender stereotypes and opinions about mathematics with performance on math tests. However, it seems that there are different factors which can influence on this relationship and change its outcome such as the students' age and gender, self-esteem, specific environment, and culture. Future research should take in consideration the wide context of this complex problem and address it at different levels by expanding studies to different cultural settings.

Chapter 1−Stereotypes

1.1 Definition of Stereotypes

The concept of the stereotype was firstly introduced by an American social psychologist Walter Lippmann (1922) to indicate “the photographs of our mind”. Walter Lippmann (1889-1974) was an American journalist who worked for 32 years in the Herlad Tribune of New York and wrote for the journal section “Today and Tomorrow”. He was also the winner of two Pulitzer awards in 1958 and 1962. Lippmann said that members of a group are perceived as quite similar, and a social stereotype makes a social reality twisted and simplified. People interpret a great confusion of reality based on the stereotypes which they formerly internalized from their culture.

Different authors gave the fallowing definitions of the stereotype:

- The stereotype described as a stable impression which does not change much based on the reality (Katz & Braly, 1935).

- Stereotype as a belief which is exaggerate, and which is associated to one category with the function to justify and rationalized the relationship that people have towards that category (Allport, 1954).

- The stereotype as a categorical response, and just the presence of one group is enough to activate the characteristics associated with the stereotype of that group (Secord, 1959).

- The ethnic stereotype as a generalization of the ethnic group which is not justified for the external observer (Brigham, 1971).

- The stereotype described with the beliefs related to the personal characteristics of individuals (Ashmore & Del Boca, 1981).

- The stereotype defines the individuals based on the attributes which are highly visible such as gender and ethnicity, and those attributes are generalized on the whole group (Snyder, 1981).

- The stereotype as the collection of associations which associate the group with different characteristics (Gaertner & Dovidio, 1986).

- The stereotype as a cognitive structure which regards knowledge, beliefs, and expectations towards one group of people (Hamilton & Trolier, 1986).

- The stereotype as generalization regarding a group of people, often inaccurate and resistant to changes (Myers, 1990).

- The stereotype sees the group with the same characteristics, not taking in consideration the variety between the members of the group (Aronson, 1998).

Stereotypes influence the self-perception and behaviour. The group perceived as our– *ingroup* is favourite and the group perceived as not our– *outgroup* is often discriminated. Furthermore, the members of the ingroup are perceived as more different, and the members of the outgroup seem more similar between them. The members of the ingroup seem to be more complex individuals and they are more often attributed with higher values and characteristics which differ the human beings from the animals (Carnaghi & Arcuri, 2007).

1.2 Activation and Classification of Stereotypes

The activation of stereotypes can be observed with the *semantic priming*. This method is based on the presentation of the *target* stimuli which we are interested to study, and which are presented after the *prime*–other stimuli semantically associated with the target (Carnaghi & Arcuri, 2007). The prime stimulus can be a word, but also a photo, a sign, some event, or some other stimulus which can activate the target stimulus. The semantic priming was first studied at about 20 years ago to investigate the type and power of implicit association between two concepts or categories. Afterwards it was also used to study the implicit attitudes and evaluations. Researchers think that racism, sexism, and stereotypes based on age are present in different measure in all people and that reflects the culture that people are surrounded with (Lopeze & Marx, 2002).

Regarding the classification of stereotypes, there are two main types of classification. The first one divides stereotypes in *personal* and *social* stereotypes. The former refers to the attitudes of the single individual, and the latter refers to the attitudes shared by most of population. The second classification divides stereotypes in *self-stereotypes* and *others-stereotypes*. The self-stereotypes refer to characteristics given to the ingroup, and the other-stereotypes refer to the characteristics attributed to the outgroup. The self-stereotypes develop before the other-stereotypes and their presence is necessary to activate the stereotypes towards the outgroup.

1.3 Functions of Stereotypes

There are different functions of stereotypes. Firstly, stereotypes use simplification and generalization of thoughts, because they are applied to the whole group and not to the singular individual, which brings the economy in the process of thinking. Social interactions are guided by anticipating the characteristics of the person, and adjusting the behaviour based on knowledge of stereotypes. In that way a person whose thinking is stereotyping is creating the personality profile of the person in interaction. This process allows people to have major stability and control of life events and to reduce cognitive insecurity and indecision. Secondly, stereotypes regard those characteristics that people do not want to recognize in themselves, which is explained with the psychodynamic approach. Thirdly, stereotypes have motivational and psychological function to justify person's behaviour towards some social group. Fourthly, stereotypes contribute to social integration with the ingroup, because the members of the ingroup usually share the same vision of the outgroup, attributing preference and positive characteristic to the ingroup and creating in that way “the sense of us” in contrast with “the sense of them” (Carnaghi & Arcuri, 2007).

Chapter 2−Gender Differences

2.1 Gender through History

First studies about gender differences emerged in 1880 (Shields, 1975). In that research women were perceived as weak gender, emphasizing the fact that women’s brain has smaller dimensions and that brings it defective functioning when compared with men’s brain. Furthermore, a Canadian psychologist and biologist George Romanes (1887) suggests that intellectual abilities are related to gender and depend on dimensions of the brain. An English psychologist and psychiatrist Henry Hevelock Ellis (1894) proposes the hypothesis that the intellectual variety is greater in men than the women, trying to explain why there is a small number of women in science professions. That hypothesis became famous in the Anglo-Saxon countries with the name of *Greater Male Variability Hypothesis.* However, this gender gap in the educational system is explained with different opportunities of men and women through history. Furthermore, women could enrol at the University to study mathematics in the United States of America just from 1890.

The 20th century was a period of the great cultural and historical changes. In the 60s and 70s two different feministic approaches have emerged. One feministic approach was placed in Europe, while the other was placed in the United States of America. The European approach was based on importance of language, preverbal period of childhood, and contact with mother, while the American approach was based on the theory developed by a British psychoanalyst and paediatrician Donald Winnicott (1976, 1986) who emphasized the pre-Oedipus period as the most relevant to explain gender differences in personality. With the feministic approach women started to fight against gender inequality in different fields and their subordinate position in society, and they started to enrol at university in greater number. The educational system of that time was discriminatory towards women, because it was based on the wrong conceptions that women and men do not have the same intellectual potentials. In schools and in other institutions the ban of any form of gender discrimination regarding studying or pursuing career have been introduced (Sals-Hoff Wilson, 1978). More women started to go to school, also in higher educational systems (Besozzi, 1998), especially enrolling to social and humanistic courses. Changes were not present just in education, but also in different fields such as literature, politics, science, sociology, psychology, social anthropology, and others. Furthermore, these feministic approaches had an important historical role in changing the traditional society values related to gender. The major reaction of society was not positive. Women who accepted feministic values and started to live with them were firstly seen in the negative light, having the anomalous interest, and with the ambiguity, like the threaten who is trying to change the traditional values of society. During this period, more scientist discussed gender differences and tried to explain them, not just morphological ones, but also gender differences in personality. Until nowadays there is still a dispute about gender differences and the definition of gender as a social construct and as a psycho-biological construct.

2.2 Social Gender Roles

Social role theory was firstly introduced by an American social psychologist Alice H. Eagly (1987), defining the phenomenon as "these beliefs are more than beliefs about the attributes of women and men. Many of these expectations are normative in the sense that they describe qualities or behavioural tendencies believed to be desirable for each sex" (Eagly, 1987). The theory suggested two types of norms, the *descriptive norms*–which are consensual expectations about what members of group actually do, and the *injunctive norms*–defined as the consensual expectations about what a group of people ought to do or ideally would do (Cialdini & Trost, 1998). Stereotypes correspond with the descriptive norms, whereas the phenomenon of gender role corresponds with both descriptive and injunctive expectations associated with women and men (Eagly, 1987). The descriptive and injunctive norms of gender roles are both well documented. Furthermore, gender roles have pervasive effects as they consistent with Social role theory (Eagly 1987; Eagly et al., 2000) and socio-cognitive research (Fiske, 1998). The major effects of that phenomenon can be seen through beliefs that people hold about the ideal women and men (Spence & Helmreich, 1978; Williams & Best, 1990), beliefs that women and men hold about their ideal selves (Wood, Christensen, Hebl, & Rothgerber, 1997), and attitudes and prescriptive beliefs that people hold about the roles and responsibilities of women and men (Glick & Fiske, 1996; Spence & Helmreich, 1978). Furthermore, gender stereotypes thus follow the observational perception in the sex-typical social roles such as higher status roles of men, and women typical traditional role of homemaker or others with lower status (Eagly et al., 2000). The relevance of the theory of social rules is shown with the fact that gender is the strongest personal characteristic that provides the strongest categorization of people, even when compared with race, age, and profession (Fiske, Haslam & Fiske, 1991; Stangor, Lynch, Duan, & Glass, 1992; van Knippenberg, van Twuyver, & Pepels, 1994). Moreover, gender stereotypes are activated easy and automatically (Banaji & Hardin, 1996; Banaji, Hardin & Rothman, 1993; Blair & Banaji, 1996).

Other theory developed based on Social role theory is *Role congruity theory* (Eagly et al., 2000). This theory grounds on gender roles and their importance in promoting gender differences in behaviour (Eagly et al., 2000). Furthermore, the theory tries to explain the relationship between gender roles and other roles, especially the leadership roles. Gender is considered to be “implicit background identity” (Ridgeway, 1997), and based on it the relevance of the task and the expectations in the workplace are defined (Berger, Norman, Balkwell, & Smith, 1992; Hembroff, 1982). There are two main types of prejudice towards female leaders. The first one regards a less favourable evaluation of women’s than men’s potential for leadership because the ability of leadership is more stereotypically associated with men than women. The second one suggests a less favourable evaluation of the actual leadership behaviour of women than men because that behaviour is perceived as less desirable in women than men. The meta-analyses of 96 studies that compared the effectiveness of male and female leaders have been conducted (Eagly, Karau, & Makhijani, 1995). Most studies were led in the organizational settings where male and female leaders had a broadly defined role (e.g., middle managers in one or more industries), or narrowly defined roles (e.g., middle-school principals in the city). The results showed that leadership positions were male-dominated, and female leaders were less effective than men leaders. Moreover, women’s effectiveness was evaluated as inferior with a greater proportion of men among the raters. Indeed, women were evaluated as less effective than men in military organisations which are considered a traditional men’s environment, but more effective than men in the domain of education, government, and social services. Women were evaluated as breing particularly effective in the positions of the middle-level leadership as opposed to the supervisory positions.

Social role theory (Eagly 1987; Eagly et al., 2000) suggests that the expectancies associated with gender roles foster behaviours consistent with those roles through expectancy confirmation processes. Furthermore, stereotyped gender expectations are particularly powerful, and they can lead to the one of the strongest evidences of the behavioural confirmation (Geis, 1993; Skrypnek, Snyder, 1982). In this context, the self-regulatory processes are especially relevant (Eagly et al., 2000), for example, because of having internalized the aspects of gender roles, women's social identities in the workplace often reflect gender stereotypes, and this is especially true in the organizations with low proportions of women in senior positions (Ely, 1994, 1995).

2.3 Development of Gender Roles and Stereotypes

The main theories which explain the development of gender roles are *Cognitively-developmental theory* developed by an American psychologist Lawrence Kohlberg (1976, 1986) and *Social learning theory* developed by an American-Canadian psychologist Albert Bandura (1977). The former empathizes biological and cognitive aspects, whereas the latter empathizes more the social influence on stereotype learning (Vasta, Marshall, & Miller, 2005). Cognitive-developmental theory suggests that children do not develop gender stereotyped beliefs before maturing the gender constancy around the age of 6 (Bussey & Bandura, 1999). In one research, the preschool children were stereotypically associating toys, tools, games, and colours (blue or pink), and some behaviours with women and men (Berk, 2015; Giles & Heyman, 2005). In the middle childhood and adolescent, knowledge regarding gender stereotypes about the personality traits and achievements becomes more pronounced. The development of gender roles is particularly relevant, and research has shown its effects on emerging of gender stereotypes (Eagly & Karau, 2002), formerly explained with the theory of gender roles (Eaglu, 1987). Recent studies in this field showed that children have the gender schema about what means to be a boy or a girl in early childhood, and those schemas are defined as the mental structures which help to organize and interpret information from environment. These schemas include knowledge about gender differences in games, reactions, personality traits, activities, and others (Vasta, Haith, & Miller, 2005).

The development of gender roles has different sources. The first source may be society, including the influences of parents, teachers and peers, and messages transmitted through television and books. Society divide activities, jobs, and professions in those typically male or female. Studies showed differences in male's and female's brain from the time of birth, with the female's brain having more connections between two hemispheres. That means that also after in life, women will use more both hemispheres during the information processing.

Furthermore, boys tend to have more imagining thinking, while girls react better on written and oral information (Marović, 2009). Boys are usually engaged in more active, competitive, and aggressive games that require more space outside of the house, they tend to explore and manipulate objects more than girls do, and they are usually better in space orientation (Marović, 2009; Vasta, 2005). Parents encourage boys more to engage in active games, while they tend to encourage girls to communicate, thus the research showed than mothers tend to talk more with their daughters than with their sons (Vasta, Marshall, & Miller, 2005). Furthermore, nursery teachers also tend to have different reactions to boys' and girls' behaviour. The influences of friends and peers are also relevant. A study showed that most children aged between 3 and 6 do not want to be a friend with the other child who breaks the gender typically expected behaviour (e.g., a boy who wears a skirt or a girl who plays with trucks) (Ruble et al., 2007; Berk, 2015). Moreover, children tend to judge negatively a boy who plays with dolls or wear girl's clothes, and a girl who is involved in aggressive and loud games (Berk, 2015; Fagot, 1984). In most societies, women will be more involved in taking care of family and children, and thus society attribute to women the characteristics such as being sensitive and caring. The belief that women show more these traits than men based just on gender different personalities is incorrect (Lippa, 2005). Starting from childhood, society tend to attribute more to girls the personality trait of being caring, and the real behavioural differences might reflect the gender stereotype (Doescher & Sugawara, 1990). Other source of developing gender roles regards the parental influences on children. Parents often tend to react differently on the same behaviour depending if they react on their daughter's or their son's behaviour. They are consciously or non-consciously influenced by gender stereotypes, transmitting to the child how he or she is supposed to behave to be accepted in society (Marović, 2009). Furthermore, the research showed that children who are raised in families with non-traditional gender roles (e.g., a father irons) develop after in life less gender stereotypes regarding attitudes and professions, and they do not show gender stereotypes when choosing their own profession or academic subjects (Berk, 2008). Other important sources of gender roles are television, books, and animated programs. Studies in this field showed that women appear less in tv publicities, and when it comes to them, they are usually presented in the stereotypically lower status women's professions such as housewives, cooks, cleaning ladies, or those taking care of children (Craig, 1992). Moreover, also the picture books for children have numerous gender stereotypes. Male characters occupy most of the picture books (about 85%), and they are presented like characters who are often engaged in the activities such as reading a journal, watching a tv or resting in the house, while the female characters are usually presented in the home-related jobs like cooking lunch, serving meals, washing clothes, doing dishes, or sewing (Crabb & Bielawski, 1994). Furthermore, male characters are presented as brave and rational, whereas female characters are usually shown as more tender, loyal, and careful (Baranović, Jugović, & Doolan, 2008).

In everyday life, men are more often attributed with the positive desirable personality traits like being rational and determined, and women are presented with less desirable characteristics such as passive and undecided (Berk, 2015; Liben & Bigler, 2002). Furthermore, gender stereotypes do not regard just the desirable personality traits, but also the achievement. Studies showed that boys have higher expectations of success when it comes to math and physical abilities, while girls have higher expectations of success regarding languages and art (Del Rio & Strasser, 2013). Moreover, research showed that children who are just 5 and 6 years old have already developed gender stereotypes related to academic achievement. In a Chilean study language was a typically female preference, while boys showed no significant differences in preference for language and math (Del Rio & Strasser, 2013).

The question which rises is: What to do about gender roles and stereotypes? New programs about the equal education should be developed. They are necessary to promote accurate communication, equal rights of women and men, and non-discriminatory behaviour (Romić, Rakonca, Jelavić, & Horvat, 2015). Society should allow to every child to express his/her own unique personality independently of gender and the typically expected gender traits, and to allow them to express feelings liberally, especially fear and sadness which are in boys often suppressed (Belamarić, 2009).

2.4 Math Gender Stereotypes

Gender differences regarding math performance are one of the most common and the strongest gender gap assumptions (Kimura, 1999). This assumption that math is more for boys than for girls seems to emerge already in the 2nd grade of the elementary school (Cvencek, Meltzoff, & Greenwald, 2011). Moreover, studies have showed that math gender stereotype is more pronounced in young boys than in young girls (Hyde et al., 1990; Keller, 2001). However, also girls are affected, and girls who identified more with the female characteristics seem to identify less with mathematics (Nosek, Banaji, & Greenwald, 2002). They think that math is not their field, and this phenomenon is called the *cognitive balance* and it is well known in social psychology (Heider, 1946). This stereotype seems to influence on the real performance in mathematics and on the gender differences in math achievement. Different studies found lower performance of girls in mathematics (Beller & Gafni, 1996; Campbell & Beaudry, 1998; Hedges & Nowell, 1995; Kimball, 1989; Randhawa, 1994). Other studies did not find the same effect, and there was no significant difference in math performance between male and female students (Georgious, Stavrindes, & Kalavana, 2007). There is the third group of studies which found the gender gap in math performance, but just in the condition in which gender was empathized (Spencer, Steele, & Quinn, 1999). Moreover, difference in performance between boys and girls was greater for difficult tasks (Neuville & Croizer, 2007), and it was more pronounced in the students who performed better at math (Hedges & Friedman, 1993; Lindberg et al., 2010; Strand, Deary, & Smith, 2006). This condition affected just girls, and it did not have any effect on math performance in boys. The phenomenon is well known in social psychology with the name of *Stereotype threat theory* (Steele & Aronson, 1995). Furthermore, also the type of presentation of math task can influence the girls' math performance (Carnaghi & Arcuri, 2007). In one study children read the text before undertaking the second part of math test. The results showed that girls performed significantly lower than boys on math test in the condition in which gender was empathized, asking girls about their gender, and in the condition in which children read the text which discusses math gender differences explained with genetic factors (Carnaghi & Arcuri, 2007). On the other hand, there were no significant differences in boys' and girls' math performance on math test in other two conditions in which students read the text which said that there are no differences between male and female in math performance, and in the condition in which the text explains gender differences based on different experiences (Carnaghi & Arcuri, 2007). Other study on 124 Italian students aged between 5 and 7 showed that the gender stereotype appears already at the age of 5 years old (Tomasetto et al., 2011). Girls reached at about 15% lower scores in the condition in which gender was empathized (Tomasetto et al., 2011). Moreover, this phenomenon was found just in the girls whose mothers believed in math gender stereotype (Tomasetto et al., 2011). The interesting fact emerged from this study is that the father's gender stereotype about math performance had no influence on the girls' performance on the math test (Tomasetto et al., 2011). It seems that parents' opinions and behaviour, especially the mother's opinions have the important influence on the development of child's gender stereotypes, and this occurs already in preschool age (Parsons, Adler, & Kaczala, 1982). Furthermore, parents transmit both explicit and implicit messages about gender typical beliefs, also with the activities proposed to children (Jacobs & Bleeker, 2004). Research has showed the importance of affective factors which influence on math performance and creates the gender gap, and that have just recently started to be studied. In the past, gender differences in math performance were explained by genetic and biological factors which are stable, and those explanations have grown math gender stereotypes.

The gender stereotype in math performance is usually observed with self-report explicit measures. Older children and adolescents are more likely to reject the gender stereotype about math performance when the explicit measures are used (Ambady et al., 2001; Hyde et al., 1990; Muzzatti & Agnoli, 2007), but often in the implicit measures the stereotype appears (Kiefer & Sekaquaptewa, 2007). The correlation between explicit and implicit measures of math gender stereotype is modest (Nosek et al., 2002). Furthermore, the study by Nosek et al. (2008) showed that 3rd graders have math gender stereotypes when implicit measures were used, but the same effect was not found with explicit measures.

There are different sources of the gender gap in math performance. Some of them regards self-efficacy (Hyde et al., 1990), different levels of math anxiety (Dew et al., 1983; LeFevre et al., 1992; Levitt & Hutton, 1983), parents' attitudes (Tocci & Engelhard, 1991), different attribution of success and failure (Dweck, Devidson, Nelson, & Enna, 1978; Yee & Eccles, 1988), and others. Indeed, boys are more likely to attribute the cause of success to their own intelligence and ability, and the failure to not studying enough. On the other hand, girls are more likely to attribute the success in math to have studied hard or to other external factors, such as the test being easy or being able to get help from others, and the failure to lack of abilities needed to face the math test (Dweck, Devidson, Nelson, & Enna, 1978; Yee & Eccles, 1988). Furthermore, girls are more likely to think that the most important thing for the academic success is studying hard and liking the teacher of the particular subject, whereas boys usually think that to reach the academic success it is important intelligence, talent, and luck (Lightbody, Siann, Stocks, & Walsh, 1996). These findings are important because studying hard is internal, controlled, and modifiable aspect, whereas on the other hand, ability is internal, stable, but non-controlled aspect (Weiner, 1985).

Gender stereotype about math performance seems to increase with age, and it is more empathized in middle school (Lummis & Stevenson, 1990). Additionally, studies showed a major relevance of math gender stereotypes from the age of 12 or 13, with the tendency to increase in high school (Hyde & Mertz, 2009). These findings are particularly significant since the math gender stereotype during high school influences on the choice of future profession. Indeed, girls are less likely than boys to show the interest towards math courses and math-related professions, because those are typically perceived as incongruent with their self-concept (Denissen, Zarret, & Eccles, 2007; Newcomb, 2007).

Chapter 3–Effects of Stereotypes

3.1 Expectancy-Value Theory of Achievement Motivation

Expectancy-value theory of achievement motivation was developed by an American educational psychologist Jacquelynne Sue Eccles and the colleagues in 1983 to observe the constructs in the model of motivation and the way in which the children beliefs' influence their success in academic tasks in immediate and long-term future. Eccles (1983) suggests that the ability and expectancy beliefs are crucial for expectancy-value theory of motivation, and those concepts are also well known in other motivational theories (Eccles et al., 1998; Pintrich & Schunk, 1996). Ability is defined as relatively stable characteristic over which people had little control (Weiner, 1985). Expectancy of success is defined as the person's belief of how successful he or she is going to be in some activity (Eccles et al., 1993; Ec, 2002). Furthermore, attributions of ability or lack of ability usually have important motivational consequences, and that also influence the child's success. Attributing success to ability has positive motivational effects, on the other hand, attributing failure in some task to lack of ability may have negative consequences.

Eccless (1983) defined the fallowing different components of achievement values: value of importance, intrinsic value, utility and usefulness of the task, and cost of the task (Eccles et al., 1983; Wigfield & Eccles, 1992). Intrinsic value is defined as enjoyment of doing the task. That means that when motivation originates intrinsically, there are important positive psychological consequences (Deci & Ryan, 1985).

The significant implications of the expectancy-value model regard that early in life, already in elementary school, children develop the distinct ability-related beliefs and subjective values regarding different domains. Eccles and colleagues (1993) found that there are distinctive subjective values and ability-expectancy beliefs within the domain of math, reading, music, and sports. Furthermore, very early in elementary school children appear to have specific beliefs regarding what they are good at and what is the value of different achievement domains. In cross-sectional studies different researchers found that younger children have more positive achievement-related beliefs than older children have (Stipek & Iver, 1989). A 3-year longitudinal study showed that the ability-related beliefs regarding the domain of math, reading, instrumental music, and sports declined across elementary school years (Eccles et al., 1993; Wigfield et al., 1997). Furthermore, the study found that older elementary school children attributed lower value to math, reading, and instrumental music than younger children. On the other hand, older children evaluated sport activities with higher values than younger children did (Eccles et al., 1993). Moreover, children's beliefs about the usefulness and importance of math, reading, instrumental music, and sport activities decreased over the three years of longitudinal study, yet, their interest in math and sports activities did not decrease.

Regarding Expectancy-value theory and math performance, it is expected that motivational variables will be the strongest predictors of math academic achievement and math anxiety. Moreover, interiorizing math gender stereotypes will be negatively associated with math performance in female students, and positively associated with their math anxiety. In one Croatian research on 693 students of 14 years old in the region of Zagreb, it has been shown that even if on average girls had better grades in mathematics (girls: $M = 3.65$; boys: $M = 3.19$), they also showed to have higher math anxiety than boys (girls: $M = 2.01$; boys: $M = 1.86$) (Jugović, Baranović, & Marušić, 2012). These findings confirm the PISA research findings (OECD, 2009) in which girls had greater math anxiety than boys in 32 of 40 examined countries. Regarding math gender stereotypes, the study showed that both male and female students did not agree with math gender stereotype statements, but on average, male students tend to accept more those beliefs (boys: $M = 1.93$; girls: $M = 1.64$). In addition, in this study the perception of math difficulty was a significant predictor of math anxiety for both male and female students, and just for the female students the important predictor of math anxiety was their interest in mathematics and their level of accepting the beliefs related to math gender stereotypes (Jugović, Baranović, & Marušić, 2012).

In summary, the strongest predictors of the academic success for both genders are the subjective beliefs about personal ability, usefulness of the subject, and expectancy of success, even when previous performance in that domain is controlled. Furthermore, these concepts should be examined separately for different domains because studies showed that ability-related beliefs and expectancy values are domain-specific. For instance, the intention to keep taking math courses was determined by the children's subjective task values (Meece et al., 1990).

3.2 Stereotype Threat Theory

Stereotype threat theory (STT) is a phenomenon in which certain groups of people are affected by conscious or unconscious beliefs and fear of confirming a negative stereotype regarding their performance in the particular domain (Steele, 1997; Steele & Aronson, 1995). According to this theory, when stereotype is primed the individuals of that group have a psychological pressure, a fear about confirming a stereotype regarding their group, and that fear interferes with their working memory finishing to confirm a negative stereotype. High level of arousal decreases the capacity of working memory (Schmader & Johns, 2003). The stereotype threat recently became a well-known phenomenon, especially in the field of social psychology. Different studies showed its effects on different social groups. The most studied effects of the stereotype threat regard math gender stereotype, stereotypes related to Afro-Americans, and the groups with low social status (Steele, Spencer, & Aronson, 2002). Also, the type of task varies in the different domains such as memory tasks, verbal memory abilities, math tasks, sport activities, and others. Regarding the math gender stereotype, research has shown that the women's math performance is disrupted under the threat not because of insufficient talent but because women feel threated to confirm a negative stereotype about their social group. Furthermore, women report more negative domain-related thoughts in the condition under the stereotype threat (Cadinu, Maass, Rosabianca, & Kiesner, 2005). It can also be observed the increase of physiological arousal (Croizet et al., 2004), and higher activation of the cortical regions associated with the procession of socio-emotional information, but not in the regions associated with problem-solving (Krendl, Richeson, Kelley,

& Heatherton, 2008). This has a negative impact on the working memory efficiency (Schmader, Johns, & Forbes, 2008).

Considering the aim of this research, the major interest was given to the stereotype threat regarding the math gender stereotype‒boys perform better than girls in mathematics and science, and they are also more interested in mathematics than girls are. Stereotype threat theory claims for the first time that the gender gap in math performance can be explained with high arousal and fear of the stereotyped group (Spencer, Steele, & Quinn, 1999). This theory is in contrast with biological and psychosocial theories which explain gender differences with different biological structures, brain differences, and different learning strategies. When the math gender stereotype is activated female students tend to have lower math performance (Davies et al., 1999). Moreover, the idea is that women perform worst in math tests under the condition in which the stereotype is primed prior of taking a math test, whereas men perform equally in both conditions (Spencer, Steele, & Quinn, 1999; Steele, 1997). On the other hand, women in a stereotype nullification condition, in which the presented information is inconsistent with the math gender stereotype (e.g., about girls doing as well as boys in mathematics) are expected to perform better than women in control condition or in stereotype threat condition (Smith & White, 2002).

There are 3 important factors which should be considered in Stereotype threat theory:

- *identification with domain*
- *testing condition*
- *level of arousal*

Steele (1997) proposed that the stereotype threat affects mostly people who identify with the domain in question, in this case, people who identify with mathematics (Forbes, Schmader, & Allen, 2008; Jamieson & Harkins, 2007; Smith & White, 2001). The identification with mathematics involves two components, feeling that you are good at math and feeling that it is important for you to be good at mathematics (Smith & White, 2001). In that case, when a person identifies with the domain in questions, he/she associated it with the self-concept and self-esteem. Furthermore, higher performing students seem to be more likely to identify with mathematics, and therefore more likely to be susceptible to stereotype threat effects (Forbes et al., 2008; Smith & White, 2001; Steele & Aronson, 1995).

The second factor concerns the testing condition or in other words the difficulty of the task. The effects of the stereotype threat seem to be more present when the testing condition regards difficult tasks instead of tasks with easy items. Furthermore, this seems to appear for two reasons. Firstly, women are more likely to perform poorly on these assessments because their fear of confirming the negative math gender stereotype is more plausible (Neuville & Croizet, 2007; O'Brien & Crandall, 2003; Spencer et al., 1999; Steele, 1997). Secondly, most difficult tasks contain items that require more processing in working memory, and the working memory is compromised under the stereotype threat condition (Schmader, Johns, & Forbes, 2008).

The third factor important to consider in Stereotype threat theory is the level of arousal. The stereotype threat influences the increase of the levels of arousal, defined as a physical activation of the organism. In other words, the stereotype threat influences the cardiovascular system, increasing anxiety and frustration. It is a well-known phenomenon of math anxiety and math performance. Math anxiety is defined as a tension, an apprehension, or a fear that interferences with math performance (Richardson & Suinn, 1972). There is a considerable theory named *Yerkes-Dodson Law* (Yerkes & Dodson, 1908) which suggests that people can perform better also in the condition of high arousal level, but not when that level becomes too high, with optimal levels being different for every individual. Furthermore, high arousal influence on performance positively in the case of the easy tasks, whereas it decreases performance when the task contains difficult items which require more working memory processing.

Knowing at what age students are susceptible to the stereotype threat effects can help researches to identify the appropriate age for designing interventions to alleviate the effect of the stereotype threat. Some studies found the stereotype threat effect very early in childhood, already in nursery school (Ambady et al., 2000). Other studies have controversy results for the students attending elementary school and middle school (Ambady et al., 2001; Good, 2001; Muzzatti & Agnoli, 2007; Neuville & Croizet, 2007; Tomasetto et al., 2011). Most studies found the stereotype threat effects already in early elementary school, especially around the age of 8 or 9 (Marsh, 1989; Muzzatti & Agnoli, 2007;). This effect seems to grow with age and it becomes stronger in adolescence (Steffens, Jelanec, & Noack, 2010).

There are different ways to activate the stereotype threat and that also depends on the age of the sample. In young children, aged between 5 and 7, the gender relevance can be activated by asking them to colour the figure (Neuville & Croizet, 2007). For instance, for boys that figure can be represented with a boy holding a ball, and for girls with the figure of a girl with a doll. The control group can colour a non-gender related figure. In older children, aged between 8 and 13, the activation of gender can be done with the gender-related items of the questionnaire, or for example presenting them the important scientific inventions made by males instead of females to activate the math gender stereotype (Muzzatti & Agnoli, 2007).

The major susceptibility of the stereotype threat showed the girls who interiorized the math gender stereotype also at the implicit level (Kiefer & Sekaquaptewa, 2007). Moreover, significant susceptibility has been found in the girls who highly identified with their gender, and it seems that for these girls being good at math is associated with their self-concept (Schmader, 2002). On the other hand, girls who showed a minor susceptibility under the condition of the stereotype threat are those girls who do not identify at high levels with their gender and who did not interiorize the math gender stereotype at the implicit level (Kiefer & Sekaquaptewa, 2007). Those girls also showed more interest towards the math-related careers (Kiefer & Sekaquaptewa, 2007).

There is currently a debate whether the gender gap in math achievement has closed (Corbet, Hill, & St. Rose, 2008; Entwisle & Hyde, 2005; Lindberg, Hyde, Peterson, & Linn, 2010; Robinson & Lubienski, 2011). Some studies found no gender differences in math performance (Hyde, 2005; Hyde & Linn, 2006; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Spelke, 2005), whereas other studies have found small gender differences (College Board, 2009, 2010; Gibbs, 2010; Gonzales et al., 2008; McGraw, Lubienski, & Strutchens, 2006; Robisnon & Lubienski, 2011). Furthermore, other studies did not find the gender difference in math performance in kindergarten, but they found the gender difference in the 3rd grade students (d = .24; Fryer & Levitt, 2010; Penner & Paret, 2008; Robinson & Luibinski, 2011). The meta-analyses of studies published between 1990 and 2007 showed no gender differences in mean math performance between boys and girls (Hyde & Mertz, 2009; Lindberg et al., 2010). Furthermore, a Cyprus study on 255 students age 14 (54% were females) found no significant difference between boys and girls in actual math achievement (Georgiou, Stavrinides, & Kalavana, 2007). Additionally, this Cyprus study showed that girls are equally good as boys in math assessment also in early adolescence, while other studies are in conflict with this position, finding the gender gap in math performance from early age (Davies & Brember, 1999; Penner, 2003), and especially in adolescence (Beller & Gafni, 1996; Cambell & Beaudry, 1998; Davies & Brember, 1999; Hedges & Nowell, 1995; Randhawa, 1994).

Many studies have investigated the effects of the stereotype threat on math performance in the sample of college women (Nguyen & Ryan, 2008). Interestingly, most of the research in this field considers the stereotype threat as a well-established phenomenon, whereas the recent review and meta-analyses call the strength of the phenomenon into question, claiming that in the literature the stereotype threat is presented as exaggerated phenomenon (Stoet & Geary, 2012). Furthermore, the stereotype threat effect is even less understandable in childhood and adolescence (Good & Aronson, 2008). Importantly, studies showed that in early elementary school, just 3 of the 6 tests used in this field showed the stereotype threat effect (50%), for upper elementary school, none of the 9 tests showed that effect (0%), in middle school 4 of the 10 tests (40%), and in high school just 2 of the 11 (18%) revealed the effect. Across different age groups of the sample, just 25% of the 36 tests have found the effect of the stereotype threat (Ganley, Mingle, Ryan, Vasilyeva, & Perry, 2013). Furthermore, considering the overall number of studies regarding the stereotype threat effects, just 43% of studies has found that effect when each age group in the study was considered as being the separate study.

The possible explanations for not finding in some cases the stereotype threat effect can be due to its limited properties. It is possible that the effects of the stereotype threat manifest just in some conditions, and even when there are numerous factors that can induce the stereotype threat, sometimes those well-known factors in some situations do not induce the same effects. The reasons are still unknown, but the future research should address this aspect as a crucial think to understand the stereotype threat and to design the appropriate age-adapted interventions. The second reason for not finding in some studies the effects of the stereotype threat regards the different activation methods of the stereotype. Ranging from the subtle implicit manipulations to those explicit, such as asking students to mark their gender in the questionnaire or to answer on the gender-related items before undertaking a math test, or even telling boys that they are better at mathematics than girls. Future research should focus on testing different manipulation methods in the same sample to understand better the possibility of different activation methods in different age groups. The third reason for not finding the effect of the stereotype threat in some studies regards the study population and its characteristics. For example, Tomasetto and colleagues (2011) showed that the stereotype threat impacts math performance just of the girls whose mothers endorse math gender stereotypes, but it did not have any effect on the girls whose mothers rejected the gender stereotype about math performance. On the other hand, some biological and social theories which explain the gender gap in math performance with biological, genetic differences, and the differences in the learning styles, suggest that other factors such as gender differences in three-dimensional spatial cognition or interest in the non-social domains might contribute to that gap

(Baron-Cohen, Knickmeyer, & Belmonte, 2005; Ceci & Williams, 2010; Ceci et al., 2009; Farrell, 2005; Ferriman, Lubinski & Benbow, 2009; Geary, 1996; Lubinski, Benbow, & Sanders, 1993). In that case there is a possible solution for the gender gap in mathematics, for instance, instructing women on how to use spatial diagrams to setup complex math word problems can reduce women's disadvantages in these tasks (Johnson, 1984).

3.3 Choking under Pressure Phenomenon

Choking under pressure is a phenomenon which has the opposite effect of the stereotype threat theory, in other words, in some conditions a positive stereotype towards some group influences negatively the performance of that group (Baumeister, 1984; Cheryan & Bodenhousen, 2000; Rosenthal & Crisp, 2007). Furthermore, the choking under pressure phenomenon has been found in boys while undertaking the math tests when the math gender stereotype has been activated (Brown & Josephs, 1999). Instead of improving their performance because of the positive expectations, in some situations, members of the positively stereotyped group will under-perform when reminded of the positive stereotype associated with their group membership. Furthermore, the phenomenon of the choking under pressure was also found in the group of Asian-American women while undertaking the math test. Lower performance was found in the condition in which ethnicity was emphasized, compared to the condition when their gender was emphasized, and the control condition which did not activate either of those (Baumeister, 1984; Cheryan & Bodenhousen, 2000). Indeed, it seems that this phenomenon is selective, and it regards just the people who identify with the group in question, in this case women who identify with their Asian background (Steele, 1997).

Regarding the math gender stereotype and choking under pressure phenomenon, the study found that the individuals who were reminded of their two positive stereotypes–being a male student and studying math–were more likely to under-perform on the math test compared to individuals reminded of just one positive stereotype (being a male student or just studying math). In this British study seventy-five 16-year old students participated in the research after completing their AS-level study (Rosenthal & Crisp, 2007).

It is still not completely clear how the identification with the domain or group in question influences on the choking under pressure phenomenon. In addition, it seems that a person needs to care about the performance in that domain to come under the stereotype threat, and fallowing that reasoning, also the choking under pressure effect should be more likely to appear in the individuals who highly identify with the domain in question (Steele, 1997). If individuals do not identify with the domain in question, it seems unlikely that they will be concerned with their performance in that domain (Steele, 1997).

In conclusion, the findings of the study showed that the positive expectations of performance can lead to the choking under pressure effect, and in consequence to the performance detriment. Therefore, the individuals who identified with the mathematics under-performed when presented with two positive stereotypes, and no such effect was found for the individuals who do not identify with the math domain, suggesting that a person needs to consider the domain in question to be important to experience the effect of the choking under pressure phenomenon (Rosenthal & Crisp, 2007).

3.4 Behavioural Confirmation and Self-verification Processes

Philosophers, psychologist and other researchers have long questioned of weather expectations imposed by others onto self, or one's self-views are more important in determining behaviour and personality. In this field of research, two crucial concepts have been introduced, the behavioural confirmation and self-verification. *Behavioural confirmation* was firstly described by Rosenthal and Jacobson (1968) in their study which showed that teacher's expectations strongly influenced student's real performance. Furthermore, positive expectations influence performance positively, and negative expectations influence it negatively. Rosenthal and Jacobson originally described the phenomenon as the *Pygmalion effect*–"when we expect behaviours of others, we are likely to act in ways that make the expected behaviour more likely to occur" (Rosenthal & Babad, 1985). The behavioural confirmation is defined as a process through which expectations held by other perceivers influence target's behaviours and self-views. Other names of this phenomenon are self-fulling prophecy, interpersonal expectancy effects, or the Pygmalion effect.

On the other hand, the self-verification is defined as the process through which the target's self-expectations guide views and behaviour of the perceiver. The phenomenon is also famous under the name of the *Galatea effect*, alluding to the ancient Greek myth in which Pygmalion created a marble structure of his ideal women who eventually was brought to life and became the power of goodness and everything he wanted and expected, but eventually she began to impose her own will and independence.

Regarding the behavioural confirmation and self-verification, these two processes can operate together or in opposition, depending of the degree of agreement between the perceiver's view of the target and target's self-view. They operate together in the situation when a person is perceived by others in the same way the individual perceives him-or-herself. The processes are in opposition whenever there is an inconsistency between the perceiver's expectations and target's self-perceptions. In this circumstance, at least three different alternatives can occur: (1) the perceiver's expectations overcome the target's self-views, (2) the target's self-views overcome the perceiver's expectations, (3) both perceiver and target are influenced by the other. Swann (1987) suggest that those two processes can act in identity negotiation, because individuals bring their goals in interaction, and try to adopt the identities that facilitate the exchange and accomplishment of those goals. This is particularly important in the period of identity formation, which is in early adolescence (Erikson, 1956, Grotevant & Cooper, 1985; Marcia, 1966, 1993). Adolescence is a developmental period characterized by pubertal physical and emotional changes and it is common for this period the emergence of the deviant behaviour and psychopathology (Angold, Costello, & Worthman, 1998; Ruuska, Kaltiala-Heino, Koivisto, & Rantanen, 2003). This period is characterized by risky dangerous behaviours and understanding the interplay between behavioural confirmation and self-verification processes during adolescence can result in better understanding of the reasons why adolescents are more likely to involve in risky behaviours such as smoking cigarettes (American Lung Association, 2006), using drugs (Maxwell, 2002), begin to drink (National Centre on Addiction and Substance Abuse at Columbia University, 2006), be involved in the unprotected sex (American Social Health Association), physical and social aggression (Simons-Morton, Hartos, & Haynie, 2004; Underwood, 2003), gang activities (Dishion, Nelson, & Yasui, 2005), or experience depression (Ma, Lee, & Stafford, 2005), eating disorders (Attie & Brooks-Gunn, 1989), and very often sub-clinical symptoms of depression (Hankin, 2006), and eating disturbances (Graber, Tyrka, & Brooks-Gunn, 2003). Furthermore, adolescence is the period of greater autonomy from parents and the period of changes of social dynamics at school (Attie, Brooks-Gunn, 1989; Hankin, 2006; Jacobs, Vernon, & Eccles; 2004).

There are three possible outcomes regarding the adolescents' behaviour when a person sees him-herself as being responsible and wise, while a friend perceives him-her-self with the antisocial tendencies: (1) the peers 'expectations may create the self-fulling effects and elicit the anti-social behaviour from the target, (2) the target's self-views may be dominant and he/she will act in a prosocial manner, and (3) both perceiver and target may influence one another (Rosen, 2006). If behavioural confirmation predominates during adolescence the first alternative will be more likely to occur, whereas if the self-verification predominates the second alternative is more likely to occur.

Above all, the behavioural confirmation process is categorized as a 3-stage model (Jussim, 1986; Snyder & Swan, 1978). In the first stage perceivers form expectations about the target. These expectations are usually based on the initial assumptions about the target, and they origin from a wide array of sources (Jussim, 1986). Furthermore, the assumptions can be form from the target's physical attractiveness (Snyder, Tanke, & Bercheid, 1977), age (Musser & Graziano, 1991), socioeconomic status (Rist, 2000), target's membership in some organization with the particular reputation (Rodgers & Maranto, 1989; Snyder & Swann, 1978), gender (Skrypnek & Snyder, 1982), stereotyped group (Jussim, Fleming, Coleman, & Kohberger, 1996), or something else. Additionally, the initial assumptions can also be based on the brief and insignificant interaction with the target (Trouilloud, Sarrazin, Martinek, & Guillet, 2002). Afterward, the perceivers start to treat target by fallowing their expectations, and this stage can be called the hypothesis testing (Snyder & Swann, 1978). Lastly, target responds to his/her treatment and consequently confirms the perceiver's expectations (Jussim, 1986; Snyder & Swann, 1978).

In order to understand better why the behavioural confirmation occurs, Snyder and Haugen (1994) proposed two mechanisms that drive this process. The first one regards the function of knowledge, and it is related to the perceiver's need to learn about their partner in interaction and to understand better the situation. The perceiver can feel that the best way for gaining the understanding from the target is to form the expectations regarding the target. The perceiver in that way is driven by any information that he/she has about the target, based on impressions, beliefs, and stereotypes to facilitate the interaction and to have the sense of predictability. The second mechanism regards the adjustive function of the perceiver, which might assume that the interaction based on expectations will be easier and more agreeable (Snyde & Haugen, 1994).

Considering the behavioural confirmation process in the school setting, the pioneering study of Rosenthal and Jacobson (1968) have found some significant findings. Their study received afterwards different critics which focused on the statistical analyses and the reliability of the intelligence test used to assess students (Snow, 1995). Rosenthal (1995) responded to criticism by acknowledging that the initial results did not change with different analyses, as well as they have been replicated by many other studies. To that end, it is important to recall the study of Rosenthal and Jacobson (1968) about the behavioural confirmation in the school setting. In that study, the elementary school children took the intelligence pre-test, and consequently, Rosenthal and Jacobson informed their teachers about the children who showed on the test “unusual potential for the intelligence growth”, and they were expected to bloom academically within the year. Furthermore, these students were selected randomly with no relation to their test scores, and that secret was hidden from their teachers. The researchers evaluated the children again 8 months after, and they found some interesting results. Furthermore, the children classified as particularly intelligent scored significantly higher in the intelligence test 8 month later. That effect started to be well-known under the name of the behavioural confirmation process, and in this case, it can be explained by different feedback, interaction, and expectations given from the teachers to the students that they believed as being particularly intelligent. These students started to engage more in studying and doing homework, and this phenomenon is famous as the self-verification process.

Importantly, the behavioural confirmation and self-verification processes are both crucial for understanding the effects of stereotypes. Furthermore, these phenomena seem to occur just in some situations. It this case it is important to consider 3 important factors: characteristics of situation, the perceiver, and the target. The relationship dynamics, considering the balance of power between the perceiver and the target influence the process of the behavioural confirmation. Furthermore, goals that target and perceiver bring to the interaction setting have the impact on weather and in what extent the behavioural confirmation will occur (Neuberg, 1989). Meta-analyses findings suggest that the personality of the perceiver has a greater influence on this phenomenon when comparing with the personality of the target (Cooper & Hazelrigg, 1988). The perceivers who are more likely to elicit the behavioural confirmation from the target usually have the strong need to control the behaviour of others, they are highly expressive with their voices, facial expressions, and body movements, and they have usually positive attributes such as being friendly and honest. The third important thing in this context is the personality of the target. Furthermore, it seems that the targets who are more likely to experience the behavioural confirmation process are those with the fallowing personality traits: being susceptible to perceiver expectations, more vulnerable to the influence of others, submissive and sensitive rather than assertive and self-assured (Cooper & Hazelrigg, 1988), and they score high at the measures of self-monitoring, particularly other-directedness, because they tend to make others happy, and to adapt easily to social situations which results in being more likely to adapt to other's expectations of them (Rotenberg, Gruman, & Ariganello, 2002). Furthermore, also the targets who score high in cue-reading ability are better to detect the perceiver's subtle communication of their expectations, and thus to adapt, and that is associated with the increases in the behavioural confirmation (Coope & Hazelrigg, 1988).

In conclusion, the behavioural confirmation process is a robust phenomenon among adults in both laboratory and non-laboratory settings. Future studies need to focus more on natural settings, outside of the laboratory, and to study this phenomenon on children. Nowadays, the research is focusing largely on whether this process could have profound implications in the work place, military, and courtroom (Kassin, Goldstein, & Savitsky, 2003; Kierein & Gold, 2000; Judice & Neuberg, 1998).

3.5 Women in Mathematics and Science Fields

Nowadays much of the future economic growth is projected in science, technology, engineering and mathematics (STEM). The STEM is defined in many ways, and it is usually interchangeably with physical, biological, and agricultural sciences, computer and information sciences, engineering, engineering technologies, and mathematics. Social and behavioural sciences, such as psychology and economics, are not included, nor the health workers, such as doctors and nurses. The STEM fields are widely considered as critical for the national economy. Thus, the need of the United States of America (U.S.) to be competitive in the global economy has led to several calls to increase the number of experts in these sectors (National Academy of Sciences, Committee on Science, Engineering & Public Policy, 2007; U.S. Government Accountability Office, 2006; U.S. Department of Education, 2006). The National Science Foundation (2006) estimated that about 5 million people work in science, engineering, and technology in the U.S., which is just over 4% of workforce, but defined more broadly the STEM workforce has been estimated to 21 million people. Mathematics' knowledge has an important role in many aspects of human life, and mastering math becomes necessary for human in order to be able to face different life problems. As the researchers Naomi and Githua (2013) claimed: "knowledge of mathematics as a tool for use in everyday life is important for the existence of any individual and society. It equips students with unique and powerful set of tools to understand the world and become productive members of the society". The problem which is well-presented is what drives gender disparities in STEM and which are the solutions?

Women form about 50% of the American population, and more than 50% of the college population regards women (National Centre for Education Statistics, 2013). Although the gender gap in science and math performance is closing, this gap remains in STEM jobs, STEM self-concepts and aspirations, with women being under-presented in these fields (Dasgupta, 2011). Considering the U.S. STEM disciplines in 2007, women earned 48 001 biological science degrees, 7944 computer science degrees, 2109 electrical engineering degrees, and just 1024 physical degrees. In comparison, men earned 31 347 biological science degrees, 34 652 computer science degrees, 16 438 engineering degrees, and 3 846 physics degrees (National Science Foundation, 2007). Furthermore, women's representation among doctoral degrees in the STEM fields had increased in last 40 years, but they still remain under-presented in these fields (National Science Foundation, 1966−2006). In 1966, women earned about 1/8 of the doctorates in biological and agricultural sciences, 6% of the Ph.D in chemistry and mathematics, 3% or less of the Ph.D in Earth, atmospheric, ocean sciences, physics, engineering, and computer sciences. In 2006, women earned almost 1/2 of the Ph.D degrees in biological and agricultural sciences, around 1/3 of the Ph.D in Earth, atmospheric and ocean sciences, chemistry, and math, and at about 1/5 of the Ph.D in computer science, engineering, and physics. Furthermore, even when girls and women perform equally or even better than their male peers on STEM tests, many of them lose interest to pursue advanced courses, majors and careers in STEM (Dasgupta, 2011). Additionally, also the prestigious Fields Medal for mathematical achievement was won by woman just once since it was first awarded in 1936. Multiple factors contribute to the underrepresentation of women in STEM fields, therefore multiple solutions are needed to correct the imbalance. In order to close the gender gap in these fields, it is necessary to understand the factors underlining this problem, and to design the interventions which will target multiple points in the developmental trajectory.

It seems that the responsibility for this gender gap might be due to gender stereotypes that origin from the gender roles and expectations learned in early childhood (Eccles, Jacobs, & Harold, 1990). Female gender stereotypes orientate them towards communal goals regarding social skills, interpersonal relationships, and being helpful and family-oriented (Konrad, Ritchie, Lieb, & Corrigal, 2000). On the other hand, male gender stereotypes orientate them to explore physical world, understand how things work, and to gravitate towards the activities which emphasize problem solving, status, and financial gain. Regarding math performance and gender, American cultural messages associate mathematics more with boys than girls (National Science Foundation, 2003). Furthermore, the research showed that the math gender stereotype is interiorized in American children in early childhood already at the age of 6 or 7, and children seem to absorb this stereotype by the age of 10 when girls showed to prefer reading than mathematics (Herbert & Stipek, 2005). These stereotypes origin from the influence of society, parents, and peers. Parents' expectations are very important in defining the academic trajectory of their children, and more they encourage their children in after school activities in STEM and participate with them, more children become interested in these activities (Simpkins, Davis-Kean, & Eccles, 2006). Furthermore, parents' beliefs about the children's math ability and effort are crucial, because that seems to have the great influence on children's math grades (Frome & Eccles, 1998). In middle school and high school, mothers' predictions regarding their daughters' motivation to persist in science and mathematics are more important than fathers' beliefs (Leaper, Farkas, & Brown, 2012). Other influence originates from peers, since the peers' acceptance is one of the central concerns during the period of adolescence (Eaton, Mitchell, & Jolley, 1991). The same-gender friends' interests influence adolescent girls' choices to continue the STEM education (Eaton, Mitchell, & Jolley, 1991). Furthermore, girls' decision about taking the advanced math and physics courses were predicted by how good their female and not male friends were at these courses during the previous year (Riegle-Crumb, Farkas, & Muller, 2006). Furthermore, it seems also that for girls' persistence in STEM courses is particularly important the classroom climate, and the attention is drawn to collaborative climate which influences positively the girls' interest and performance in mathematics (Wang, 2012). Collaborative climate can be defined as the classroom climate which allows students to exchange ideas, their own position, to experience self-confidence, mastery, and success in the task (Durik & Eccles, 2006; Patrick, Ryan, & Kaplan, 2007; Patrick, Kaplan, & Ryan 2011). Other significant aspect regards personal goals and values attributed to the STEM education. The studies showed that the personally relevant tasks enhance motivation, attention, learning, and task identification (Hidi & Harackiewicz, 2000). Importantly, girls seem to show more interest in math than boys when mathematics is explained through the applied perspective (Geist & King, 2008; Halpern, 2004). Furthermore, all students prefer to learn the subject via hand-on projects rather than through the abstract instructions (Mitchell, 1993). In that way the subject seems more interesting and meaningful (Mitchell, 1993). Regarding the personal values, it seems that boys and men value more money, power, achievement, challenge, and risk taking, whereas girls and women seem to value more altruism, interpersonal orientation, family time, and knowledge development (Eccles, 1994, Konrad et al., 2000, Post-Kammer, 1987). Additionally, the STEM fields are usually perceived as non-engaging in communal goals, whereas on the other hand, the service professions such as social work, nursing, teaching, and human resources are seen to facilitate communal goals (Diekman, Brown, Johnston, & Clark, 2010). Whereas women are thought to be more interested in communal goals, they are also more interested in pursuing those professions (Su, Rounds, & Armstrong, 2009). Significantly, the survey showed that many girls graduate from high school well prepared to pursue the STEM career, but just few of them major in science and engineering in college. Furthermore, regarding the high school credits earned in the U.S. schools in mathematics and science, girls showed to earn more credits than boys since 1994. Additionally, in 2007, boys on average earned 7.1 credits, whereas girls earned 7.3 credits (U.S. Department of Education, National Center for Education Statistics, 2007). Considering the average grades in the U.S. high schools in mathematics and science from 1990 to 2005, girls had on average higher grades than boys, for instance, in 2005 girls had on average the grades of 2.76, in comparison with boys in 2005 who on average had the grades equal to 2.56 (U.S. Department of Education, National Center for Education Statistics, 2007). Nevertheless, many people continue to associate science and math fields with men, and humanities and arts fields with women, including even the people who actively and strongly reject these stereotypes at the conscious level (Valian, 1998). Taking the implicit bias test about the gender stereotypes can help them to recognize the implicit stereotypes, so they can work on it to compensate that. Furthermore, the research showed that people not only associate these fields with "male", but they often tend to hold negative opinions of women in "masculine" positions, for instance, women who are scientist or engineers. The classical idea is that men "naturally" excel in mathematics and science and women are "naturally" good in the fields using language skills. Additionally, the research found that the majority of women and men of all racial-ethnic groups hold strong implicit association of male with science and female with liberal arts (Nosek et al. 2002). These social beliefs and learning environments seem to have a huge effect on girls' and women's achievement and interest in science and math. Although the research showed no significant difference in average IQ between gender, still there are different strengths and weakness for each gender (Lynn & Irwing, 2004). Generally, boys perform better on tasks using spatial orientation and visualization, and certain quantitative tasks, whereas girls outperform boys on tests relying on verbal skills, especially writing, and some memory tests, and perceptual speed (Halpern & Aronson et al., 2007; Hedges & Nowell, 1995; Kimura, 2002). However, it seems that the gender disparity in the STEM fields is due more to gender stereotypes and expectations. Many girls and women reported to be not interested in science and engineering. In one research in 2009 on students aged between 8-17 years old, 24% of boys and only 5% of girls reported to be interested in undertaking the engineering career (American

Society for Quality, 2009). Other research found that 74% of college boys aged 13 to 17 reported that computer science or computing would be a good college major for them, while the same was reported by just 32% of their female peers (WGBH Education Foundation & Association for Computing Machinery, 2009).

Another important factor of academic success and choosing the future career is the way in which the intelligence is presented, as fixed or growth mindset (Dweck & Leggett, 1988). Carol Dweck is a social psychologist at the Stanford University who studied for 40 years the foundations of motivation. Her research provides evidence that the *growth mindset*, viewing intelligence as a changeable, malleable attribute that can be developed is likely to lead to a greater persistence in adversity, and consequently to success (Blackwell et al., 2007; Dweck & Leggett, 1988; Mangels, Dweck, et al., 2006; Dweck 2008). On the other hand, the *fixed mindset* sees the intelligence as an inborn, uncontrollable trait. The significance of the individual's mindset often does not emerge in early childhood, until the child faces challenges that appear usually in middle school. When challenges arrive, there in the important difference between the students with fixed mindset and growth mindset. Unfortunately, math skills are usually seen as the fixed ability (Williams & King, 1980). A study including 373 moderately-to-high-achieving seventh graders in the U.S. showed that the student's motivational framework was crucial in their achievement and it determined whether student's math grades would improve (Dweck et al., 2006). Furthermore, when teachers and parents told girls that their intelligence can expand with experience and learning, girls performed better on math tests and they were more interested in studying math in the future. Two years after endorsing the intellectual growth mindset, these students were outperforming the students with the fixed mindset, when controlling for the prior achievement. The findings have shown that the intellectual growth mindset improves performance by itself (Dweck et al., 2006). Therefore, teachers and parents should create the growth mindset environment which would encourage girls' achievement and interest in math and science.

Regarding gender stereotypes at the workplace, the research found that women receive lower performance ratings at male gender-typed positions than women in staff jobs, considering those to be more female-typed positions, which agrees with the lack-of-fit principle (Lyness & Heilman, 2006). The study included 489 jobs of upper-and-senior-level managers from the large financial service organizations (Lyness & Heilman, 2006). When only gender was changed, men were evaluated more favourably than women in male-dominant leadership roles, but equally in other roles (Eagly, Makhijani, & Klonsky, 1992). Furthermore, also another study which took in consideration 49 experiments in simulated employment context showed the stereotype driven disparity between job candidates and roles (Davison & Burke, 2000). In male-typed-jobs (e.g., salesperson, life insurance agent) men were preferred over women, whereas in female-typed-jobs (e.g., secretary, director of a Day Care Center) women were preferred over men (Davidson & Burke, 2000).

Regarding the STEM fields and gender differences, there is the evidence that women who are also mothers face difficulties in the academic environment (Mason & Goulden, 2002). The research showed that among tenured faculty in the science, 12 to 14 years after earning a doctorate, 70% of men and only 50% of women had children living in their home (Mason & Goulden, 2002). Furthermore, the same study showed that among professors who had children within the first year of the doctorate, 77% of men but only 53% of women had achieved tenure 12 to 14 years after earning the doctorate (Mason & Goulden, 2002). In addition, 38% of women and 18% of men reported that they have less children that they wanted (Mason & Goulden, 2004). Notably, many people think that women leave the STEM academic careers because they cannot balance work and family responsibilities (Mason et al., 2009; Xie & Shauman 2003). Married women with children seem to be more disadvantaged in the STEM jobs compared with married men in relation to tenure and promotion decisions (Xie & Schauman, 2003). Even if in business and industry the family responsibilities can be seen as a barrier to advancement for both men and women, it seems that women are more affected than men (Simard et al., 2008). Women are more likely than men to report foregoing marriage or children, but also delaying having children. Studying the people who left the engineering career, women were more likely than men to report that the reason for leaving does not regard just another career to pursue, but it also regards the family-related issues (Frehill et al., 2008; Society of Women Engineers, 2006). Furthermore, women who work in the STEM fields are more likely to have a partner who also works in the same field and faces similar demanding work schedule. However, the priority is often given to the men's career (Hewlett et al., 2008).

Why is so important to solve the gender disparity in the STEM fields? Attracting more women in the STEM workforce will maximize innovation, creativity, and competitiveness (National Association of Colleges and Employers, 2009). The STEM fields are trying to solve some of the most important challenges for the everyday life and future such as finding cures for diseases like cancer and malaria, finding the solutions for global warming, clear drinking water, developing renewable energy sources, understanding the origins of the Universe, building bridges, cars, wheelchairs, designing computers, X-ray machines and many others.

When women are not involved in those inventions, design of the product may be more adapted to men. For example, some early voice-recognition systems were adapted to typical male voices which resulted in literally not recognizing women's voices. Similar cases are extended to many other industries and product design. For instance, the first generation of automotive airbags was designed by predominantly male group of engineers which resulted in airbags which were not suitable for women, leading to numerous, otherwise avoidable deaths of women and children (Margolis & Fisher, 2002). Attracting more women in the STEM workforce would bring major diversity in these fields, which would lead to better designed scientific and technological products that would be likely to represent all users (National Association of Colleges and Employers, 2009). On the positive side, if that women still earn less than men in science and engineering fields, they tend to earn more than women who work in other sectors (National Association of Colleges and Employers, 2009). Furthermore, the research found that when women apply for the STEM faculty positions at major research universities, they were more likely to be hired than men (National Research Council, 2009). Nevertheless, there is still small number of women who apply for these positions in the first place (National Research Council, 2009).

In order to attract more women in the STEM fields, colleges and universities should not just recognize and reduce math gender stereotypes, but they also should work on the improvement of the integration of female faculty into the university culture and change of the work-policies to be better suitable for all faculty members. Also, changing the admission requirements, presenting the overview of the field in the introductory courses, and providing the student loan can help to solve the gender disparity problem (Hill & Corbett, 2010).

Chapter 4 – Math Anxiety

4.1 Definitions and Consequences of Math Anxiety

The experience of the math anxiety was firstly mentioned back in the 16th century in the famous verse “Multiplication is vexation…and practice drives me mad”, but the concept of the math anxiety was introduced for the first time by Dreger and Aiken (1957). However, it has just recently received increased attention. The MA can be defined as an individual emotional reaction to mathematics which may affect the achievement of learning mathematics, and it is seen as the factor that may cause low math performance. Gunduz (2015) described it as: “Math anxiety is an idea that evokes an emotional reaction spoiling the performance of people engaged in the numbers and mathematics”. Furthermore, the MA is defined as a “feeling of tension, apprehension, or fear that interferes with math performance” (Ashcraft, 2002). Additionally, the MA is an emotional reaction which usually includes the felling of anxiety, fear, depression, or nervousness in the situations when individuals are faced with math learning process such as the math test. This emotional reaction may cause difficulty in concentration, and consequently, inability to solve the math problem which can result in the failure in the math test. In addition, the MA interferes with the individual’s performance in mathematics, manipulation of numbers, and problem-solving activity (Lai, Zhu, Chen, & Li, 2015; Ingole & Pandya, 2015). That means that students might experience the MA when they learn mathematics in the class or independently, when they do the math exercises or complete the math test. The students’ negative attitudes and perception, such as disliking math or feeling nervous and bored by it often lead to the feeling of nervousness, fear, and anxiety, or in other words to the phenomenon of the MA which can lower the mathematics achievement (Mullis, Martin, Foy, & Arora, 2012). Furthermore, the research has shown that in adults the MA can negatively impact the performance of basic numerical operations such as simple addition or counting which are important for more complex math concepts (Ashcraft & Faust, 1994; Ashcraft, 2002; Maloney et al., 2010). Moreover, the findings in the laboratory setting suggest that math-anxious individuals have difficulty with basic math tasks which are typically learned before elementary school such as judging the magnitudes of number pairs (Maloney, Ansari, & Fugelsang, 2011; Maloney, Risko, Ansari, & Fugelsang, 2010; Núñez-Peña & Suárez-Pellicioni, 2015). This is the important finding because the MA influences the learning process and mastery of mathematics which lead over time to poor math skills, and that can have the adverse effect on the long-term career choices and professional success (Hembree, 1990; Krinzinger et al., 2009; Ma, 1999; Meece et al.,1990). Furthermore, the adults who experience

MA often perform poorly on the standardized math tests (Ashcraft & Krause, 2007; Hembree, 1990), tend to avoid arithmetic classes (Ashcraft & Moore, 2009; Hembree, 1990), develop negative beliefs regarding their own math abilities (Ashcraft & Kirk, 2001; Lent et al., 1991), and experience greater MA and avoidant behaviour towards mathematics. Regarding the type of math exercises and MA, the research showed that MA influences more performance on the math problems which require complex verbal reasoning and problem solving, as opposed to the numerical operations which require basic symbolic processing and math fact retrieval (Wu, Barth, Amin, Malcarne, & Menon, 2012).

In summary, the long-term consequences of MA result in avoidance of math and math-related situations (Ashcraft & Ridley, 2005). Moreover, the negative consequences of MA also include the fallowing problems: poor performance on standardized math tests and difficulty with math-related problem solving (Hembree, 1990), low performance at courses involving numerical reasoning (Núñez-Peña, Suárez, Pellicioni, & Bono, 2013), reduced efficiency in solving simple arithmetic problems (Imbo & Vandierendonck, 2007), and difficulties in basic numerical processing (Ma & Xu, 2004).

The MA is a common global phenomenon that is highly prevalent. The prevalence varies quite widely and depends on the population being sampled, and especially on criteria which are used to categorize people as mathematically anxious. The Program for International Student Assessment (PISA) which evaluates 15-year-old students' academic achievement worldwide, in the research across on average 65 countries found that 33% of the 15-yeard-old students reported feeling helpless when solving math problems (OECD: PISA, 2012). Moreover, 25% of the four-year-college students in the U.S. reported the symptoms of MA, and 80% of the U.S. community college students suffer from moderate to high degrees of MA (DS Yeager, 2012). Moreover, another research showed that 11% of the university students presents high levels of MA that would require counselling (Richardson & Suinn, 1972). Betz (1978) found that about 68% of students enrolled at mathematics classes experienced high MA. Furthermore, Ashcraft and Moore (2009) estimated that 17% of population has high levels of MA. Johnston-Wilder and colleagues (2014) found that about 30% of apprentices experienced high MA, and about 18% were affected but at the lower level. Chinn (2009) suggested the significantly lower prevalence of MA when in his research between 2% and 6% of the secondary school students in England reported to experience high levels of MA. This lower prevalence of MA is probably due to the strict criteria applied in defining students with high MA.

4.2 Relationship between Math Anxiety and Math Performance

Regarding the relationship between MA and math performance, it is still unclear their relationship; the MA may cause math difficulties, and the experience of math difficulties and failure may consequently result in experiencing MA. Does students' math anxiety impair their ability to do math, or students develop math anxiety because of the pre-existing difficulty with math, or the relationship is bidirectional? There are two main theories which try to solve this problem. The first one is *Deficit Theory* which suggests that MA is elicited by experiences of poor performance in math (Ma & Xu, 2004). On the other hand, the *Deleterious Anxiety Model* suggests that children with MA impaired the math performance because anxiety interferes with cognitive processes such as working memory (Ashcraft & Kirk, 2001). High levels of MA are associated with lower math performance. In particular, the correlation between MA and math performance is equal to -.29 as observed in the meta-analyses (Hemnree,1990; Ma, 1999). Data from the PISA research in 2012 showed that in 63 of the 64 education systems involved in the PISA survey, students reporting higher levels of MA displayed lower levels of math performance than their peers who reported lower levels of MA (OECD, 2013). Moreover, regarding gender and MA, in 56 of 64 countries of the PISA research female students reported higher math anxiety than their male peers (OECD, 2013). Furthermore, the MA was mentioned for a long time as the main cause of the under-representation of female students in math and science courses (Ernest, 1976; Hembree, 1990; Meece et al., 1982; Tobias & Weissbrod, 1980). Across the OECD countries, 14% of the variation of math performance is explained by the MA, when controlling for gender and socioeconomic status (OECD, PISA 2012). In particular, on average across the OECD countries, a 1-point increase in MA was associated with the larger decrease in math performance for the students at the 90^{th} percentile in math performance than for the students at the 10^{th} percentile (Cohen's *ds* = .32 vs. *ds* = 25). Thus, students with higher potential to succeed in math are at greater risk of not reaching their full potential if they experience the MA (OECD, 2013). Moreover, the PISA data showed that the negative relationship between MA and math performance is the strongest for the students with high working memory efficiency. These students perform worse on the complex addition problems, and markedly worse on the same problems when simultaneously asked to hold a group of letters in mind to recall later (Aschraft & Kirk, 2001). Studies suggest that MA creates worries that influence on the cognitive system responsible for the short-term storage and manipulation of information (Miyake & Shah, 1999). The MA seems to influence the math performance at both individual and environmental level, and this broader contextual level is including students, parents, and teachers (Suárez-Pellicion, Núñez-Peña & Colomé, 2015). It also seems that MA is particularly related to the self-rating, and people who think that they are bad at mathematics are also more likely to be anxious about that (Goetz et al., 2010; Hembree 1990; Hoffman, 2010; Jain & Dowson, 2009; Pajares & Miller, 1994). The key problem with most studies is that they are correlational instead of longitudinal, and thus, it is hard to establish the direction of cause of math anxiety and poor math performance (Ahmed et al., 2012). Furthermore, the construct which is closely related to the self-rating is the self-efficacy defined by an American social psychologist Albert Bandura (1977). Ashraft and Rudig (2012) adapted the definition of self-efficacy to the matter of mathematics, and they define it as "individual's confidence in his or her ability to perform mathematics and is thought to directly impact the choice to engage in, expend effort on, and persist in pursuing mathematics". Furthermore, the research on the elementary school students found that the MA showed a mean correlation of -.73 with enjoyment of mathematics, and the correlation of -.82 with confidence in mathematics (Hembree, 1990).

There are two main explanations of why people with MA tend to underperform in math; the first one is that people with MA tend to avoid the activities that involve mathematics, thus, they have less practice (Ashcraft, 2002). The other more common explanation is that MA might affect math performance by overloading the working memory (Ashracft et al., 1998). Anxious people are likely to have intrusive thoughts about how badly they are doing and that may distract the attention from the task or math problem and overload the working memory resources (Berggren & Derakhshan, 2013; Eysenck & Calvo, 1992; Fox, 1992; Mandler & Sarason, 1952). Moreover, that deficit of the working memory has a strong effect particularly on arithmetic tasks, especially the tasks that involve multi-digit arithmetic and/or carrying (Caviola et al., 2012; Fuerst & Hitch, 2000; Gathercole & Pickering, 2000; Hitch, 1978; Swanson & Sachse-Lee, 2001). One of the possible solutions of how to decrease the pressure on the working memory caused by the MA is to ask the individuals to focus on the problem steps by talking aloud, and that can help them to reduce the pressure-induced worries which have the negative impact on math performance (DeCaro et al., 2010).

The behavioural and psychological studies may provide factors that can explain the gap between students with high and low MA and math performance, including the individual (cognitive, affective/psychological) and environmental (social/contextual) factors. The cognitive factors regard working memory, strategy use, and attention. The empathize is put especially on the working memory and its impairments with MA which reduces its resources important for cognitively demanding tasks. Moreover, the math-anxious individuals perform poorly on the tasks such as addition and carrying, but do not show the decrease of performance in the problems which require simple fact retrieval (Ashcraft & Kirk, 2001). Other explanation regards the affective/psychological factors. The physiological measures of anxiety include heart rate and skin conductance (Dew et al., 1984), cortisol secretion (Mattarella-Micke et al., 2011; Pletzer et al., 2010), brain measures from EEG recordings (Núñez-Pena & Suarez-Pellicioni, 2014, 2015), and functional MRI (Lyons & Beilock, 2012; Pletzer et al., 2015; Young et al., 2012). Regarding MA, the cortisol secretion is a response to stress, and therefore the individuals with high MA may show higher levels of the cortical secretions when presented with math stimuli or activities (Hellhammer et al., 2009). Moreover, the research showed that in people with high working memory capacity who experience MA, there is a negative relationship between cortisol secretion and math performance, while people with low MA showed a positive relationship between these two (Mattarella-Micke et al., 2011). Considering the EEG measures, the individuals with high MA showed higher amplitude in frontal areas for both size and distance effects when compared with individuals with low MA (Núñez-Peña & Suárez-Pellicioni, 2014, 2015). Furthermore, the research showed that high levels of MA are associated with increased cardiovascular activity (Faust, 1992), increased salivary cortisol concentration (Mattarella-Micke, Kozak, Foster, & Beilock, 2011), and increased activation in brain regions associated with the pain perception (Lyons & Beilock, 2012), and negative emotional processing (Young & Menon, 2012). The functional MRI showed that at the age between 7 and 9, children already have the same neural correlates of MA as adults have (Young et al., 2012). Moreover, the 2nd and 3rd graders who reported being highly math-anxious showed increased negative emotional processing during the math performance which was recorded with the hyperactivity in their right amygdala (Young, 2012). Furthermore, the high-math-anxiety individuals showed greater activity in the right amygdala, implicated in the processing of negative emotions than their low-math-anxious peers (Young et al., 2012). They also showed reduced activity in the regions important to support working memory and numerical processing such as dorsolateral prefrontal cortex and posterior parietal lobe.

The other part of the affective/psychological factors refers to motivation. Studies found that children and adults with high levels of intrinsic motivation showed inverted relation between MA and the math performance; moderate levels of MA were associated with better math performance compared with extremely low or extremely high levels of MA. On the other hand, those with low math motivation showed a linear negative relation between MA and math performance (Wang et al., 2015). Thus, motivation can be considered as a moderator between MA and math performance. This can be explained in the way that math motivation might decrease the avoidance style usually observed in the math-anxious individuals and affects positively on actively approaching the math tasks. The third factor regarding MA and math performance refers to environmental factors such as social or contextual factors. In particular, teachers' and parents' MA, support and expectations, and students' perceived classroom environment seem to affect math performance (Beilock et al., 2010; Fast et al., 2010; Maloney et al., 2015; Vuković et al., 2013).

Regarding the assessment of MA, two standardized instruments which are most frequently used are "Mathematics Anxiety Research Scale" (MARS; Richardson & Suinn, 1972), and "The Abbreviated Math Anxiety Scale" (AMAS: Hopko, Mahadevon, Bare, & Hunt, 2003). The first instrument is a 25-item questionnaire which measures test, numerical, and course math anxiety with a 5-point Likert scale. The latter one is a 9-item self-report abbreviated instrument for a rapid assessment of MA with a 5-point Likert scale that scores from 9 to 45. Other instruments commonly used to assess MA are the following: "Fennema-Sherman Mathematics Attitude Scales" (Fennema & Sherman, 1976), "Mathematics Attitude and Anxiety Questionnaire" (Thomas & Dowker, 2000), "Children Attitude to Math Scale" (James, 2013), "Children anxiety in math scales" (Vuković, 2013), and "The Mathematics Assessment for Learning and Teaching" (MALT; Williams, 2005).

In conclusion, the PISA data showed that MA is a cross-national problem, and still there are no many solutions about how to face it in the different cultural contexts. Many studies found that numerous people have extremely negative attitudes towards math and that may sometimes lead them to experience of MA (Ashcraft, 2002; Hembree, 1990; Maloney & Beilock, 2012). When studying the relationship between MA and math performance, even if MA is negatively affecting math performance, it is important to consider different components of the anxiety often named "cognitive" and "affective" components (Ho et al., 2010; Wigfield & Meece, 1988), and also to consider that arithmetic itself is not a single entity, but it regards many components (Dowker, 2005).

4.3 Types of Math Anxiety and its Relationship with other Forms of Anxiety

Math anxiety is an entity on its own and it is necessary to consider it separately, but also to take in consideration its relationship with the other forms of anxiety, especially with the test anxiety and general anxiety (Ashcraft et al., 1998; Hembree, 1990). Furthermore, the two-factor model of MA has been proposed regarding its affective and cognitive dimension (Bandalos et al., 1995; Meece, Wigfield & Eccles, 1990; Wigfield & Meece 1988). That model was also proposed for the test anxiety by Liebert and Morris (1967), and many researchers see MA as a subject-specific manifestation of the test anxiety (Bandalos, Yates & Thordike-Christ, 1995; Brush, 1981; Dew, Galassi & Galassi, 1983; Hembree, 1990). However, test anxiety relates to tests and their consequences, such as the anxiety of failing the test, and it can be experienced in different test situations and not just in the school settings (Pekrun, 2001). There are two dimensions of test anxiety which refer to affective and cognitive test anxiety. Affective test anxiety regards fear, tension, dread, and unpleasant physiological reactions to testing situations (Morris & Liebert, 1970; Sarason, 1986; Schwarzer, Van der Ploeg & Spielberger 1982). Cognitive anxiety refers to the worry component of anxiety which displays through negative expectations, preoccupation, and worry thoughts in anxiety-causing testing situations (Morris et al., 1982; Morris & Liebert, 1970; Sarason, 1986; Wigfield & Meece, 1988). Regarding two anxiety dimensions and math performance, the research showed that the cognitive test anxiety has a significantly negative relationship with test performance including also the performance which is perceived by individual (Deffenbacher, 1978; Wine, 1971). On the other hand, the results of the affective test anxiety are less consistent (Deffenbacher, 1978; Wine, 1971). Furthermore, some studies found a negative correlation between affective anxiety and test performance (Deffenbacher, 1978, 1980; Doctor & Altman, 1969; Sharma & Rao, 1983; Spiegler, Morris & Liebert, 1968), other studies found no significant relationship between those two (Liebert & Morris, 1967; Morris & Liebert, 1970). Regarding the dimensions of MA and math performance, the affective component of MA has been found to negatively correlate with math performance more strongly than the cognitive factor of MA (Wigfield & Meece, 1988). Furthermore, the affective factor of MA also seems to correlate negatively with the children’s perceptions and expectations about their math ability and with the math performance more strongly than the cognitive factor. Furthermore, the cognitive factor of MA has been found to correlate positively with the importance that children give to math and with the ratings of the effort attributed to math (Wigfield & Meece, 1988). In one study on 672 sixth-grade students across three nations regarding China, Taiwan, and the U.S., the findings showed that the affective factor of MA was strongly and negatively correlated to math performance in all three nations, whereas the cognitive factor brought inconsistent results across the national samples (Ho, Senturk, Lam, Zimmer, Hong, Okamoto, & Chiu, 2000). That is, this relation was no significant for the sample from China and the U.S., whereas there was a slight positive correlation between the cognitive MA and math performance in the Taiwanese sample (Ho, Senturk, Lam, Zimmer, Hong, Okamoto, & Chiu, 2000). That suggests that in that sample the cognitive worry factor may have the role of the motivator (Ho, Senturk, Lam, Zimmer, Hong, Okamoto, & Chiu, 2000).

Regarding other types of anxiety which correlate with MA, test and general anxiety are discussed. Test anxiety regards the anxiety in test situations, such as when taking a math test, and it is usually assessed with “The Children’s Test Anxiety Scale” (Wren & Benson, 2004) which is a 30-item questionnaire about children’s thoughts and automatic reactions in the situations of taking the math test. The results score from 30 to 120, and the questionnaire has adequate reliability and validity (Wren & Benson, 2004). Other contemporary measures of the test anxiety are “Reactions to Tests Questionnaire” (Sarason, 1984), and “Test Anxiety Inventory” (TAI; Spielberger, 1980) which measures different components of test anxiety during and after examinations. Nevertheless, it is important not to use the term test anxiety as interchangeably with the math anxiety, or with the other similar type of anxiety which is the achievement anxiety. Test anxiety refers to anxiety in any test situation, while the math anxiety is a subject specific anxiety and it refers to both math tests and math learning process (Ashcraft, 2002). On the other hand, the achievement anxiety in typical for situations that imply the possibility of failure, but they are not necessarily test-taking situations, such as the anxiety that one might experience in competitive sports (Pekrun, 2001).

General anxiety regards an individual’s tendency to feel anxious about everyday situations, and involves psychological anxiety, worry, and social anxiety. It is usually measured with the “Revised Children’s Manifest Anxiety Scale- Second Edition” (Reynolds & Richmond, 2008) which is a 10-item abbreviated questionnaire that origins from a 49-item questionnaire and measures all these three areas. Furthermore, MA correlates with the test anxiety with the Pearson’s coefficient between .30 and .50 (Ashcraft et al., 1998; Hembree, 1990) and about .35 with the general anxiety (Hembree, 1990). Thus, general anxiety is less correlated with MA when compared with the test anxiety (Hembree, 1990). In particular, test anxiety and MA are more likely to share similar risk factors, for instance, those which ground in the fear towards experiences of school and achievement. A part of being correlated with math performance with the Person's coefficient between -.29 and -.34 (Hembree, 1990; Ma, 1999), the studies showed that MA is also negatively correlated with reading performance with the Person's coefficient equal to -.17 (Hembree, 1990; Ma, 1999). Reading performance was assessed with the "Hodder Group Reading Tests II" (HGRT-II; Vincent & Crumpler, 2007) which includes the multi-choice and free choice items assessing children's understanding of words, sentences, and passages.

Regarding different anxiety forms related to gender, a study that assessed 1720 UK students (age groups: 8-9 and 11-13) showed that girls are more likely to be in high anxiety profiles when compared with their male peers (Carey, Devine, Hill, & Szücs, 2017). Moreover, girls experienced higher levels of academic anxiety than boys, however, boys showed to be more likely to be categorized in the high-test anxiety and MA profile compared to their general anxiety level. In other words, girls who fall into the high academic anxiety profile often develop it because of their general predisposition to anxiety, while boys showed to develop high levels of academic anxiety without having the predisposition towards the general anxiety. When the anxiety profile and age were considered, children who were 8 and 9 years old performed worst in math and reading when they were categorized into the high anxiety profile. On the other hand, students aged 11-13 demonstrated the more complex relationship between the anxiety profiles and math-and-reading performance. Additionally, these students had higher math and reading performance that would have been predicted just by their MA profile (Carey, Devine, Hill, & Szücs, 2017).

In conclusion, MA and test anxiety are both divided into two dimensions or components named affective and cognitive dimension (Bandalos et al., 1995; Liebert & Morris, 1967; Meece, Wigfield & Eccles, 1990; Wigfield & Meece 1988), and they correlate differently with math performance (Deffenbacher, 1978; Wigfield & Meece, 1988; Wine, 1971). Regarding MA and other forms of anxiety, individuals with high levels of MA are more likely to also present other anxiety forms such as general and test anxiety and to have lower math performance when compared with the students with low MA (Carey, Devine, Hill, & Szücs, 2017). Math anxiety correlates with both test and general anxiety, and because of this relationship it is important to investigate the subgroups of students who present different forms of anxiety (Carey, Devine, Hill, & Szücs, 2017). That would provide a greater insight into different anxiety forms and its developmental changes, greater knowledge about the mechanisms of the relationship between MA and math performance, and consequently, the insight into the specific interventions for students who present different profiles of MA or those with other forms of anxiety (Carey, Devine, Hill, & Szücs, 2017).

4.4 Sources of Math Anxiety and Poor Math Performance

Gender differences in math performance develop by the third grade of elementary school and the stereotype threat which increases MA is usually the explanation of the gender gap observed in math performance (Fryer & Levitt, 2010; Penner & Paret, 2008; Robinson & Lubienski, 2011; Spencer, Steele, & Quinn, 1999). The question that arises is which are the sources of MA? Studies in this field found different possible antecedents of MA which make a person more likely to develop the feeling of fear and tension towards mathematics. Research usually takes in consideration the following factors: socio-economic status of parents, parents' and teachers' attitudes towards math and their own MA, classroom climate and testing environment, previous math experiences of success or failure, self-efficacy and self-concept, general anxiety, genetics, culture and nationality, and the variables such as age, gender, academic achievement, and working-memory capacity.

- Socio-economic status of parents

Regarding the socio-economic status of parents and MA, research usually takes in consideration parents' income, profession, and educational level. Studies showed that MA is affected by the family income and parents' educational level (Geyik, 2015). Moreover, the negative correlation between MA and socio-economic status of parents was found in different studies worldwide (Adimoraa, Nwokennab, Omejec, & Ezed, 2015; Geyik, 2015). However, differences in MA related to socio-economic status are less pronounced than differences in MA related to gender (OECD, PISA 2012). These differences are particularly wide in following countries: Greece, Bulgaria, Denmark, Singapore, and Lichtenstein (OECD, PISA, 2012). Regarding MA and socio-economic status, 81% of economically disadvantaged students reported worries that it will be difficult for them to attend math classes compared with just 63% of advantaged students who reported the same (OECD, PISA 2012). Moreover, 46% of economically disadvantaged students reported getting very tense when doing math homework compared with 25% of economically advantaged students who reported the same (OECD, PISA 2012). Furthermore, in Singapore 70% of economically disadvantaged students and 49%

of advantaged students reported worries about having difficulties in math classes (OECD, PISA 2012). In addition, 47% of economically disadvantaged students and just 28% of advantaged students reported to feel nervous when doing math problems, and 47% of disadvantaged students and 23% of advantaged students reported getting tense when doing math homework (OECD, PISA 2012). Furthermore, the socio-economic status of parents is not the only one to affect the math performance, but that is also true for the economic position of the country in which the person lives (Chiu & Xihua, 2008).

- Parents' and teachers' attitudes towards math and their own MA levels

Developmental theory and empirical evidence suggest that parental attitudes and their gender stereotypes about mathematics have the important influence on children's academic attitudes, performance, and beliefs, especially in math domain (Eccles, 2006). Parents and teachers represent the role models for children, and their attitudes and beliefs about the ability in mathematics may indirectly influence on the students' MA, and therefore on their math performance (Beilock, Gunderson, Ramirez, & Levine, 2010). Social influences such as social pressure, stereotypes, expectations, and parents' and teachers' quantity and quality of teaching support and math input may all affect math performance and development of MA (Soni & Kumari, 2015). Furthermore, it seems that this influence is particularly important at the very beginning of school experience, the period in which children develop their interests and form beliefs about their competence in different school subjects (Nicholls, 1978). Parents have an important influence on their children, especially in the earliest school years, and they may reinforce the beliefs about math gender stereotypes also with explicit messages such as the comments about gender differences in math ability. Implicit messages can have the same effect as well, for instance, purchasing more games or materials related to math and science for sons than for daughters (Jacobs & Bleeker, 2004). Also, interaction with children while they are doing their math homework can elicit the same effect (Bhanot & Jovanović, 2005; Lindberg, Hyde, & Hirsch, 2008). Furthermore, the study showed that parents who endorse math gender stereotypes have lower perception of competence and lower expectations of success in mathematics for their daughters than for their sons, independently of their actual grades in mathematics (Jacobs & Eccles, 1992). The study also found that parents' math gender stereotypes have important consequences on their children. Furthermore, when mothers endorse the math gender stereotype that affected their children's self-perception of math ability, interest in subject, and math achievement (Jacobs & Eccles, 1992). Moreover, the girls whose mothers believed in math gender stereotypes suffered from the performance decrement under the stereotype threat, while the stereotype threat had no significant effect on the girls whose mothers did not believe in math gender stereotypes (Tomasetto, Alparone, & Cadinu, 2011). Regarding the Italian study, both mothers and fathers did not strongly endorse math gender stereotype beliefs about the math ability, however, mothers had less math gender stereotypes (M = 2.22, SD = .80) than fathers (M = 2.45, SD = .85) (Tomasetto, Alparone, & Cadinu, 2011). In addition, studies showed the benefits of parents' home support in studying and doing homework such as parental involvement in math-related activities and expectations which may reduce MA (Vuković, Roberts, & Wright, 2013). Moreover, the benefits of parents' home support in doing homework may in some cases affect negatively the child's performance, such as in situations when parents are highly math-anxious which led to the increases of MA in these children (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015).

Regarding teachers' influence on the students' MA, studies showed that children are more likely to imitate behaviour and attitudes of the same-gender adults than the adults of the opposite gender (Bussey & Bandura, 1984; Perry & Bussey, 1979). The early elementary school teachers in the U.S. are almost exclusively female, with the teacher female rate about 90% (National Education Association, 2001). Furthermore, teacher represents a role model for children, and gender is highly salient feature especially at the early school age which makes girls more likely than boys to notice and have a negative impact of teacher's negative attitudes and fear about math (Steele, 2003). Moreover, the U.S. studies showed that children who interact with the high-math-anxious adults show poorer math performance than their peers (Beilock, Gunderson, Ramirez, & Levine, 2010). That was evident for both teachers' and parents' high MA levels. Therefore, the first graders with highly math-anxious teachers performed poorer in math over the school year than the students with the low math-anxious teachers. Those students showed greater knowledge of mathematics over the school year (Beilock, Gunderson, Ramirez, & Levine, 2010). Additionally, children with highly math-anxious parents showed poorer knowledge of mathematics than their peers with low math-anxious parents, but that was true only when parents were helping them in doing homework (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015). That shows that interaction moderates the relation between parents' MA and their children's math performance (Maloney, Ramirez, Gunderson, Levine, & Beilock, 2015).

- Classroom climate and testing environment

Students' perceived classroom climate or environment plays an important role in their math performance (Fast, Lewis, Bryant, Bocian, Cardullo, Rettig, & Hammond, 2010). Studies showed that students attending 4th to 6th grades who perceived their classroom climate as more caring, challenging, and mastery-oriented performed better in mathematics and have higher levels of math self-efficacy (Fast, Lewis, Bryant, Bocian, Cardullo, Rettig, & Hammond, 2010). The level of self-efficacy is important because it predicts the students' level of MA, which have a negative impact on math performance (Jameson, 2013). Moreover, competitive testing environment can create anxiety related to the math performance expectations (Ramirez & Beilock, 2011). That is particularly pronounced in the Asian countries with high academic expectations such as China, South Korean, and Japan (Stankov, 2010).

- Previous experiences of success or failure in mathematics

One of the factors which is often taken in consideration regarding MA is a previous experience of failure or threat about mathematics. That can be studied by asking students about their success on the math tests, and one of the indicators are the grades in mathematics referring students' actual math achievement. It is possible that MA and math beliefs are partially the product of students' previous performance in math, however, some studies showed that also the students who perform similarly in mathematics still choose different courses, educational pathways, and careers (Bong & Skaalvik, 2003; Wang, Eccles, & Kenny, 2013).

- Self-efficacy and self-concept

The term self-efficacy was firstly developed by Bandura (1977) and defined as the persons' belief that through their actions they can produce a desired effect which may be a powerful incentive to act or keep studying hard in the period of difficulties. Math self-efficacy refers to students' convictions that they can perform successfully on the academic tasks at designated level (Schunk, 1991). There is an important link between math performance and self-efficacy. Students' better performance in math leads to higher levels of self-efficacy, on the other hand, students who have low math self-efficacy tend to underperform in mathematics despite their real abilities (Bandura, 1997; Schunk & Pajares, 2009). Furthermore, math self-efficacy is strongly associated with math performance (OECD, PISA 2012). Countries in which students had on average higher math performance are those in which students reported more to feel confident about solving pure or applied mathematics problems (OECD, PISA 2012). When students have negative beliefs about completing successfully a math task that leads to the reduction of effort and their beliefs become the self-fulfilling prophecy. Moreover, those students are less likely to regulate their behaviour towards achievement or to be motivated and engaged in learning (Klassen & Usher, 2010; Schunk & Pajares, 2009). Self-efficacy seems to correlate significantly with gender and socio-economic status. On average across OECD countries, 67% of boys and only 44% of girls reported to feel confident about performing a math calculation (OECD, PISA 2012). Differences in self-efficacy levels are even strongly related to socio-economic status (OECD, PISA 2012). Economically disadvantaged students are generally less likely to feel confident about their math ability, and this remains statistically significant even when their real math performance was considered (OECD, PISA 2012). The correlation between math performance and self-efficacy is from moderate to strong in most countries, thus, between at least .30 and .50., and this relationship is relatively stable (OECD, PISA 2012). Lower correlation was found in just few countries such as Indonesia (.10 in 2003, and .17 in 2012), and Thailand (.24 in 2012) (PISA 2003, PISA 2012).

Self-concept is defined as a belief in own abilities, it is important outcome of education which is strongly related to successful learning (Marsh, 1986; Marsh & O'Mara, 2008). Students' math self-concept closely relates to the findings about self-efficacy and math performance (OECD, PISA 2012). Moreover, students with low math self-concept perform worst in mathematics than students who reported to be more confident in their own math abilities (OECD, PISA 2012). On average across OECD countries, 43% of students reported to agree or strongly agree with the statement that they are not good at mathematics (OECD, PISA 2012). There are also gender differences in math self-concept which were particularly pronounced in following countries: Switzerland, Denmark, Germany, Macao-China, Lichtenstein, Luxembourg, while no gender differences in math self-concept were found in Malaysia, Albania, and Kazakhstan (OECD, PISA 2012).

- Genetics and general anxiety (GA)

The genetically based differences in general anxiety contribute to genetic differences in MA (Wang et al., 2014). Studies found that there is a positive correlation between MA and general anxiety with the Person's coefficient about .35 (Wang et al., 2014). Furthermore, studies suggest that the genetic factor contribute to the experience of MA with about 40% of the variance, with the remain 60% given by the non-shared environmental factors (Wang et al., 2014). Studies conducted by Wang and colleagues (2014) on 514 twelve-year old twin pairs concluded that it is unlikely to find the genetic factors specific to MA. Furthermore, it is more likely that MA results from the combination of genetic predisposition associated with both general anxiety and mathematical cognition in the situations when a person is exposed to some negative experiences with math. Regarding anxiety levels and gender, the study showed that girls were more likely to be in the general anxiety and high anxiety profiles, whereas boys were more likely to be in the low anxiety and academic anxiety profiles (Carey, Devine, Hill, & Szücs, 2017).

- Culture and nationality

Math anxiety is a cross-cultural problem, still, the levels of MA experienced by students differ across countries (OECD, PISA 2012). The tendency of small children to like mathematics, and their deterioration of the attitudes with age seems to be common in different countries (Dowker, 2005; Ma & Kishor, 1997). However, MA levels, math performance, liking mathematics, attributing math success to effort or ability, and importance given to math are different across countries (Askew et al., 2010; Stevenson et al., 1990). It seems that the social pressure to do well in examination, which is different across countries, influences on MA and consequently on math performance (Tan & Yates, 2011). Additionally, that can also be related to the different educational systems and curricula across countries. Another reason that may reflect cultural and ethnic differences in MA refers to the ability to admit that one experiences MA, and to a different relationship between MA and math performance in different cultures (Catsambis, 1994; Lubienski, 2002). Studies showed that the ethnic minority of both U.S. and UK reported more positive attitudes towards math even if their math performance did not significantly differ from the performance of other students (Catsambis, 1994; Lubienski, 2002; National Audit Office, 2008). Furthermore, comparing Western European and Asian countries, there was a significant difference in reporting MA among students living in Europe and Asia. Children in high-achieving Asian countries such as Korea and Japan tend to show high MA when compared with high-achieving students in Western European countries such as Finland, the Netherlands, Lichtenstein, and Switzerland (Lee, 2009). These students reported significantly lower levels of MA (Lee, 2009). Furthermore, the gender gap in math performance was present in a different measure in several social contexts because of the different socio-economic position of the country and variety of gender equality indicators in different societies (Else-Quest, Hyde, & Linn, 2010; Guiso, Monte, Sapienza, & Zingales, 2008).

- Age

Different studies reported the contradictory results about the age in which a child starts to experience MA, however the common agreement is that 2nd to 3rd grade children can already experience high MA in the context when math performance is required (Young, 2012). Although MA is already present in early age, younger children still do not usually show a severe MA when compared with older children (Wu et al., 2012). Moreover, MA appears to increase with age during childhood, and the attitudes towards mathematics tend to change negatively as children get older (Dowker, 2005; Ma, Kishor, 1997; Mata et al., 2012). For instance, one study found that 2/3 of 11-year-olds rates mathematics as their favourite subject when compared with just few 16-year-olds who reported the same (Wigfield & Meece, 1988). One of the main explanations is that general anxiety appears to increase with age, likewise clinical anxiety disorders which have a pick in early adolescence (Kessler et al., 2005). It is possible that the increase in general anxiety reflects the lower math performance and higher MA. Another possible reason is that older children are more exposed to people's negative attitudes about mathematics such as social stereotypes regarding gender differences in math ability (Dowker, Sarkar, & Looi, 2016). In addition, with getting older negative experiences regarding failure in mathematics are likely to increase, and mathematics becomes more complex concerning bigger numbers that require higher demands including abstract non-numerical aspects (Dowker, Sarkar, & Looi, 2016).

- Gender

Concerning girls and boys and their MA levels, the research showed that girls are more likely to be placed in higher anxiety profiles, and boys are more likely to be in low anxiety profiles (Carey, Devine, Hill, & Szücs, 2017). Particularly, a study on 1720 students in the UK showed that girls were more likely to be placed into the general anxiety and high anxiety profiles, whereas boys were more frequently placed in the low anxiety and academic anxiety profiles (Carey, Devine, Hill, & Szücs, 2017). One of the main explanations for this difference in that the experience of anxiety is due to girls' general predisposition to anxiety and anxiety disorders. Thus, girls' academic anxiety often reflects their general anxiety, whereas boys' academic anxiety seems to develop without having the predisposition to general anxiety. Both general and academic anxiety were higher in girls, however, boys were more likely to be placed in the high academic anxiety profile relative to their general anxiety levels (Carey, Devine, Hill, & Szücs, 2017).

- Academic achievement and working-memory capacity

High-achieving students are more at risk to experience higher levels of MA (OECD, PISA 2012). The international study found that on average across OECD countries, a 1-point increase in math performance for students at the 90th percentile in math performance was associated with a larger decrease in math performance than for students who are at the 10th percentile (OECD, PISA, 2012). Thus, students with higher potential to succeed in mathematics are those with a greater risk of not reaching their full potential and success if they are math anxious (OECD, PISA 2012).

The working memory capacity is also associated with the experience of MA (Aschraft & Kirk, 2001). Math anxiety seems to impair the working memory resources, and that can result in failure or in the poor math performance. That is especially true in the case of difficult problems or the math exercises with the complex additional problems which require simultaneously to hold a group of letters in mind (Aschraft & Kirk, 2001). Moreover, studies showed that when high-working-memory students face anxious situations they tend to rely on inefficient strategies which are less demanding for the working memory or to make mistakes while trying to apply more advanced strategies (Ramirez, Chang, Maloney, Levine, & Beilock, 2016). Furthermore, one study showed that students with high working memory capacity and high MA learned less math over the school year in comparison with high-working memory and low-math anxiety students (Ramirez et al., 2013). On the other hand, MA seems to have no significant effect on math learning in the first and second grade students with low-working memory capacity (Ramirez et al., 2013; Vuković et al., 2013; Wang & Shah, 2014).

In conclusion, MA reduces the resources of working-memory necessary for short-term storage and manipulation of information (Miyake & Shah, 1999). The disruptive influence of MA on math performance has an important impact on learning and performing well in math (Beilock & Carr, 2005; Raghubar, Barnes, & Hecht, 2010). Comparing the math performance of high and low-working memory students, those with high working-memory capacity perform better in mathematics, however, the gap in performance between those groups is narrowed by MA (Ramirez et al., 2013).

4.5 International Findings Concerning Math Anxiety, Math Performance, and Math Attitudes

The international PISA survey carried out in 2012 found that the countries in which students reported higher levels of MA are also those with lower than average performance in mathematics (OECD, PISA 2012). On average across OECD countries the MA is associated with the decrease in math performance of 34 score points. In almost all countries of PISA survey girls reported higher MA than boys, except for the fallowing countries: Albania, Turkey, Bulgaria, Indonesia, Kazakhstan, Montenegro, Malaysia, Serbia, and Romania (OECD, PISA 2012). On the other hand, in Jordan, the United Arab Emirates, and Qatar boys reported to experience higher MA levels than girls. Furthermore, gender differences in MA tend to be particularly wide in Denmark, Finland, and Lichtenstein in which girls reported more than 20% higher levels of MA than their male peers (OECD, PISA 2012). There are differences in MA not related only to gender, but also to socio-economic status, but they resulted to be less pronounced than gender differences in MA (OECD, PISA 2012). Moreover, those differences tend to be particularly wide in Greece, Bulgaria, Denmark, Singapore, and Lichtenstein with socio-economically disadvantaged students reporting to feel higher levels of MA. For instance, the survey showed that in Greece 81% of economically disadvantaged students and only 63% of advantaged students reported worrying in mathematics classes (OECD, PISA 2012).

Regarding the international findings in science test scores, the PISA research carried out in 2015 showed that the highest mean scores in science were reached in Singapore (556), Japan (538), Estonia (534), Chinese Taipei (532), and Finland (531) (OECD, PISA 2015). The same countries had also the highest scores in the specific assessments of reading, math, and science. The PISA survey in 2015 assessed about 540 000 students who completed the evaluation in science, reading, mathematics, and collaborative problem solving as a minor area of assessment. There are two European countries at the top of the list in mean science scores which are Estonia and Finland. Estonia is in the first place in Europe with the mean science score of 534 and with the math score of 520 (OECD, PISA 2015). Furthermore, Finland was in the second place in Europe with the mean science score of 531 and math score of 511 (OECD, PISA 2015). Italy reached the mean science score of 481 which put it in the 34th

position across OECD countries with the math score of 490. Considering the overall PISA results in 2015, at about 20% of students did not reach the baseline of proficiency in reading and science. Moreover, the socio-economically disadvantaged students were three times more likely not to attain the baseline level in proficiency in science (OECD, PISA, 2015). Furthermore, the percentage of variation in science performance explained by students' socio-economic status was 12.9%, and in Italy was equal to 10% (OECD, PISA 2015). The countries which attainted the lowest PISA mean science scores are: Dominican Republic (332), Algeria (376), Kosovo (378), FYROM (384), Tunisia (386), Lebanon (386), Peru (397), Brazil (401), and Indonesia (403) (OECD, PISA, 2015).

Regarding the self-efficacy, the PISA survey in 2012 found that the math self-efficacy slightly increased across OECD countries between 2003 and 2012. In particular, the increase was found in Portugal, Germany, Thailand, Turkey, and Spain, whereas the decrease was in New Zeeland, Hungary, the Slovak Republic, and Uruguay (OECD, PISA 2012). Regarding the math self-efficacy related to gender, both boys' and girls' self-efficacy slightly increased between 2003 and 2012 (OECD, PISA 2012). In addition, self-efficacy increased in boys for the mean value of .08 units and in girls for .06 units. Across OECD countries, 67% of boys and 44% of girls reported to feel confident about math calculations, which shows that the gender gap in math self-efficacy is still present (OECD, PISA 2012). However, gender differences in math self-efficacy narrowed in the fallowing countries: Macao-China, the Slovak Republic, Greece, and Finland. The correlation between math self-efficacy and math performance was between moderate (at least .30) and strong (at least .50), and it remained relatively stable in the period between 2003 and 2012 (OECD, PISA 2012).

Math self-concept was also measured in the PISA survey (OECD, PISA 2012). On average across OECD countries, 43% of students reported to agree or strongly agree with the statement which said that they are not good at mathematics. Furthermore, 60% of students reported to learn math quickly in the fallowing countries: Jordan, the United Arab Emirates, Qatar, Kazakhstan, Singapore, the United States, and Costa Rica. On the other hand, fewer than 40% of students reported to learn math quickly in the fallowing countries: Chinese Taipei, Korea, Vietnam, and Japan (OECD, PISA 2012). Gender differences in math self-concept were particularly wide in Switzerland, Denmark, Germany, Macao-China, Lichtenstein, and Luxembourg. There were no significant gender differences in math self-concept in Malaysia, Albania, and Kazakhstan (OECD, PISA 2012).

Regarding school size and expectations about students' future career, students in larger schools scored higher in science and were more likely than students in smaller schools to work in science-related jobs in the future (OECD, PISA 2015). Moreover, students in smaller schools reported to experience better classroom climate during their science lectures, and those students were less likely to skip days of school or to arrive late for school after accounting for the socio-economic status (OECD, PISA 2015). The countries which are at the top of the list in skipping a day of school in two weeks prior the research were Montenegro, Italy, Uruguay, Slovak Republic, and Brazil. On the other hand, countries with lower number of skipped days of school were Japan, Korea, Chinese Taipei, Hong Kong, and Iceland (OECD, PISA 2015). Comparing the data from 2012 and 2015, the number of skipped days of school increased mostly in Colombia (39%), Montenegro (35%), and Slovak Republic (42%), whereas that percentage mostly decreased in the United Arab Emirates (-18%) (OECD, PISA 2015).

Regarding the number of students in the class, students in smaller classes reported more frequently the adjustment of their teachers to students' needs, knowledge, and level of understanding compared with that reported by students in bigger classes. Interestingly, regarding the number of science classes, students scored higher in science for every additional hour spent per week in the regular science lectures, but they tend to perform worst in science in the school systems in which students spend more time learning after school by doing homework, receiving additional instructions, or private study (OECD, PISA 2015).

4.6 Potential Treatments of Math Anxiety and Future Research

Considering MA and its important role in students' math performance, it is crucial to understand how MA can be treated, or even better, how MA can be prevented. That would be ideally to do in early childhood, before children start to experience MA. Although there are many studies about the MA, further research regarding the effectiveness of different strategies and early interventions is needed (Dowker, Sarkar, & Looi, 2016). Research should study not only how to reduce MA, but also the way to increase positive emotions towards mathematics (Dowker, Sarkar, & Looi, 2016).

These are some of the potential treatments of MA (Ashman, 2015; Cruikshank & Sheffield, 1992; Dowker, Sarkar, & Looi, 2016):

- Parents and teachers can model positive attitudes towards mathematics, and they can avoid expressing negative attitudes about maths in front of children. Even if this is one of the possible treatments for MA, this strategy can be difficult in the case when parents are highly anxious.
- Modelling positive attitudes towards mathematics can be achieved by using math in everyday life.
- Media can promote more mathematics as interesting and important.
- Teachers can provide math activities and establish attainable short-term goals that can be completed successfully.
- Frequent, short-term tests for both routine and non-routine problems can be used.
- Easy, but unfamiliar problems can be applied to build students' confidence.
- Teachers can develop alternatives to written tests such as observations.
- Systematic desensitization and cognitive behaviour therapy can be applied to reduce anxiety in general.
- The strategy named "writing out" (Ramirez & Beilock, 2011) regards writing down about one's worries prior of undertaking a math test was proofed to be beneficial for highly-anxious individuals (Ramirez & Beilock, 2011). This expressive writing which consists of writing down worries 10 minutes prior of the math test was beneficial exclusively for highly-anxious individual, whereas it did not have any beneficial effect for individuals with low MA. Furthermore, students in the expressive writing condition outperformed those in the control condition by 6%. This technic was grounded on the previous findings in which writing about traumatic events or highly emotional events

decreased rumination behaviour in people with clinical depression (Smyth, 1998). Additionally, the expressive writing seems to disrupt negative emotional cognitions and to allow students to focus on the math task instead of focusing on attendant anxiety (Ramirez & Beilock, 2011). Although this strategy has numerous beneficial effects, it was not tested in the situations with real math tests, therefore, these findings need to be verified.

- Intensive 8-week one-in-one math tutoring programme was developed to reduce MA (Supekar et al., 2015). This strategy regards three sessions of math tutoring of 40-50 minutes per week in children aged between 7 and 9 years old (Supekar et al., 2015). Children filled in the Scale for Early Mathematics Anxiety (Wu et al., 2012), and they also underwent the brain scan with the fMRI before and after the training. During the scanning children did the arithmetic problem-solving task and the number identification task (control task). The study found the beneficial effect of the relatively short and intensive one-on-one cognitive tutoring. The tutoring reduced MA through the modulation of neural functions. Furthermore, the fMRI scan showed changes in the functional response and connectivity in the emotion-related circuits associated with basolateral amygdala but just in children who previously expresses high MA.
- Non-invasive brain stimulation technic such as the transcranial electrical stimulation (tES) is the technic in which mild electrical currents are applied to scalp to increase or decrease the neural activity underneath the cortex. Particularly, the transcranial direct current stimulation (tDCS) is the most widely used form of tES. This neuromodulation technic is the non-invasive and painless technic that apply low direct current, usually between 1 mA and 2 mA, which is transmitted into cortical tissue through scalp-electrodes (Krause, Márquez-Ruiz & Cohen Kadosh, 2013; Krause & Cohen Kadosh, 2014; Nitsche et al., 2008). This technic is usually applied with 1mA for 30 minutes in the left and right dorsolateral prefrontal cortices to increase cognitive control and decrease negative emotions elicited by mathematics stimuli. At the same time, it can also be measured the change in the salivary cortisol (Sarkar et al., 2014). The findings suggest that the tDCS might be able to alleviate stress caused by MA, thus to improve math performance in students with high MA. Although the results suggest the beneficial effect of the tDCS in highly-anxious individuals, further research is needed to confirm the ecological validity applying the technic in real-life settings and examinations (Krause & Cohen Kadosh, 2014; Looi et al., 2016). Furthermore, future research should also investigate the effect of the tES on performance in difficult math tasks, because it

seems that the beneficial effect would be greater in the case of difficult tasks (Popescu et al., 2016).

The future research should investigate more the practical ways to improve understanding of mathematics among students. Some suggestions have been provided by the Irish Educational Research Centre in Dublin (Perkins & Shiel, 2016) such as:

- Making use of software linked to spatial reasoning, geometry, and functions.
- Engaging students in more technical subjects and courses to develop better girls' spatial relations skills.
- Encouraging students, especially higher-achieving girls, to engage more with more complex tasks to explore problem-solving in novel ways.
- Providing the opportunities to integrate concepts related to space and shape in other subjects such as geography (e.g., location of cities in relation to one another, map reading, latitude and longitude, time zones), history (sense of time in space, location, building, archaeology), science (properties of particles, shape related to natural phenomena), and literature (timescales, directions).

There are also other strategies provided by the Irish Educational Research Centre for the higher-achieving students such as:

- Providing the opportunities for students to engage more in complex novel problems and to explore different solutions also by using technology.
- Participation in activities such as Mathematics Olympiad and Maths Weeks or in other similar activities.
- Encouraging students to engage more in self-directed learning also by using different resources and developing short courses with the aim to provide those skills.
- Encouraging students to engage with interactive platforms, especially with the tasks related to space, shape, and rotation which may also broaden their understanding of other school subjects.
- Reassuring students to be more reflective about their mathematical thinking by applying more dialogical pedagogy in math classes and by arranging students to work in small groups to solve complex math problems.

Although there are numerous studies about MA and math performance, future research should also address some other aspects to expand knowledge in this field. It is crucial for the future research to integrate findings of behavioural, cognitive, and biological field. Furthermore, future studies should investigate the way in which different aspects of MA are related to one another such as social and neurological aspects and their change with children's age. Additionally, other studies concerning social influences on people are needed to focus not just on gender stereotypes, but also to other forms of social influences such as parents' and teachers' pressure regarding academic achievement. Also, motivational aspects should be studied, especially the relationship between MA and motivation, considering both intrinsic and extrinsic motivation and their connection with anxiety (Gottfried, 1982; Lepper, 1988; Ryan & Pintrich, 1997). In conclusion, longitudinal interdisciplinary interventions are needed to reduce the prevalence of MA among students.

Chapter 5−Original Research in Italy and Croatia

Overview

The present research aimed to study students' emotional components, memory and executive functions, math attitudes, and math performance. Particularly, emotional components regarded students' self-reported math and general anxiety, and other emotional and behavioural problems perceived by their teachers. Math attitudes concerned students' self-reported math self-esteem and self-concept, and math beliefs such as explicit math gender stereotypes, value attributed to math, self-perception of math-ability, and perceived math difficulty. The research was conducted in both Italy and Croatia to compare the possible differences of two cultural contexts in children attending 3rd and 5th grade of public elementary schools. Specifically, this cross-cultural comparison was mainly focused on the students' math attitudes, math self-esteem, and math performance.

There were five main goals of the present research project. The first goal was to investigate the relationship between emotional variables such as general anxiety, math anxiety, and other emotional and behavioural problems and math performance. The second goal was to observe whether there is a relationship between math performance and performance on the tasks of short-term memory, working memory, and executive functions. The third goal of the research was to study math performance in relation with math attitudes such as students' self-esteem and self-concept, especially math self-esteem, explicit math gender stereotypes, and the opinions about mathematics. The fourth goal was to observe whether there is a significant relationship between the students' emotional components, memory, executive functions, and their math attitudes. The fifth goal of the research was to investigate the possible cultural differences in math attitudes including also math self-esteem, and math performance in children attending school in Italy and Croatia.

Considering the main findings of the previous research in this field the hypotheses of the present research are:

- Math anxiety will be significantly negatively associated with math performance (Ashcraft, 1998, 2002; Fuers & Hitch, 2000; Gathercole & Pickering, 2000; Hembree, 1990; Hitch, 1978; Ma, 1999; OECD, PISA, 2012).
- General anxiety will be significantly negatively associated with math performance, but the association will be lower than between math anxiety and math performance (Wang et al., 2014).
- Better performance on tasks of memory and executive functions will be positively associated with higher math performance on math tests (Ashcraft & Kirk, 2001).
- Negatively oriented math beliefs and attitudes will be significantly associated with lower math performance (Bandura, 1997; Beilock, Gunderson, Ramirez, & Levine, 2010; Midke, Kozak, Foster, & Beilock, 2011; OECD, PISA, 2012; Schunk & Pajares, 2009; Soni & Kumari, 2005).
- Math anxiety will be significantly positively associated with negatively oriented math beliefs and attitudes (Goetz et al., 2010; Hembree, 1990; Hoffman, 1990; Jain & Dowson, 2009; Pajares & Miller, 1994).
- Math anxiety will be significantly negatively associated with the performance on the memory tasks and tasks of executive functions (Ashcraft et al., 1998; Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007).
- There will be significant gender and age-based differences in both math anxiety and math attitudes; girls will have higher levels of math anxiety than boys, and the 3rd graders will have lower levels of math anxiety and more positively oriented math beliefs and attitudes than the 5th graders (Carey, Devine, Hill, & Szücs, 2017; Dowker, Sarkar, & Looi, 2016; OECD, 2013; Wu et al., 2012).
- There will be significant differences in math attitudes and math performance in two countries due to different culture backgrounds and different teaching styles, the differences will especially regard the self-perception of math ability, math self-esteem, and perceived math difficulty (OECD, PISA, 2012).

5.1 Methods

5.1.1 Participants

The sample of the research was composed of 147 students attending five public elementary schools of the town of Trieste located in Northeaster Italy. Specifically, five classes of 3^{rd} graders and four classes of 5^{th} joined the research (see Table 1). Thirteen students were eliminated from statistical analyses, 12 of them due to learning disabilities and individualized educational programs, and one student was excluded because of emotional problems.

Other research was conducted in the northern Adriatic coast of Croatia on the island of Krk in the region of Primorsko-Goranska. The sample was composed of 79 students attending one public elementary school of the island of Krk. Specifically, two classes of 3^{rd} graders and two classes of 5^{th} graders joined the research (see Table 2). Two students were eliminated from statistical analyses, one due to autistic spectrum disorder and one because of intellectual disability.

Table 1

Number of participants, class attending, mean age, and standard deviation of the Italian sample

Grade	Number	Mean age
3^{rd}	70 (37 M, 33 F)	8.98 (*SD* = .42)
5^{th}	64 (31 M, 33 F)	11.05 (*SD* = .46)
Total	134 (68 M, 66 F)	9.97 (*SD* = 1.13)

Note. M indicates males and F indicates females

Table 2

Number of participants, class attending, mean age, and standard deviation of the Croatian sample

Grade	Number	Mean age
3^{rd}	45 (24 M, 21 F)	8.56 (*SD* = .50)
5^{th}	34 (16 M, 18 F)	10.62 (*SD* = .49)
Total	79 (40 M, 39 F)	9.44 (*SD* = 1.14)

Note. M indicates males and F indicates females

5.1.2 Procedure

Schools were informed about the research carried out by the Department of the Life Sciences of the University of Trieste named “Learning math and attitudes towards mathematics”. After the school principals approved the school’s adherence in the research project, professors were informed about the research. The informed consent was given to professors who decided to join the research, and it was afterwards administered to students. Only students who brought signed informed consent could participate in the research, which meant that the parent gave the permission that the child can participate in the research. Two collective and one 1-hour individual assessment was completed. Study 1 regarded a collective assessment with the whole class which included the administration of the self-report questionnaires measuring emotional components, and the questionnaire in which the teacher needed to asses each student regarding his/her emotional and behavioural problems.

Study 2 was a 1-hour individual assessment in which different measures of cognitive and executive functions were used. Study 3 was a collective assessment with the whole class, and it was related to the assessment of students’ self-esteem and their beliefs about mathematics, and the assessment of math performance with different time-limited math tests regarding math calculation and reasoning. Furthermore, also the data related to gender, class attended, and age was collected. All the teachers were informed that the feedback of main findings will be given respecting the privacy norms.

The research on the Croatian sample included some of the measures used in the Italian Study 3. Specifically, the goal was to investigate the relationship between students’ opinions about mathematics, explicit math gender stereotypes, and math self-esteem with math performance on different time-limited math tests of calculation and reasoning.

5.1.3 Measures

The fallowing instruments were used in Study 1:

1) The Abbreviated Math Anxiety Scale-Second edition (AMAS-2; Hopko, Mahadevan, Bare, & Hunt, 2003)

A 9-item self-report questionnaire is a popular and psychometrically validated measure of MA which uses a 5-point Likert-type scale. Recruiting a sample consisting of 1239 undergraduate students, a new questionnaire was created from the *Math Anxiety Rating Scale-Revised* (MARS-R; Plake & Parker, 1982). Factor loadings and screen-plot analyses were used to create a new measure, and the exploratory analysis was conducted on the AMAS-2 using principal components extractions with varimax rotation. Test-retest was applied in the interval of two weeks. The AMAS-2 ask people about their level of MA experienced ranged from 1 (*low anxiety*) to 5 (*high anxiety*). For instance, the items ask students about their level of anxiety experienced in different situations related to math lectures and math learning (e.g., use tables at the back of the math book; take examination in a math course; being given a "pop" quiz in a math class etc.). Internal consistency (α = .90) and test-retest reliability (r = .85) of the measure are strong. Furthermore, the AMAS-2 is abbreviated and more parsimonious measure of MA in comparison with the original instrument MARS-R from which it was adapted. It consists of two subscales named *Math Learning Anxiety* (5 items) and *Math Testing Anxiety* (4 items). The Italian version of the scale was administered to 1013 primary school students (51% males) who were recruited from three different cohorts (8-11 years old). Children attended Italian urban State-run schools in northern and central Italy (Caviola, Primi, Chiesi, & Mammarella, 2017). The validity of the Italian version of the AMAS-2 scale was respectively .83 for the subscale of the Math Learning Anxiety and .88 for the Math Testing Anxiety (Caviola, Primi, Chiesi, & Mammarella, 2017).

2) The Revised Children's Manifest Anxiety Scale-Second edition (RCMAS-2; Reynolds & Richmond, 2008)

The RCMAS-2 questionnaire is a 49-item self-report measure, one of the most commonly used measures to assess level and nature of anxiety experienced by children and adolescents aged from 6 to 19 years. It is used to assess anxiety for clinical (diagnosis and treatment evaluations) and research purposes, and in the educational setting. Furthermore, it is used to evaluate children for academic stress, test anxiety, peer/family conflicts, drug problems, but also to assess anxiety levels in the classroom or in other social situations. It is widely applied by educators, psychologist, counsellors, and other professionals who work with children. The RCMAS-2 is adapted from the original *Revised Children's Manifest Anxiety Scale* (RCMAS; Reynold & Richmond, 1985) which presentation was the most frequently cited article in the *Journal of Abnormal Child Psychology*. The standardized sample of the RCMAS-2 was composed of 2 368 individuals from the U.S aged between 6 and 19 years old (Reynold & Richmond, 1985). Scoring norms are divided into 3 age groups (6-8; 9-14; 15-19). Regarding psychometric properties, Cronbach's alpha value of the total score is .92, and the scale scores are between .75 and .86 (Reynold & Richmond, 1985). Furthermore, the abbreviated form of the RCMAS-2 scale has Cronbach's alpha value of .82. The fallowing six scales are included in the original RCMAS-2 questionnaire:

- *Physiological Anxiety* (PHY): it refers to somatic problems caused by anxiety such as feeling nausea, insomnia, headache, or tiredness (12 items);
- *Worry* (WOR): it refers to feel nervousness, fear, and being hypersensitive to environmental pressure. Worries are quite undefine and indicate fear of being heart or fear of social outcast (16 items);
- *Social Anxiety* (SOC): it refers to feel not valuable and not good enough in comparison with others. It includes situations in the social environment and those regarding performance (12 items);
- *Defensiveness* (DEF): it assesses whether a child can liberally admit having some imperfections in everyday life or he/she has defensive attitude towards imperfections (9 items);
- *Inconsistent Responding index* (INC): it is calculated based on the congruency of the answers given in the nine pairs of items, and together with the scores of the Defensiveness subscale indicates answers which are given without understanding the question, randomly, or missing answers. It can indicate child's incomprehension of the topic, uninterest, or some physical problems such as low visual acuity.
- *Total Anxiety* (TOT): it refers to the test scoring with the high scores in this test indicating high levels of anxiety. That can represent a variety of problems such as problems at school with school performance and early dropping out school, difficulties in the family, addictive behaviours, and eating disorders (40 items).

The RCMAS-2 reflects some changes when compared with the original RCMAS. The RCMAS-2 provides even more effective measure for understanding and treating anxiety in school-aged children. Furthermore, in the RCMAS-2 the scales of the Physiological Anxiety and Total Anxiety are the same as in the RCMAS, the Lie scale was renamed into the Defensiveness, the Worry/Oversensitivity scale was renamed into the Worry scale, and the Social Concerns/Concentration became the Social Anxiety scale. The RCMAS-2 added a new scale named the Inconsistent Responding Index. Additionally, double-negative phrasing in the Lie scale was replaced for better understanding in the Defensiveness scale, and the RCMAS-2 added the cluster of new items about the anxiety reflecting school performance. With those modifications the RCMAS-2 showed to be adapted to some changes in perception of children in the 21st century regarding their experience of anxiety, especially in the Social Anxiety subscale and using the items referring to the anxiety related to performance. The RCMAS-2 recognises students' concerns about the increased pressure to succeed in school. Furthermore, the second edition of RCMAS is available also in the short 10-item form, and there is also an audio CD available for the audio presentation of the RCMAS-2 items for children who have reading difficulties. The Italian version of the questionnaire was administered to 1344 students (635 males and 709 females) who attended primary and middle State-run schools in both northern and southern Italy (Scozzari, Sella, & Di Pietro, 2012). The subscales of the Italian version of the RCMAS-2 have the values of Cronbach's alpha between .68 and .89 (Scozzari, Sella, & Di Pietro, 2012).

In the present research the short form of the questionnaire was administered. The RCMAS-2 Short form consists of the first 10 items of the RCMAS-2 and it was used for the brief assessment of general anxiety in the sample of children attending elementary public school. Furthermore, the RCMAS-2 Short form consists of the Total Anxiety Scale, and other three scales which are Physiological Anxiety (2 items), Worry (4 items), and Social Anxiety (4 items). The short form represents a quick assessment with the yes/no form of items that can be completed in less than 5 minutes. The items are written for the second-year elementary students' readability level. The psychometric properties of the RCMAS-2 Short form were examined in the U.S. ethnically diverse sample of 1 003 elementary and secondary school students (Reynolds & Richmond, 2008).

3) Teacher's Report Form (TRF) for the age group 6-18 (TRF is the teacher version of the Child Behavior Checklist (CBCL), Achenbach, 2001; Frigerio, Cattaneo, Cataldo, Schiatti, Molteni, & Battaglia, 2004, Italian version)

The Teacher's Report Form (TRF) is a child behaviour checklist adapted for students aged from 6 to 18 years. It was created by Thomas M. Achenbach from the University of Vermont, "Research Center for Children, Youth, and Families" (U.S.) to assess behaviour of children and adolescents with the items including emotional, behavioural, and physical state. The original questionnaire is composed of 113 items and some additional questions about how well a teacher knows a child, how much time does he/she spend with a child in the class or service per week, about the evaluation of his/her school performance in each subject with the scale that range from 1 (*far below grade*) to 5 (*far above grade*), about most recently achieved test scores, how hard is he/she working, how appropriate is his/her behaviour, how much a student is learning, does a student have some disability, which are teacher's concerns about that student, and teacher is also asked to describe which are the best things about the particular student. Specifically, the TRF includes the following scales: withdrawal, somatic complaints, anxious/depressed, social problems, thought problems, attention problems, delinquent behaviour, aggressive behaviour, internalizing, and externalizing. The Italian version of the TRT was administered to 1464 teachers of children and adolescents attending 60 public schools and kindergartens, and one private kindergarten (Frigerio, Cattaneo, Cataldo, Schiatti, Molteni, & Battaglia, 2004). Children were between 4 and 18 years old, and they were coming from three randomly selected provinces (Milano, Como, and Lecco). In the Italian version of the questionnaire, Cronbach's alpha value ranged from .86 to .94 (Frigerio, Cattaneo, Cataldo, Schiatti, Molteni, & Battaglia, 2004).

In the present research the abbreviated form of the questionnaire was used with 14 items and the answer scale which included 0 (*not true as far as you know*), 1 (*somewhat or sometimes true*) to 2 (*very true or often true*). The additional questions were not included, and teachers were just asked to mark gender and class attended for each student. The following 14 items were used from the original questionnaire: 12, 14, 31, 32, 33, 34, 35, 45, 50, 52, 71, 89, 103, 112.

Study 2 concerned the individual administration that occurred about two weeks after the first meeting with children and concerned the following measures:

1) Wechsler Intelligence Scale for Children-Fourth edition (WISC-IV; Wechsler, 2003)

The Wechsler intelligence scales were developed by a Romanian-American clinical psychologist David Wechsler (1939) from the Bellevue hospital (U.S.) to measure intelligence performance. Since 1939 the scales were developed and revised for both adults and children. The WISC-IV is designed for children aged from 6 to 16 years and 11 months. The test includes 10 core and 5 additional subtests. These are summed into four following indexes:

- *Verbal Comprehension Index* (VCI): it measures verbal concept formation and it includes the test of Similarities, Vocabulary, Comprehension, and the additional tests of Information and Word Reasoning.
- *Perceptual Reasoning Index* (PRI): it measures non-verbal and fluid reasoning with the tests of Block Design, Picture Concepts, Matrix Reasoning, and the additional test is Picture Completion.
- *Working Memory Index* (WMI): it measures working memory with the tests including Digit Span, Letter-Number Sequencing, and the additional test is the Arithmetic.
- *Processing Speed Index* (PSI): it measures the speed of information processing with the tests of Coding and Symbol Search, and the additional test of Cancellation.

There is also one Full Scale IQ (FSIQ) which ranges from the lowest 40 to the highest 160 points. The subtests are given for the additional examination of processing abilities.

In the present research two tests of the Working Memory Index were used which are *Digit Span* and *Letter-Number Sequencing*. These tests assess children's ability to memorize new information, hold it in short-term memory, concentrate, and manipulate that information to produce some result or reasoning processes. That is important for higher-order thinking, learning, and achievement. Furthermore, the ability to perform well on these tests is related to concentration, planning ability, cognitive flexibility, sequencing skills, and it is also sensitive to anxiety. These abilities are crucial in the process of learning and achievement, but they are also important to work effectively with ideas presented in the school setting.

- Digit Span: it includes two parts, Digits forwards and Digits backwards

This test requires children to repeat 3-9 digits forwards and 2-9 digits backwards. It measures short-term memory, attention, and concentration.

- Letter-Number-Sequencing: it includes mixed series of numbers and letters

The test requires children to rearrange numbers and letters in the way that numbers come first, from the smallest to the biggest, after that, letters are arranged in the alphabetic order. A child receives a full credit also if he/she arranges letters followed by numbers, if the letters and numbers are correctly ordered. This test measures the working memory capacity which defines a person's ability to organize and manipulate two or more different verbal concepts in quick and accurate way. The accurate performance in this test is given by the student's ability to remember numbers and letters and to rearrange them following the instructions, which requires manipulation of information while remembering it.

2) The Developmental Neuropsychological Assessment-Second edition (NEPSY; Korkman, Kirk, & Kemp, 1998; NEPSY-II; Korkman, Kirk, & Kemp, 2007)

The NEPSY test represents a neuropsychological assessment of academic, social, and behavioural aspects and difficulties in children and adolescents. The test can be applied in clinical and school setting, and the test results can be used for diagnostic purposes and intervention planning in different developmental disorders. Furthermore, the test scorings can help in creating the appropriate Individual Education Plans (IEPs) in the case they are required, and to guide placement and intervention decisions. The NEPSY-II used in the present study contains substantial modification when compared with the original NEPSY (Korkman, Kirk, & Kemp, 1998). General changes in the NEPSY-II concerned the subtests (adding new one and dropping others), changes regarding administration, items, recording, scoring, and children's age for which the test is adapted. The NEPSY-II includes six domains:

- *Attention and Executive Functioning*: this domain contains the subtests of Animal Sorting, Auditory Attention and Response Set, Clocks, Design Fluency, Inhibition, and Statue. The test of Knock and Tap, Tower, and the Visual Attention were excluded from the second version of NEPSY. The Animal Sorting, Clocks, and Inhibition are the tests included just in the second edition of the NEPSY. The tests of this domain measure how well children can plan, organize, change, and control behaviour.

- *Language*: the tests of this domain measure how well children understand and use words and sentences to communicate with others. This domain contains the following tests: Body Part Naming and Identification, Comprehension of Instructions, Oro-motor Sequences, Phonological Processing, Repetition of Nonsense Words, Speeded Naming, and Word Generation.
- *Memory and Learning*: this domain includes the test of List Memory, List Memory Delayed, Memory for Designs, Memory for Designs Delayed, Memory for Faces, Memory for Faces Delayed, Memory for Names, Memory for Names Delayed, Narrative Memory, Sentence Repetition, and Word List Interference. The tests which are added in the NEPSY-II are Memory for Designs, Memory for Designs Delayed, and Word List Interference. These tests assess children' ability to memorize, store, and remember information.
- *Sensorimotor*: this domain includes tests of Finger Tapping, Imitating Hand Positions, Manual Motor Sequences, and Visuomotor Precision. The NEPSY-II excluded the Finger Discrimination test. The tests of this domain measure how well children control hand movements.
- *Social Perception*: this domain includes two subtests of Affect Recognition and Theory of Mind. They assess children's ability to understand other people's feelings and thoughts. Both tests were added in the NEPSY-II.
- *Visual Processing*: this domain includes the test of Arrows, Block Construction, Design Copying, Geometric Puzzles, Picture Puzzles, and Route Finding. The NEPSY-II added the test of Geometric Puzzles and Picture Puzzles. The tests of this domain measure how well children perceive and arrange visual information.

The test score classification can be divided into five categories:

- Above Expected Level: children with the test scores that fall within the range which is above 75% of their peers
- At Expected Level: children whose scores fall within the range which are equal to 50% of their peers
- Borderline: children with the test scores that fall into the range below than 75% of their peers.

- Below Expected Level: children with the test scores that fall into the range below than 90% of their peers.
- Well Below Expected Level: children whose scores fall into the range below than 98% of their peers.

In the present research three subtests from the domain of Attention and Executive Functioning were used:

- Design Fluency

In this test the child needs to connect two or more dots within arrays containing five dots each. There are 2 versions of the test that were used, and for each test version there is a 1-minute time limit. Before undertaking the test, a few examples were presented. The first version regards arrays with the systematic position of dots, while the second version of the test represents arrays with the non-ordinary position of dots. There were no modifications to this subtest from the first version of NEPSY published in 1998.

- Inhibition

In this test a child needs to look at the series of black and white shapes (Version 1), and black and white arrows (Version 2). The first version requires a child to name shapes (Condition 1 or Naming: circle or square), to alternate response (Condition 2 or Inhibition: to say circle when there is a square and vice versa), and to alternate response based on the colour of the shape (Condition 3 or Switching: to alternate response for the white shapes, but not for the black ones). The second version of the test requires a child to name the direction of the arrow (Condition 1: up or down), to alternate response (Condition 2: to say up when the arrow direction is down and vice versa), and to alternate response based on the colour (Condition 3: to say alternate response just for the white arrows, but not for the black arrows). After the instructions and examples were provided, a child is asked to answer quickly because of the time limit. The test takes in consideration the fallowing parameters: the total time, number of uncorrected errors, number of self-corrections, and total number of errors in the condition of Naming, switching total completion time which regards how quickly the task was completed (slower time = lower scaled scores), switching total errors made on task (more errors = lower % rank), switching uncorrected errors which regard the errors with no attempt to correct (more errors = lower % rank), and switching self-corrected errors about the errors that were self-corrected (more self-corrections = lower % rank) in the condition of Inhibition and Switching. The naming and inhibition scores (first and second condition) reflect executive functions, while the switching scores (third condition) concerns shifting attention. The test measures inhibition, verbal cognitive flexibility, and set shifting.

Low Inhibition Switching Combined scores integrates both error rates and completion time with more weight given to accuracy than speed. High scores on this task indicate good control of switching skills (shifting attention), and low scores could indicate very slow switching speed or poor control over switching behaviour. Error scores and time should be evaluated separately to determine the reason in the case of poor performance. Furthermore, slow switching time and low or average number of switching errors suggest that cognitive processing is slowed by switching demands. On the other hand, slow switching time and high number of switching errors suggest that switching demands may foster poor inhibition due to the impulsive approach. These results suggest that a child may have problems with impulsivity and cognitive flexibility. Furthermore, high uncorrected errors indicate that a child has poor self-monitoring skills, on the other hand, self-corrected errors reflect good self-monitoring behaviour. High rates of self-corrected errors indicate problems with controlling the shifting but with some compensatory self-monitoring behaviour.

The Inhibition subtest is the new subtest which was added in the NEPSY-II version and it has strong roots in the Stroop test (Stroop, 1935). There is a time limit of 3 minutes for the first and second test condition in both test versions (shapes/arrows), and 4 minutes for the third test condition.

- Animal Sorting

This test requires a child to sort eight cards into two groups of four cards using various self-initiated sorting criteria about what four cards have in common based on the image features and card patterns. The cards represent different animals in various contexts, and a child is presented with one example regarding a group of big and small animals in which the criterion of the group sorting is the animal size. Some of the possible card sorting criteria are weather on the image (sunny vs. rain), mountains on the image, water on the image, common vs. non-common animals, animals sitting or in movement, animals directed towards right or left, yellow vs. blue colour of the card, black frame of the cards vs. no frame on the cards, and other sorting criteria. There are 12 possible sorting criteria which are considered as correct answers with the maximum score of 12. There is also a possibility to add some new sorting criteria but only if the rule of four cards into one group is respected. The test considers as errors a repeated sorting criterion (including the example repetition), a new sorting criterion not respecting the rule of four cards, but also a new sorting criterion even if the rule of four cards in one group is respected. Just 12 criteria which are listed on the test scoring form are considered as correct answers.

This test evaluates children's ability to formulate basic concepts, transfer those concepts into action or categories, and to shift set from one concept to another. This sorting type of tasks is common in neuropsychological testing, but the thing that makes it different from other tests is that the Animal Sorting is adapted to evaluate children, so no reading is required to complete the task.

This test was developed during the first version of the NEPSY test, but it was not included in the final published version. Eventually, the test was included in the current NEPSY-II version as a new subtest with some modifications such as those concerning the reduction of categories. The test measures initiation, cognitive flexibility, self-monitoring, and conceptual knowledge. High number of errors can suggest idiosyncratic or immature reasoning, whereas high number of repeated sort errors can indicate poor cognitive flexibility and self-monitoring. A time limit for completing the task is 6 minutes. The test should not be administered if a child gives no answers within the first 2 minutes.

Study 3 included four questionnaires about self-esteem, explicit math-gender stereotypes, and beliefs about mathematics, and six questionnaires with time limited math exercises. The math exercises were adapted for children's age (3^{rd} and 5^{th} grade of the elementary school).

1) Explicit Math-Gender Stereotypes (Passolunghi & Tomasetto 2014, adapted from Muzzatti & Agnoli, 2007)

The Explicit Math-Gender Stereotypes Questionnaire is a self-report questionnaire composed of 20 items which are assessing the endorsement of explicit math gender stereotypes and beliefs and opinions about mathematics. There are four main purposes of the questionnaire: to measure the explicit gender stereotypes towards mathematics, value attributed to math, self-perception of math ability, and perceived math difficulty. Half of the items reflects the aim of the research, whereas the remaining 10 items were used to hide the real purpose of the research.

Those 10 items are about the opinions and beliefs concerning history lectures. All questions share the same form, they are closed-ended type of items, and children are asked to mark just one answer on the 5-point-Likert-type response scale. The main purposes of the questionnaire are:

a) Explicit Math-Gender Stereotypes

The items n. 6, 15, and 17 are assessing the explicit gender stereotypes towards mathematics. The questions ask students if in their opinion, in the opinion of their professors, and of their classmates, girls and boys are equal in mathematics 'ability or some of them is better at math. The responses range from 1 (*Girls are definitely better*) to 5 (*Boys are definitely better*). The score of "3" indicates a neutral answer, the opinion of gender equality in math performance. In addition, higher score is gender stereotypic, whereas lower score implies the opinions which are opponent of the typical math gender stereotypes. The internal consistency of three items of the subscale is satisfactory (Cronbach's alpha = .82).

b) Value Attributed to Math

The items n. 2, 9, and 19 are measuring the value attributed to mathematics. Those three items ask students if they like mathematics, if studying math will be useful for them one day, and if for them is important to be good at math. Higher score indicates high value attributed to mathematics, whereas lower score indicates low value attributed to math. The internal consistency of Cronbach's alpha is equal to .66.

c) Self-perception of Math Ability

The items n. 7 and 12 are assessing the self-confidence in math. The items ask students if they think that they are good at math, and if their parents and teachers think that they are good at math. Higher score indicates high self-confidence, whereas lower score indicates low self-confidence towards mathematics. The item-item correlation value is satisfactory (r = .74).

d) Perceived Math Difficulty

The items n. 4 and 13 are measuring the perceived difficulty of math and the experiences associated with mathematics. Students are asked how difficult for them is mathematics, and if they have positive experiences related to math lectures. Higher score indicates low difficulty perceived in math and positive experiences related to mathematics.

2) Multidimensional Self-concept Scale (MSCS; Bracken, 1992, 2003);

The MSCS is a questionnaire composed of 6 components, and each component includes 25 items. Overall, it assesses self-concept with its different dimensions because of the background idea of different dimensions involved in formation of the global self-concept (Figure 1). The questionnaire has the hierarchic structure, and it is based on assumption that the central component is the overall self-concept, while 6 components are interrelated and overlapping (Bracken, 1992). The following components are included in the MSCS questionnaire:

Interpersonal relationships: it refers to social interactions of children and adolescents with different ability to interact with other people and to obtain different reactions. The awareness of being loved and accepted by peers creates an important role for self-concept and self-esteem.

Competence of environmental control: it refers to success or failure in solving problems, obtaining goals, determining the desirable situations, functioning effectively, and obtaining the environmental control.

Emotionality: it refers to the capacity to recognize, assess, describe, and control emotions. That ability develops with age when the emotional reactions stabilized. In the period of growing up the emotional reactions are often instable, and they can go from the excitement to depression, which may influence the school performance.

Academic success: it refers to the self-assessment of academic performance and experiences in the school setting. School is the place in which children and adolescents spend most of their time. It is the place where they become aware of their ability to maintain attention and reach their goals. Furthermore, they develop interest towards certain subjects, and start to be aware of difficulties in other subjects comparing themselves with peers and receiving feedback from classmates, professors, and other adults.

Family life: it refers to the child's self-perception in relation to people that he/she depends on. A family represents a safe base, and when a child does not have stable family relationships, he/she may be more likely to be afraid of new experiences and risks because child did not develop the feeling of acceptance and encouragement from the loved ones.

Bodily experience: it refers to the self-concept related to body perception which also depends on the direct and indirect feedback given by other people about the perception of our body. Acceptance of our own body is a crucial factor of self-concept and self-esteem, otherwise it can be a major cause of insecurity which have an impact on the social relationships.

In the present research two components of the MSCS questionnaire were used. Those two components are *Competence of environmental control* and *Academic success,* with each component including 25 items and a 4-point Likert-type scale with answers ranged from 1 (*Absolutely not true*) to 4 (*Absolutely true*). The MSCS questionnaire was standardized on the sample of 2501 children and adolescents (47% males) from 17 different places of the U.S. aged between 9 and 19 years old (Bracken, 1992). The questionnaire has considerable statistical properties with the internal consistency of Cronbach' alpha value higher of .96, and the test-retest reliability higher of .90. The Italian version of the questionnaire was standardized on the sample of 1062 students (561 males and 501 females) aged between 12 and 15 years, living in seven Italian regions in northern and southern Italy (Bergamini & Pedrabissi, 2003). The total value of Cronbach's alpha for the MSCS Italian version of the questionnaire is equal to .96, and all the subscales have Cronbach's alpha higher of .80. Specifically, two components used in this research which are Competence of environmental control and Academic success have respectively Cronbach's alpha value of .82 and .86.

In conclusion, the MSCS questionnaire is a quick tool to assess different dimensions of self-concept in children and adolescents following the framework of the hierarchical model of self-concept (Bracken, 1992, 2003). Furthermore, the MSCS is the questionnaire which allows us to understand the relationship between self-concept and other traditional psychological constructs, such as socio-emotional adaptation and personality when integrated with other personality tests or psycho-educational tests. The MSCS can be used for group assessment, or in other cases, for individual screening and diagnostic assessment.

Specific levels of self-concept coming from different contexts and/or dimensions					
Interpersonal relationships	Competence of environmental control	Emotivity	Academic success	Family	Bodily experience

↓

Formation of the global self-concept

Figure 1. The model of the interactive acquisition of self-concept

3) Self-esteem Questionnaire (Bandura, 1994)

A 10-item questionnaire measures students' perception about how good and how capable they are at math learning. Five items ask students about how good they are, and other 5 items ask them about how capable they are in different situations related to math learning process such as "How good are you at learning math?"; "How good are you at problem-solving?"; "How capable are you at doing your homework?"; "How capable are you at maintaining the concentration in math learning when there are other things to do?"). The questionnaire reflects the self-esteem related to mathematical learning and it contains also two items concerning child's capability related to the general school contexts such as organisation of school activities and interest in subjects studied at school.

4) Number Sense (Cornoldi, Mammarella, & Caviola, in press)

Children were provided with instructions and 3 examples before undertaking this math test. The test requires children to mark the biggest number in the serious of 3 or 4 numbers. All the students need to complete 12 exercises within a minute. For the 3rd grade the exercises included 3-and-4-digit numbers and decimals. For the 5th grade the test included also the numbers with 7 digits, fractions, and decimal numbers. This test was used just to introduce the topic to the students, and it is was not part of either calculation or reasoning tests.

5) Approximate Calculation (Cornoldi, Mammarella, & Caviola, in press)

This math test is a part of calculation tests and it includes 15 exercises for both 3rd and 5th grade of elementary school. The time limit for both 3rd and 5th graders was 1.30 minutes. The test for the 3rd and 5th graders included addictions, subtractions, and multiplications with 1-2 digit-numbers for the 3rd grade, and for the 5th grade up to 3 digit-numbers. The maximum score in this test is 15 for both 3rd and 5th grade.

6) Fluency (Cornoldi, Mammarella, & Caviola, in press)

The test of math fluency is a part of calculation tests and it includes the assessment with 15 addictions of 2-digit numbers for the 3rd graders, and 15 exercises for the 5th graders to be completed within a minute for both 3rd and 5th graders. Furthermore, the test adapted for the 5th grade included 7 addictions with 3-digit numbers and decimals, 5 subtractions with 2-3-digit numbers, and 3 multiplications with 1-2-digit numbers. The maximum score on this test is 15 for both 3rd and 5th grade.

7) Matrix (Cornoldi, Mammarella, & Caviola, in press)

This test requires children logical reasoning to complete an empty box of the grid which fallows two possible logical rules including numbers in the row or in the column of the grid. The test adapted for the 3rd grade requires children to complete 12 grids (2x2; 2x3) including 1-2-digit numbers within 2 minutes. The test for the 5th grade included 12 grids (2x2; 2x3) with 1-and-2-digit numbers to complete within 2 minutes. The maximum score on this test is 12 for both 3rd and 5th graders.

8) Inferences (Cornoldi, Mammarella, & Caviola, in press)

The test is a part of logical reasoning and it includes 3 types of exercises which are logical reasoning with images, math operations, and inferences with calculations. The first type includes different images (lollipops, sweets, flowers, leaves, socks, forks etc.), and the test requires students to calculate the value of requested images fallowing logical reasoning. The second type of the exercises requires students to complete the missing operation in the parenthesis (+; -; x; :) so the given result is true. The third type of the exercises requires students to write the results of the operations given on the left side of the test fallowing the logical reasoning of the already completed operations on the right part of the test. The operations already calculated on the right side of the test were a cue for the operations to be done on the left side of the test, so the test did not require students to calculate the results, but to complete it fallowing the logical reasoning (e.g., 390:15 = ?; given on the right part of the test 26x15 = 390). The test adapted for the 3rd graders includes 3 examples of each type of exercises to complete before undertaking the real test. The real test contains 3 exercises with images, 3 with math operations, and 2 with calculations fallowing logical reasoning which were administered all together and children have 1.30 minutes to complete the test. The test for the 5th graders includes 4 images within 1 minute of time. The other 2 parts of the test were administered together, and they included 4 math operations and 4 calculations to complete together within 1 minute after completing the examples. The maximum score on this test is 8 for the 3rd grade and 11 for the 5th grade.

9) Written Calculation (AC-MT 6-11; Cornoldi, Lucangeli, & Bellina, 2002, 2012)

This test evaluates the abilities of calculation and problem-solving. The new edition of the test includes math exercises adapted for the 3rd, 4th and 5th grade of elementary school, and math exercises adapted for middle school. The test is useful for both professors and psychologist, and it is quick to administer. In the present research the arithmetic part of written calculations was administered. The test includes 8 operations adapted for students' age. For the 3rd grade the test includes 2 additions and 2 subtractions with 2-digit numbers, 2 multiplications with 1-and-2-digit numbers, and 2 divisions with 1-and 2-digit numbers. For the 5th grade the test includes 2 additions with 3-4-digit numbers and decimal numbers, 2 subtractions with 3-4-5-digit numbers and decimals, 2 multiplications with 1-2-3-4-digit numbers, and 2 divisions with 1-2-and-4-digit numbers. The maximum score that one can get in this test is 8. Scores are classified in four categories and that depends on the number of correct exercises adapted for students' age. The score of 8 is classified as optimal score, from 6 to 7 is good enough, from 4 to 5 requests the attention of professionals, and the scores from 0 to 3 requests the professional intervention.

The research on the Croatian sample included the Explicit Math Gender Stereotypes Questionnaire (Passolunghi & Tomasetto 2014, adapted from Muzzatti & Agnoli, 2007), Self-esteem Questionnaire (Bandura, 1994), and the math tests of Approximate Calculation (Cornoldi, Mammarella, & Caviola, in press), Fluency (Cornoldi, Mammarella, & Caviola, in press), Matrix (Cornoldi, Mammarella, & Caviola, in press), and Inferences (Cornoldi, Mammarella, & Caviola, in press). The math tests were adapted for students' age. Approximate

Calculation and Fluency are tests of math calculation whereas Matrix and Inferences are math reasoning tests.

5.2 Results

5.2.1 *Scale Reliability*

The measures used in the present research have the values of Cronbach's alpha coefficient ranged between those considered unacceptable ($\alpha < .50$) to those considered excellent ($\alpha > .90$). Most of the measures have Cronbach's alpha values which are acceptable and good indicators of the scale reliability (see Table 3 and Table 4).

Table 3

Scale reliability of the measures in the Italian research

Measures	Cronbach's alpha coefficient
AMAS-2	.84
RCMAS-2-abbreviated	.78
Self-esteem questionnaire	.87
Explicit math gender stereotypes	.92
Value attributed to math	.48
Self-perception of math ability	.81
Perceived math difficulty	.64
MSCS 1	.91
MSCS 2	.89
TRF-abbreviated	.85
WISC-IV	.61
NEPSY-II	.57

Note. AMAS-2 is the acronym of the second edition of the Abbreviated Math Anxiety Scale, RCMAS-2 is the second edition of the Revised Children's Manifest Anxiety Scale, Self-esteem Questionnaire measures math and general self-esteem, Explicit math gender stereotypes, Value attributed to math, Self-perception of math ability, and Perceived math difficulty are the subscales of the Explicit Math Gender Stereotypes Questionnaire (Passolunghi & Tomasetto, 2014), MSCS 1 and MSCS 2 are the Multidimensional Self-concept Scale (the part of the Competence of the environmental control and the Academic success), the TRF is the Teacher's Report Form- abbreviated version, WISC-IV states for Wechsler Intelligence Scale for Children-fourth edition, NEPSY-II is the Developmental Neuropsychological Assessment-second edition

Table 4

Scale reliability of the math tests in the Italian research

Measures	Cronbach's alpha coefficient
Number Sense (3rd grade)	.81
Number Sense (5th grade)	.78
Approximate Calculation (3rd grade)	.72
Approximate Calculation (5th grade)	.71
Fluency (3rd grade)	.82
Fluency (5th grade)	.67
Matrix (3rd grade)	.81
Matrix (5th grade)	.86
Interferences (3rd grade)	.76
Interferences (5th grade)	.77
Written Calculation (3rd grade)	.53
Written Calculation (5th grade)	.56

Note. Number Sense, Approximate Calculation, Fluency, Matrix, Interferences, and Written Calculation are the math tests adapted for the 3rd and 5th graders

The scale reliability of the measures used in the Croatian research has the values of Cronbach’s alpha coefficient ranged from acceptable levels (α > .60) to good levels of Cronbach’s alpha (α > .80) (see Table 5 and Table 6).

Table 5

Scale reliability of the measures in the Croatian research

Measures	Cronbach’s alpha coefficient
Self-esteem questionnaire	.74
Explicit math gender stereotypes	.61
Value attributed to math	.70
Self-perception of math ability	.67
Perceived math difficulty	.85

Note. Self-esteem Questionnaire measures math and general self-esteem, Explicit math gender stereotypes, Value attributed to math, Self-perception of math ability, and Perceived math difficulty are the subscales of the Explicit Math Gender Stereotypes Questionnaire (Passolunghi & Tomasetto, 2014)

Table 6

Scale reliability of the math tests in the Croatian research

Measures	Cronbach’s alpha coefficient
Approximate Calculation (3rd grade)	.66
Approximate Calculation (5th grade)	.65
Fluency (3rd grade)	.70
Fluency (5th grade)	.80
Matrix (3rd grade)	.84
Matrix (5th grade)	.83
Interferences (3rd grade)	.71
Interferences (5th grade)	.65

Note. Approximate Calculation, Fluency, Matrix, and Interferences are the math tests adapted for the 3rd and 5th graders

5.2.2 *Main results from Italian studies*

Study 1–Emotional variables and their relationship with math performance

The Student's t statistical analysis (*t*-test) was applied to compare whether there is a statistically significant difference between male and female students in the mean scores of the measures used in Study 1. The analyses did not find the statistically significant difference either for the mean scores of the AMAS-2 or for the RCMAS-2. Regarding the subscales of the RCMAS-2 abbreviated version, a *t*-test did not find a statistically significant difference in the mean scores in any of three subscales which are Physiological Anxiety, Worry, and Social Anxiety when controlling for gender and class attended.

Furthermore, a *t*-test was used to verify whether there is a difference between the 3rd graders and 5th graders in math anxiety and general anxiety. The results did not find a statistically significant difference related to children's age. Considering a correlational analysis of the anxiety measures on the entire sample, the measure of the math anxiety (AMAS-2) and the measure of the general anxiety (RCMAS-2) are significantly positively correlated ($r = .33$, $p < .001$). Furthermore, a correlational analysis on the 3rd graders did not result significant for AMAS-2 and RCMAS-2. There were also no statistically significant correlations either between anxiety measures and math performance on different math tests or when the tests were divided into the calculation and reasoning tests.

Regarding the students attending the 5th grade, a correlational analysis between AMAS-2 and RCMAS-2 questionnaire was statistically significant ($r = .47$, $p < .001$). Furthermore, differently from the younger students attending the 3rd grade, as showed in Table 7, in the 5th graders the AMAS-2 is significantly negatively correlated with the performance on both types of math tests which are calculation ($r = -.41$, $p = .001$) and reasoning tests ($r = -.26$, $p = .042$). Specifically, the profile of the high math anxiety was negatively correlated with the performance on some math tests such as Written Calculation ($r = -.46$, $p < .001$), Fluency ($r = -.41$, $p = .001$), Interferences ($r = -.27$, $p = .034$), and Approximate Calculation ($r = -.26$, $p = .036$). On the other hand, the RCMAS-2 did not significantly correlate either with the calculation ($r = -.039$, $p = .757$) or with the reasoning math tests ($r = .029$, $p = .817$). Furthermore, hierarchical regression analyses showed that in the 5th graders the AMAS-2 was a predictor of performance on both calculation ($R^2 = .21$, $F(3, 63) = 5.25$, $p = .003$, $\beta = -.53$, $t = -3.95$, $p < .001$) and reasoning tests ($R^2 = .21$, $F(3, 63) = 5.25$, $p = .003$, $\beta = -.43$, $t = -3.20$, $p = .002$).

Table 7

Correlations on the 5th graders in Study 1

		AMAS-2	RCMAS-2	Calculation	Reasoning
AMAS-2	Pearson Correlation	1	.466**	-.411**	-.255*
	Sig. (2-tailed)		.000	.001	.042
	N	64	64	64	64
RCMAS-2	Pearson Correlation	.466**	1	-.039	.029
	Sig. (2-tailed)	.000		.757	.817
	N	64	64	64	64
Calculation	Pearson Correlation	-.411**	-.039	1	.668**
	Sig. (2-tailed)	.001	.757		.000
	N	64	64	64	64
Reasoning	Pearson Correlation	-.255*	.029	.668**	1
	Sig. (2-tailed)	.042	.817	.000	
	N	64	64	64	64

Note. AMAS-2 indicates the second edition of the Abbreviated Math Anxiety Scale and RCMAS-2 indicates the second short edition of the Revised Children's Manifest Anxiety Scale.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

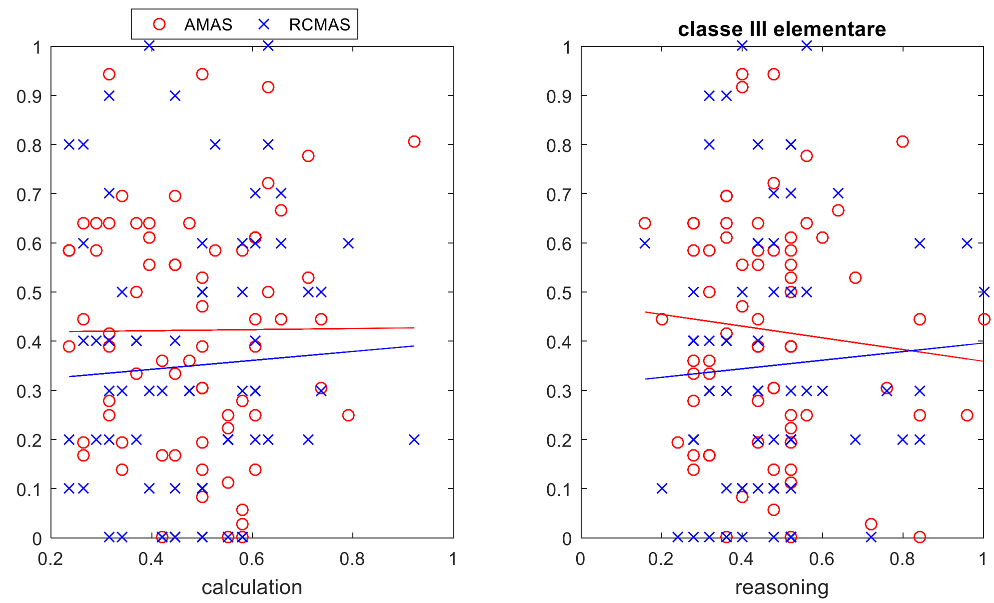

Figure 2. Relation between calculation, reasoning, and anxiety (AMAS-2, RCMAS-2) on the 3rd graders

All the parameters have been normalized between 0 and 1.

Table 8

Relationship between anxiety measures and math performance in the 3rd graders

Relationship	*m*	*q*	R^2	*p*
AMAS-2 vs. calculation	0.0111	0.4169	.0001	.9536
RCMAS-2 vs. calculation	0.0909	0.3064	.0024	.6841
AMAS-2 vs. reasoning	-0.1192	0.4783	.0077	.4715
RCMAS-2 vs. reasoning	0.0803	0.3089	.0030	.6518

Note. Values of the coefficients of the regression line *m* and *q*, coefficient of determination R^2, and *p*-value

All the regression lines showed that in the 3rd graders there is no significant relationship either between anxiety (AMAS-2 and RCMAS-2) and calculation or anxiety and reasoning (see Figure 2, Table 8).

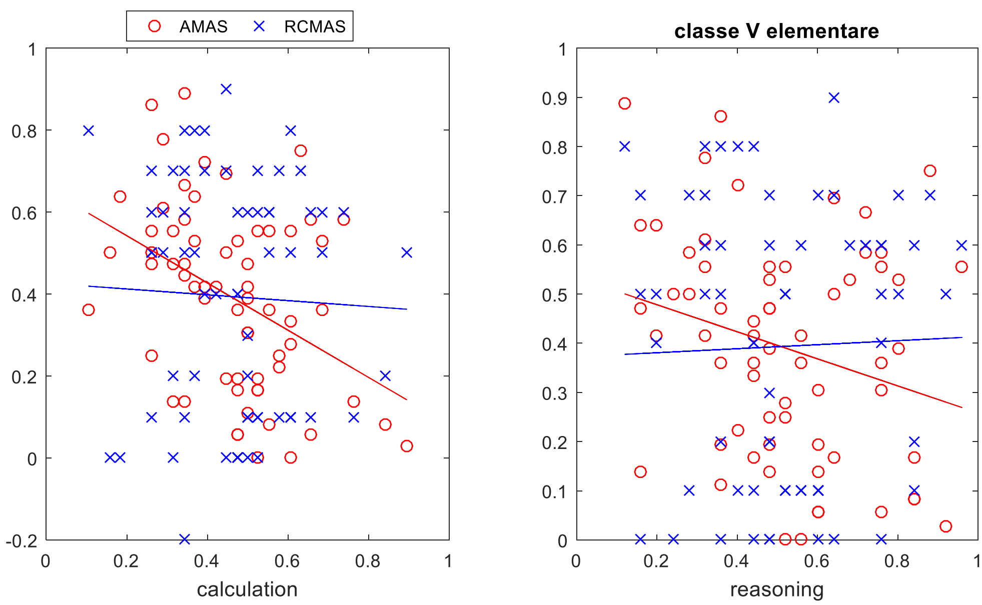

Figure 3. Relation between calculation, reasoning, and anxiety (AMAS-2, RCMAS-2) on the 5th graders

Table 9

Relationship between anxiety measures and math performance in the 5th graders

Relationship	*m*	*q*	R^2	*p*
AMAS-2 vs. calculation	-0.5762	0.6576	.1690	.0007**
RCMAS-2 vs. calculation	-0.0711	0.4267	.0015	.7574
AMAS-2 vs. reasoning	-0.2531	0.5333	.0652	.0417*
RCMAS-2 vs. reasoning	0.0408	0.3726	.0009	.8174

Note. Values of the coefficients of the regression line *m* and *q*, coefficient of determination R^2, and *p*-value

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

The regression lines showed a significant relationship just between AMAS-2 and calculation ($p < .001$ and $R = 41\%$ = modest relationship) and between AMAS-2 and reasoning ($p < .05$ and $R = 25\%$ = low relationship), but there is no significant relationship between RCMAS-2 with either calculation or reasoning tests (see Figure 3, Table 9).

The Teacher's Report Form-abbreviated version was used to assess students' emotional and behavioural problems estimated by their teachers/professors. Interestingly, there were no significant differences either for the behavioural and emotional problems of the students attending 3rd and 5th grade or between male and female students when the entire sample was considered. Furthermore, when considered just the students attending the 5th grade, there was a significant difference between the scores on the Teacher's Report Form for male and female students ($t = 2.23$, $p = .029$). Specifically, higher number of emotional and behavioural problems was attributed to male students (males: $M = 5.48$, $SD = 3.55$; females: $M = 3.51$, $SD = 3.48$). When just the 3rd graders were considered, the TRF did not have any significant correlation with the measures of Study 1 and Study 2. On the other hand, the scores on the TRF were significantly correlated with the math performance on both math calculation ($r = .29$, $p = .015$) and reasoning tests ($r = .25$, $p = .037$) administered in Study 3. Furthermore, the scores on the TRF were a predictor of math performance on both calculation ($\beta = .29$, $t = 2.51$, $p = .015$) and reasoning math tests ($\beta = 2.47$, $t = 2.09$, $p = .040$).

When considered just the sample of the students attending the 5th grade, the scores on the TBF were significantly positively correlated with the scores on the RCMAS-2 (r = .27, p = .031), and significantly negatively correlated with the Self-esteem Questionnaire (r = -.36, p = .003) and with the MSCS 2 questionnaire (r = -.29, p = .018). On the other hand, differently from the results of the 3rd graders, the scores on the TBF in the 5th graders were not significantly correlated with the math performance on calculation (r = -.11, p = .40) and reasoning math tests (r = .00, p = .99).

Anxiety in relationship with math attitudes

Pearson's correlation coefficient analyses (r) found a statistically significant correlation between the measures of anxiety and both self-esteem and beliefs about mathematics. Running the analyses on the entire sample, the AMAS-2 and the subscale of Self-perception of math ability of Explicit Math Gender Stereotypes Questionnaire resulted to be significantly negatively correlated (r = -.32, p < .001), whereas the AMAS-2 had a moderate positive correlation with the subscale of perceived math difficulty (r = .47, p < .001) (see Table 11). Regarding general anxiety, the RCMAS-2 was significantly negatively correlated with the self-perception of math ability (r = -.22, p = .011), and significantly positively correlated with the perception of math difficulty (r = .24, p = .005). When self-esteem and anxiety were considered, the Self-esteem Questionnaire resulted to be significantly negatively correlated with both measures of anxiety which are AMAS-2 (r = -.48, p < .001) and RCMAS-2 (r = -.34, p < .001). Furthermore, regarding the measures of the Multidimensional Self-concept Scale, the MSCS 1 (Competence of the Environmental Control) was significantly negatively correlated with both AMAS-2 (r = -.45, p < .001) and RCMAS-2 (r = -.40, p < .001). In addition, also the MSCS 2 (Academic Success) was negatively correlated with both measures of anxiety. Specifically, the MSCS 2 was significantly negatively correlated with the AMAS-2 (r = -.43, p < .001) and with the RCMAS-2 (r = -.39, p < .001) (see Table 10).

Table 10

Correlations between anxiety and self-esteem measures on the entire sample

		AMAS-2	RCMAS-2	QAUTO	MSCS1	MSCS2
AMAS-2	Pearson Correlation	1	.329**	-.476**	-.445**	-.431**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	134	134	133	134	134
RCMAS-2	Pearson Correlation	.329**	1	-.340**	-.402**	-.392**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	134	134	133	134	134
QAUTOC	Pearson Correlation	-.476**	-.340**	1	.528**	.566**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	133	133	133	133	133
MSCS1	Pearson Correlation	-.445**	-.402**	.528**	1	.767**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	134	134	133	134	134
MSCS2	Pearson Correlation	-.431**	-.392**	.566**	.767**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	134	134	133	134	134

Note. AMAS-2 is the second edition of the Abbreviated Math Anxiety Scale, RCMAS-2 is the second short version of the Revised Children's Manifest Anxiety Scale, QAUTO indicates the Self-esteem Questionnaire, MSCS 1 and MSCS 2 are respectively Competence of the Environmental Control and Academic Success of the Multidimensional Self-concept Scale.
** Correlation is significant at the 0.01 level (2-tailed).

Table 11

Correlations between anxiety measures and math attitudes on the entire sample

		AMAS-2	RCMAS-2	QESPMGS	QESPSP	QESPPMD
AMAS-2	Pearson Correlation	1	.329**	-.166	-.324**	.467**
	Sig. (2-tailed)		.000	.055	.000	.000
	N	134	134	134	134	134
RCMAS-2	Pearson Correlation	.329**	1	-.153	-.220*	.240**
	Sig. (2-tailed)	.000		.077	.011	.005
	N	134	134	134	134	134
QESPMGS	Pearson Correlation	-.166	-.153	1	.303**	-.314**
	Sig. (2-tailed)	.055	.077		.000	.000
	N	134	134	134	134	134
QESPSP	Pearson Correlation	-.324**	-.220*	.303**	1	-.568**
	Sig. (2-tailed)	.000	.011	.000		.000
	N	134	134	134	134	134
QESPPMD	Pearson Correlation	.467**	.240**	-.314**	-.568**	1
	Sig. (2-tailed)	.000	.005	.000	.000	
	N	134	134	134	134	134

Note. AMAS-2 indicates the second edition of the Abbreviated Math Anxiety Scale, RCMAS-2 is the second short edition of the Revised Children's Manifest Anxiety Scale, QESPMGS is the Explicit Math Gender Stereotypes Scale, QESPSP is the Self-perception of math ability scale, and QESPPMD indicates the Perceived Math Difficulty scale.

** Correlation is significant at the 0.01 level (2-tailed).

*Correlation is significant at the 0.05 level (2-tailed).

When the analyses were divided for the subgroups of 3rd and 5th graders the results confirmed the output that was generated with the analyses on the entire sample referring to math anxiety and the measures of self-esteem and beliefs about mathematics. However, differently from the 3rd graders in which the RCMAS-2 was negatively correlated with both Self-perception of math ability (r = -.28, p = .019) and Explicit math gender stereotypes (r = -.32, p = .006), in the students attending the 5th grade the RCMAS-2 was not significantly correlated with beliefs and stereotypes about mathematics.

Study 2‒Short-term memory, working memory, and executive functions

Regarding the measures of short-term memory, working memory, and executive functions included in Study 2, there is no statistically significant difference between boys and girls in the mean scores of the WISC-IV and NEPSY-II tasks when the entire sample was analysed. Considering the measures of Study 2 in relation with the measures of Study 1, math anxiety was correlated with some of the measures of executive functions and working memory. Specifically, the AMAS-2 resulted to be significantly negatively correlated with the WISC-IV task of Letter-number sequencing ($r = -.19$, $p = .033$) as showed in Table 12, and with the tasks of executive functions such as the Design Fluency ($r = -.18$, $p = .042$) and the switching part of the Inhibition task ($r = -.22$, $p = .012$) (see Table 13). When the measures of self-esteem were considered, the WISC-IV task of Letter-number sequencing was positively correlated with both measures of Multidimensional Self-esteem Test, the MSCS 1 ($r = .21$, $p = .014$) and the MSCS 2 ($r = .19$, $p = .032$).

Table 12

Correlations between memory tasks, math anxiety, and self-esteem on the entire sample

		AMAS-2	MSCS1	MSCS2	WISC_MC	WISC_LN
AMAS-2	Pearson Correlation	1	-.445**	-.431**	-.157	-.185*
	Sig. (2-tailed)		.000	.000	.069	.033
	N	134	134	134	134	134
MSCS1	Pearson Correlation	-.445**	1	.767**	.057	.211*
	Sig. (2-tailed)	.000		.000	.513	.014
	N	134	134	134	134	134
MSCS2	Pearson Correlation	-.431**	.767**	1	.139	.186*
	Sig. (2-tailed)	.000	.000		.110	.032
	N	134	134	134	134	134
WISC_MC	Pearson Correlation	-.157	.057	.139	1	.443**
	Sig. (2-tailed)	.069	.513	.110		.000
	N	134	134	134	134	134
WISC_LN	Pearson Correlation	-.185*	.211*	.186*	.443**	1
	Sig. (2-tailed)	.033	.014	.032	.000	
	N	134	134	134	134	134

Note. AMAS-2 is the Abbreviated Math Anxiety Scale (second edition), RCMAS-2 is the second short version of the Revised Children's Manifest Anxiety Scale, MSCS 1 and MSCS 2 are respectively the Competence of the Environmental Control and the Academic Success of the Multidimensional Self-concept Scale, WISC_MC is the Digit span of the WISC-IV test, and the WISC_LN indicates the Letter-Number-Sequencing task of the WISC-IV test.

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 13

Correlations between the tasks of executive functions and math anxiety on the entire sample

		AMAS-2	NEPSY_FG	NEPSY_INI_3
AMAS-2	Pearson Correlation	1	-.176*	-.216*
	Sig. (2-tailed)		.042	.012
	N	134	134	134
NEPSY_FG	Pearson Correlation	-.176*	1	.135
	Sig. (2-tailed)	.042		.120
	N	134	134	134
NEPSY_INI_3	Pearson Correlation	-.216*	.135	1
	Sig. (2-tailed)	.012	.120	
	N	134	134	134

Note. AMAS-2 indicates the second edition of the Abbreviated Math Anxiety Scale, NEPSY_FG is the Design Fluency NEPSY-II task, NEPSY-INI-3 is the Inhibition (Switching part) of the NEPSY-II test.
Correlation is significant at the 0.05 level (2-tailed).

Considering just the 3rd graders, the component of executive functions which included the tasks of Design fluency, Animal sorting and 3 versions of the Inhibition tasks was significantly positively correlated with the performance on the WISC-IV memory tasks of Digit span (r = .26, p = .028) and the Letter-number sequencing (r = .41, p < .001). The component of executive functions was used to investigate the overall relationship of different measures of executive functions with other measures. When math performance was studied on the 3rd graders, the scores at the calculation tests were positively correlated with the performance on the tasks of executive functions (r = .40, p = .001), but the same was not true for the performance on the reasoning tests (r = .23, p = .058). Specifically, as showed in Table 14, the component of executive functions was positively correlated with the performance on the math tests of Fluency (r = .38, p = .001), Written Calculation (r = .29, p = .016), and Approximate Calculation (r = .27, p = .026). When single measures of executive functions were considered separately, the scores of the switching part of the Inhibition NEPSY-II task were significantly positively correlated with both math Fluency test (r = .26, p = .033) and the Approximate

Calculation test (r = .24, p = .049). Furthermore, the hierarchical regression analyses showed that the performance on the tasks of executive functions was a significant predictor of the performance on the calculation tests (R^2 = .18, ΔR^2 = .18, F(3, 65) = .4.82, p = .004, β = .42, t = 3.39, p = .001). Specifically, the NEPSY-2 Inhibition task was a significant predictor of performance on the calculation tests (R^2 = .21, ΔR^2 = .21, F(5, 63) = 3.33, p = .010, β = .32, t = 2.44, p = .018). On the other hand, the performance on the WISC-IV tasks used in this study was not a significant predictor of math performance on the math calculation tests (R^2 = .04, ΔR^2 = .04, F(3, 66) = 1.27, p = .286). Regarding the math tests of reasoning, neither the performance on tasks of executive functions nor the performance on the WISC-IV tasks was a significant predictor of performance on math reasoning tests (tasks of executive functions: R^2 = .30, ΔR^2 = .09, F(5, 63) = 1.20, p = .321; WISC-IV tasks of Digit span and Letter-number sequencing: R^2 = .04, ΔR^2 = .04, F(2, 66) = 1.38, p = .258). Interestingly, the scores on the tasks of executive functions did not have statistically significant correlation with either AMAS-2 (r = -.20, p = .092) or RCMAS-2 questionnaires (r = -.07, p = .559).

Table 14

Correlations between executive functions and math performance on the 3rd graders

		Executive functions	PF	CA	CALSCR
Executive functions	Pearson Correlation	1	.377**	.266*	.288*
	Sig. (2-tailed)		.001	.026	.016
	N	70	70	70	70
PF	Pearson Correlation	.377**	1	.593**	.439**
	Sig. (2-tailed)	.001		.000	.000
	N	70	70	70	70
CA	Pearson Correlation	.266*	.593**	1	.243*
	Sig. (2-tailed)	.026	.000		.042
	N	70	70	70	70
CALSCR	Pearson Correlation	.288*	.439**	.243*	1
	Sig. (2-tailed)	.016	.000	.042	
	N	70	70	70	70

Note. PF indicates the Fluency math test, CA is the Approximate Calculation, and CALSCR is the Written Calculation AC-MT math test.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

When just the 5th graders were considered, the performance on the tasks of executive functions was significantly positively correlated with performance on both memory tasks of

WISC-IV which are the Digit span task ($r = .37$, $p = .002$) and the Letter-number sequencing task ($r = .41$, $p = .001$). Performance on the tasks of working memory and executive functions resulted also to be significantly correlated with math performance. Furthermore, when considered the math tests of calculation and reasoning, as showed in Table 15, just the performance on the calculation tests resulted to be significantly positively correlated with the performance on some tasks of memory and executive functions. Specifically, the math calculation tests resulted to be significantly correlated with WISC-IV Digit span ($r = .33$, $p = .008$), Letter-number sequencing task ($r = .36$, $p = .004$), NEPSY-II task of naming part of Inhibition ($r = .38$, $p = .002$), and the switching part of the Inhibition task ($r = .35$, $p = .004$). Specifically, the performance on the WISC-IV Digit span task was positively correlated with the performance on some of the math tests such as Fluency ($r = .43$, $p < .001$), Inferences ($r = .31$, $p = .013$), and on limits with the Approximate Calculation test ($r = .24$, $p = .056$). Furthermore, the performance on the WISC-IV Letter-number sequencing task was positively correlated with the math tests of Fluency ($r = .47$, $p <.001$) and Written Calculation ($r = .26$, $p = .038$). Regarding the measures of executive functions, the performance on the Design fluency task of the NEPSY-II was positively correlated with the performance on the Fluency math test ($r = .27$, $p = .033$). Furthermore, the Inhibition (naming part) was positively correlated with Written calculation ($r = .35$, $p = .005$), Approximate Calculation ($r = .33$, $p = .007$), and Fluency test ($r = .32$, $p = .011$). The NEPSY-II Switching part of the Inhibition task also resulted to be positively correlated with performance on math tests of Approximate Calculation ($r = .38$, $p = .002$) and Fluency ($r = .31$, $p = .013$). When considered the hierarchical regression analyses, the performance on the tasks of executive functions was a predictor of performance on the math calculation tests ($\beta = .30$, $t = 2.31$, $p = .024$). Specifically, the NEPSY-II Inhibition task (Naming) ($\beta = .28$, $t = 1.99$, $p = .052$) and the Design fluency task were on limits the predictors of math performance on calculation tests ($\beta = .25$, $t = 2.00$, $p = .050$). When the math reasoning tests were taken in consideration, just the performance on the Design fluency task of executive functions was a significant predictor of the performance on the math reasoning tests ($\beta = .27$, $t = 2.10$, $p = .041$).

Table 15

Correlations between memory, executive functions, and calculation tests on the 5th graders

		Calculation	WISC_MC	WISC_LN	NEPSYINI1	NEPSYINI3
Calculation	Pearson Correlation	1	.329**	.356**	.378**	.352**
	Sig. (2-tailed)		.008	.004	.002	.004
	N	64	64	64	64	64
WISC_MC	Pearson Correlation	.329**	1	.613**	.259*	.327**
	Sig. (2-tailed)	.008		.000	.039	.008
	N	64	64	64	64	64
WISC_LN	Pearson Correlation	.356**	.613**	1	.316*	.228
	Sig. (2-tailed)	.004	.000		.011	.070
	N	64	64	64	64	64
NEPSY_INI1	Pearson Correlation	.378**	.259*	.316*	1	.483**
	Sig. (2-tailed)	.002	.039	.011		.000
	N	64	64	64	64	64
NEPSY_INI3	Pearson Correlation	.352**	.327**	.228	.483**	1
	Sig. (2-tailed)	.004	.008	.070	.000	
	N	64	64	64	64	64

Note. WISC_MC is the Digit span of the WISC-IV test, WISC_LN indicates the Letter-Number-Sequencing task of the WISC-IV test, NEPSY_INI1 is the Inhibition (Naming part) of the NEPSY-II test, and NEPSY_INI3 is the Inhibition (switching part) of the NEPSY-II test.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Study 3–Self-esteem, explicit math gender stereotypes, and beliefs about mathematics

The *t*-test analyses did not find the statistically significant difference between male and female students for the mean scores of the Self-esteem Questionnaire. On the other hand, there is a statistically significant difference between boys and girls in two questionnaires of the Multidimensional Self-concept Scale which are the Competence of the Environmental Control ($t(132) = -2.39$, $p = .018$) and the Academic Success ($t(132) = -2.73$, $p = .007$). Girls scored higher for both self-concept tests related to the environmental control and academic success. Considering the subscales of the Explicit Math Gender Stereotypes Questionnaire in regard with children's gender and age, the Student's *t*-test was used. The results showed more explicit math gender stereotypes in boys than girls, in other words, boys were more than girls attributing the excellence in mathematics to males than females ($t(132) = 3.72$, $p < .001$) (see Table 16). Furthermore, regarding children's age, the explicit math gender stereotypes were more present in the 3rd graders than in the 5th graders ($t(132) = 3.34$, $p = .001$), so more 3rd graders than 5th graders attributed the excellence in mathematics to males than females. The self-perception of math ability was also higher in the 3rd graders ($t(132) = 2.37$, $p = .019$). On the other hand, the perceived math difficulty was higher in older students, that means in those attending the 5th grade ($t(132) = -2.37$, $p = .019$) (see Table 17).

Table 16

Results of t-test and Descriptive Statistics of Explicit Math Gender Stereotypes by gender

	Gender						95% CI for Mean Difference		
	Male			Female					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Math Gender Stereotypes	9.65	3.25	68	7.86	2.18	66	0.84, 2.73	3.72**	132

**$p < .001$

Table 17

Results of t-test and Descriptive Statistics of beliefs about mathematics by class attended

Outcome	Class attended						95% CI for Mean Difference		
	3rd			5th					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Math gender stereotypes	9.54	2.72	70	7.92	2.88	64	0.66, 2.58	3.34**	132
Perceived math ability	8.14	1.59	70	7.38	2.10	64	0.14, 1.40	2.37*	132
Perceived math difficulty	4.33	1.90	70	5.19	2.26	64	-1.57, -1.48	-2.37*	132

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

The Pearson's correlation coefficient was used to study whether there is a statistically significant correlation between self-esteem, math gender stereotypes and other opinions about mathematics. The MSCS 1 showed high positive correlation with the measures of self-esteem and self-concept such us the Self-esteem Questionnaire ($r = .53$, $p < .001$) and the MSCS 2 ($r = .77$, $p < .001$). The self-concept related to academic success (MSCS 2) was also positively correlated with the Self-esteem Questionnaire ($r = .57$, $p < .001$). When the subscales of the questionnaire of the Explicit Math Gender Stereotypes and the Multidimensional Self-concept Scale were considered, just the MSCS 1 was statistically correlated with some of the subscales. Specifically, the MSCS 1 was negatively correlated with the subscale of perceived math difficulty ($r = -.38$, $p < .001$), and positively correlated with the subscale of self-perception of math ability ($r = .32$, $p < .001$). The measures of self-esteem and self-concept such as the Self-esteem Questionnaire, the MSCS 1, and the MSCS 2 were not significantly correlated with the math performance on the math tests administered in Study 3.

Regarding Study 3 in which different math tests were administered, the statistical *t*-test analyses on the 3rd graders did not find a significant difference between male and female students for any of the 6 math tests. Regarding the test scores of the Written Calculation test, the mean score obtained by the 3rd graders was classified as the acceptable test score for that age group ($M = 6.10$, $SD = 2.09$).

Regarding stereotypes and beliefs about mathematics measured with the Explicit Math Gender Stereotypes Questionnaire, the Pearson's correlation analyses did not find a statistically significant correlation between math beliefs and math performance measured in this study. Furthermore, the scores on the measures of the self-esteem also did not have statistically significant correlation with the performance on the math tests of calculation and reasoning.

Considering Study 3 on the 5th graders, male and female students did not perform differently on the math tests, a part for the Matrix test in which boys outperformed girls ($t(62) = 2.31$, $p = .024$; males: $M = 7.74$, $SD = 3.57$; females: $M = 5.82$, $SD = 3.05$). Regarding the measures of self-concept and math performance, there were no significant correlations either between MSCS 1 and math performance or between MSCS 2 and math tests used in this study. On the other hand, the scores of the Self-esteem Questionnaire were positively correlated with the performance on both calculation ($r = .48$, $p < .001$) and reasoning math tests ($r = .43$, $p < .001$) (see Table 18). Furthermore, the questionnaire which measures the self-esteem related to mathematics resulted to be a predictor of math performance for both math calculation and math reasoning tests (math calculation: $\beta = .64$, $t = 3.93$, $p < .001$; math reasoning: $\beta = .63$, $t = 4.14$, $p < .001$). Specifically, there is a significant correlation between the self-esteem related to mathematics and the math tests of Written Calculation ($r = .56$, $p < .001$), Fluency ($r = .51$, $p < .001$), Interferences ($r = .43$, $p < .001$), Matrix ($r = .35$, $p = .004$), and Approximate Calculation ($r = .28$, $p = .024$).

Table 18

Correlations between self-esteem, calculation, and reasoning tests on the 5th graders

		QAUTO	Calculation	Reasoning
QAUTO	Pearson Correlation	1	.485**	.427**
	Sig. (2-tailed)		.000	.000
	N	63	63	63
Calculation	Pearson Correlation	.485**	1	.668**
	Sig. (2-tailed)	.000		.000
	N	63	64	64
Reasoning	Pearson Correlation	.427**	.668**	1
	Sig. (2-tailed)	.000	.000	
	N	63	64	64

Note. QAUTO indicates the Self-esteem Questionnaire which measures the self-esteem related to math

** Correlation is significant at the 0.01 level (2-tailed).

Regarding beliefs and opinions about mathematics and math performance, Study 3 has shown that beliefs are important when it comes to performance on math tests. Specifically, the scores of the subscale of the Explicit Math Gender Stereotypes resulted to be significantly positively correlated with the math performance on both calculation and reasoning math tests (calculation: $r = .41$, $p = .001$; reasoning: $r = .32$, $p = .009$) (see Table 19). In particular, that was true for the test of Approximate Calculation ($r = .41$, $p = .001$), Number Sense ($r = .35$, $p = .004$), Written Calculation ($r = .33$, $p = .007$), Fluency ($r = .32$, $p = .011$), Matrix ($r = .30$, $p = .016$), and Interferences ($r = .28$, $p = .026$). Furthermore, the subscale of the Explicit Math Gender Stereotypes resulted to be a significant predictor of math performance on calculation tests ($\beta = .30$, $t = 2.66$, $p = .010$). When statistical analyses were conducted separately for male and female students, the results revealed that the significant positive correlation observed between explicit math gender stereotypes and math performance was true just for male students. Furthermore, their beliefs about boys being better at mathematics seem to have an impact on their real performance on the math tests. Specifically, the explicit math gender stereotypes were positively correlated with both calculation ($r = .59$, $p <. 001$) and reasoning tests ($r = .45$, $p = .012$). In particular, that was true for all 6 math test which are Number Sense ($r = .63$, $p = .000$), Approximate Calculation ($r = .57$, $p = .001$), Fluency ($r = .53$, $p = .002$), Inferences ($r = .45$, $p = .010$), Matrix ($r = .39$, $p = .031$), and Written Calculation test ($r = .49$, $p = .005$).

Table 19

Correlations between math gender stereotypes, calculation, and reasoning on the 5th graders

		QESPMGS	Calculation	Reasoning
QESPMGS	Pearson Correlation	1	.412**	.323**
	Sig. (2-tailed)		.001	.009
	N	64	64	64
Calculation	Pearson Correlation	.412**	1	.668**
	Sig. (2-tailed)	.001		.000
	N	64	64	64
Reasoning	Pearson Correlation	.323**	.668**	1
	Sig. (2-tailed)	.009	.000	
	N	64	64	64

Note. QESPMGS indicates the Explicit Math Gender Stereotypes scale.

** Correlation is significant at the 0.01 level (2-tailed).

Furthermore, also the subscale of the Self-perception of math ability was positively correlated with both math calculation and math reasoning tests (see Table 20). In particular, thinking about yourself as the one who is able to solve math exercises resulted to be positively correlated with math performance for all 6 math tests used in this study. Specifically, this correlation went from strong correlation for the Matrix test (r = .58, p < .001), Written Calculation (r = .54, p < .001), Interferences (r = .49, p < .001), Approximate Calculation (r = .45, p < .001), and Fluency (r = .44, p < .001) to medium correlation for the test of Number Sense (r = .29, p = .020). Furthermore, the Self-perception of math ability resulted to be the significant predictor of math performance on both math calculation (β = .34, t = 2.52, p = .014) and math reasoning tests (β = .56, t = 4.51, p < .001).

Table 20

Correlations between perceived math ability, calculation, and reasoning on the 5th graders

		QESPSP	Calculation	Reasoning
QESPSP	Pearson Correlation	1	.537**	.605**
	Sig. (2-tailed)		.000	.000
	N	64	64	64
Calculation	Pearson Correlation	.537**	1	.668**
	Sig. (2-tailed)	.000		.000
	N	64	64	64
Reasoning	Pearson Correlation	.605**	.668**	1
	Sig. (2-tailed)	.000	.000	
	N	64	64	64

Note. QESPSP indicates the subscale of the Self-perception of math ability.

** Correlation is significant at the 0.01 level (2-tailed).

Regarding the subscale of the Perceived math difficulty and math performance, the perception of mathematics as difficult was negatively correlated with the math performance on both calculation and reasoning tests (Table 21). Thus, that was true for all 6 math tests used in Study 3. Specifically, the correlation ranged from strong in the Written Calculation (r = -.58, p < .001), Matrix (r = -.42, p = .001), Interferences (r = -.40, p = .001), and Fluency test (r = -.40, p = .001) to medium correlation for the Approximate Calculation (r = -.37, p = .002), and the Number Sense test (r = -.28, p = .024). Furthermore, the perceived math difficulty was a significant predictor of the math performance on both math calculation (R^2 = .26,

$F(2, 61) = 10.47$, $p < .001$, $\beta = -.51$, $t = -4.58$, $p < .001$), and math reasoning tests ($R^2 = .28$, $F(2, 61) = 12.12$, $p < .001$, $\beta = -.47$, $t = -4.33$, $p < .001$).

Table 21

Correlations between perceived math difficulty, calculation, and reasoning on the 5th graders

		QESPPMD	Calculation	Reasoning
	Pearson Correlation	1	-.505**	-.457**
QESPPMD	Sig. (2-tailed)		.000	.000
	N	64	64	64
	Pearson Correlation	-.505**	1	.668**
Calculation	Sig. (2-tailed)	.000		.000
	N	64	64	64
	Pearson Correlation	-.457**	.668**	1
Reasoning	Sig. (2-tailed)	.000	.000	
	N	64	64	64

** *Note.* QESPPMD indicates the Perceived math difficulty subscale.

** Correlation is significant at the 0.01 level (2-tailed).

5.2.3 Results from a Croatian Study

The study conducted on the Croatian sample revealed a significant positive correlation between the math performance on calculation and reasoning tests ($r = .57$, $p < .001$) when results of the 3rd graders were analysed. Furthermore, there was a significant positive correlation between the math performance on calculation tests and students' self-esteem related to math ($r = .36$, $p = .015$), and the correlation was on limits of the significant level with students' self-perception of math ability ($r = .29$, $p = .051$). On the other hand, the performance on the reasoning tests was not significantly correlated with other measures used in the research. Regarding emotional variables measured in the study, the self-esteem related to mathematics was significantly positively correlated with self-perception of math ability ($r = .63$, $p < .001$) and with value attributed to math ($r = .45$, $p = .002$). On the other hand, the self-esteem related to math was significantly negatively correlated with perceived math difficulty ($r = -.39$, $p = .008$).

When the results of the 3rd graders were considered in relation with gender, there were no significant differences between male and female students in any of the math tests of calculation and reasoning. On the other hand, when the opinions about mathematics were considered, boys showed to have more math gender stereotypes than girls, in other words, more boys than girls thought that male students are better at mathematics ($t = 3.10$, $p = .003$; boys: $M = 10.17$, $SD = 2.22$; girls: $M = 8.28$, $SD = 1.85$). Furthermore, male and female students differed significantly also in perceiving the value of mathematics. Specifically, girls attributed higher value to mathematics than their male peers ($t = -2.18$, $p = .035$; boys: $M = 10.67$, $SD = 3.33$; girls: $M = 12.43$, $SD = 1.99$) (see Table 22).

Table 22

Mean differences in math opinions and stereotypes in the Croatian 3rd graders by gender

Outcome	Gender						95% CI for Mean Difference		
	Male			Female					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Math gender stereotypes	10.17	2.22	24	8.28	1.85	21	.66, 3.10	3.10**	43
Value attributed to math	10.67	3.33	24	12.43	1.99	21	-3.39, -.13	-2.18*	43

Note. *$p < .05$, **$p < .001$

When the subscales of the Explicit Math Gender Stereotypes Questionnaire were taken in consideration, the value attributed to math was positively correlated with self-perception of math ability ($r = .39$, $p = .009$), and negatively correlated with perceived math difficulty ($r = -.56$, $p < .001$). Self-perception of math ability was negatively correlated with perceived math difficulty ($r = -.32$, $p = .035$). The subscale of the Math Gender Stereotypes was not significantly correlated either with the other subscales of the Explicit Math Gender Stereotypes Questionnaire or with the performance on math calculation and reasoning tests (see Table 23). When the hierarchical regression analyses were conducted, the self-esteem related to math resulted to be the only significant predictor of the math performance on the calculation tests administered in this study ($R^2 = .13$, F (2, 42) = 3.27, $p = .048$, $\beta = .36$, $t = 2.51$, $p = .016$).

Table 23

Correlations between math self-esteem and math opinions on the Croatian 3rd graders

		Self-esteem	QESMGS	QESPVAM	QESPSP	QESPMD	Calculation
Self-esteem	Pearson Correlation	1	.103	.450**	.634**	-.392**	.360*
	Sig. (2-tailed)		.500	.002	.000	.008	.015
	N	45	45	45	45	45	45
QESMGS	Pearson Correlation	.103	1	-.092	-.033	-.029	.218
	Sig. (2-tailed)	.500		.547	.829	.850	.151
	N	45	45	45	45	45	45
QESPVAM	Pearson Correlation	.450**	-.092	1	.387**	-.562**	.034
	Sig. (2-tailed)	.002	.547		.009	.000	.826
	N	45	45	45	45	45	45
QESPSP	Pearson Correlation	.634**	-.033	.387**	1	-.315*	.292
	Sig. (2-tailed)	.000	.829	.009		.035	.051
	N	45	45	45	45	45	45
QESPMD	Pearson Correlation	-.392**	-.029	-.562**	-.315*	1	-.186
	Sig. (2-tailed)	.008	.850	.000	.035		.222
	N	45	45	45	45	45	45
Calculation	Pearson Correlation	.360*	.218	.034	.292	-.186	1
	Sig. (2-tailed)	.015	.151	.826	.051	.222	
	N	45	45	45	45	45	45

Note. QESPMGS is the Explicit Math Gender Stereotypes Scale, QESPVAM is the Value Attributed to Math Scale, QESPSP is the Self-perception of Math Ability Scale, and QESPMD indicates the Perception of the Math Difficulty Scale. Self-esteem indicates the self-esteem related to math.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

When compared the students attending the 3rd and 5th grade, there was a significant difference between their mean scores of the self-esteem related to mathematics (t = -2.59, p = .012). Specifically, the 5th graders had higher levels of the self-esteem related to math (M = 39.96, SD = 6.39) than the 3rd graders (M = 35.22, SD = 6.68). The self-perception of math ability was also significantly higher in the 5th graders (t = -2.23, p = .029; M = 8.18, SD = 1.49) than in the 3rd graders (M = 7.40, SD = 1.59) (see Table 24). The value attributed to math, perception of math difficulty, and explicit math gender stereotypes did not significantly differ between the 3rd and the 5th graders.

Table 24

Mean differences in math self-esteem and perceived math ability by age in the Croatian sample

Outcome	Class attended						95% CI for Mean Difference		
	3rd			5th					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Math self-esteem	35.22	6.68	45	39.06	6.39	34	-6.79, -.88	-2.59*	77
Perceived math ability	7.40	1.59	45	8.18	1.49	34	-1.47, -.08	-2.23*	77

*p < .05

Regarding just the students attending the 5th grade, the math performance on the calculation tests was significantly correlated with the performance on the math reasoning tests (r = .37, p = .030). Furthermore, the performance on the math calculation tests was not significantly correlated with other variables measured in this study. On the other hand, the math performance on the reasoning tests was significantly positively correlated with self-perception of math ability (r =.46, p = .006).

The self-esteem related to mathematics was positively correlated with self-perception of math ability (r = .65, p < .001) and with value attributed to math (r = .47, p = .005). On the other hand, the self-esteem was negatively correlated with perceived math difficulty (r = -.42, p = .014). Regarding the subscales of the Explicit Math Gender Stereotypes Questionnaire, the self-perception of math ability was positively correlated with the value attributed to math (r = .64, p < .001), and negatively correlated with the perceived math difficulty (r = -.59, p = .000). Furthermore, the value attributed to math was significantly negatively correlated with the perceived math difficulty (*r* = -.38, *p* = .026) (see Table 25). When the hierarchical regression analyses were generated, the only predictor of the math performance on the reasoning tests was the self-perception of math ability (R^2 = .071, *F* (2, 31) = 5.88, *p* = .007, *t* = 2.95, β = .45, *p* = .006).

Table 25

Correlations between math self-esteem and math opinions on the Croatian 5th graders

		Self-esteem	QESMGS	QESPVAM	QESPSP	QESPMD
Self-esteem	Pearson Correlation	1	-.025	.467**	.649**	-.418*
	Sig. (2-tailed)		.889	.005	.000	.014
	N	34	34	34	34	34
QESMGS	Pearson Correlation	-.025	1	-.042	-.116	.234
	Sig. (2-tailed)	.889		.814	.513	.182
	N	34	34	34	34	34
QESPVAM	Pearson Correlation	.467**	-.042	1	.643**	-.382*
	Sig. (2-tailed)	.005	.814		.000	.026
	N	34	34	34	34	34
QESPSP	Pearson Correlation	.649**	-.116	.643**	1	-.586**
	Sig. (2-tailed)	.000	.513	.000		.000
	N	34	34	34	34	34
QESPMD	Pearson Correlation	-.418*	.234	-.382*	-.586**	1
	Sig. (2-tailed)	.014	.182	.026	.000	
	N	34	34	34	34	34

Note. QESPMGS is the Explicit Math Gender Stereotypes Scale, QESPVAM is the Value Attributed to Math Scale, QESPSP is the Self-perception of Math Ability Scale, and QESPMD indicates the Perception of the Math Difficulty Scale. Self-esteem indicates the self-esteem related to math.

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

When the results on the 5th graders were considered in relation with student' gender, there were no significant differences of the math performance between male and female students, a part for the reasoning test of Interferences in which girls outperformed boys

(t = -2.28, p = .029: boys: M = 6.06, SD = 1.81; girls: M = 7.61, SD = 2.15). Furthermore, when the opinions about mathematics were considered, boys showed to have significantly more math gender stereotypes that girls, that means that boys were more prone to think that male students are better at mathematics (t = -2.31, p = .032; boys: M = 9.75, SD = 2.38; girls: M = 8.28, SD = 0.96) (see Table 26).

Table 26

Mean differences in math gender stereotypes and reasoning in the Croatian 5th graders by gender

Outcome	Gender						95% CI for Mean Difference		
	Male			Female					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Inferences	6.06	1.81	16	7.61	2.15	18	-2.93, -.17	-2.28*	32
Math gender stereotypes	9.75	2.38	16	8.28	0.96	18	.14, 2.80	-2.31*	32

*p < .05

The t-test for Independent sample was used to compare the mean differences of math self-esteem, opinions about mathematics, and the math performance on calculation and reasoning tests of the Italian and Croatian 3rd and 5th graders. Considering just the 3rd graders, there were significant differences at math performance on calculation and reasoning tests (calculation: t = 13.09, p < .001; reasoning: t = 4.19, p < .001). The math performance on calculation and reasoning tests was higher in the Italian than Croatian 3rd graders (Italian sample calculation: M =18.23, SD = 5.72; reasoning: M = 11.76, SD = 4.34; Croatian sample calculation: M = 7.11, SD = 3.38; reasoning: M = 8.69, SD = 3.46). Specifically, the significant difference was between the mean scores on the math calculation Fluency test (t = 10.06, p < .001; Italian sample: M = 7.77, SD = 2.81; Croatian sample: M = 3.20, SD = 2.05) (see Table 27).

Table 27

Mean differences in calculation, reasoning, and math Fluency by country in the 3rd grade

Outcome	Country						95% CI for Mean Difference		
	Italy			Croatia					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Calculation	18.23	5.72	70	7.11	3.38	45	-9.43, 12.80	13.09**	113
Reasoning	11.76	4.34	70	8.69	3.47	45	1.62, 4.52	4.19**	113
Fluency	7.77	2.81	70	3.20	2.05	45	3.67, 5.47	10.06**	113

$^{**}p < .01$

When math self-esteem and opinions about mathematics between Croatian and Italian 3rd graders were compared, there were significant differences in the mean scores of the value attributed to math (t = 4.67, p < .001), the self-perception of math ability (t = 2.45, p = .016), and in the perceived math difficulty (t = -2.52, p = .013). Specifically, the 3rd graders attending the school in Italy scored higher on the subscale of the Value attributed to math (M = 13.74, SD = 1.81) than their peers attending the 3rd grade in Croatia (M = 11.49, SD = 2.90). Furthermore, the Italian students scored higher also at the subscale of the Self-perception of math ability (M = 8.14, SD = 1.59) than their Croatian peers (M = 7.40, SD = 1.59). Regarding the perceived math difficulty, the students attending the 3rd grade in Croatia scored higher in this subscale, that means that they perceived mathematics as more difficult than the Italian 3rd graders (Croatian sample: M = 5.31, SD = 2.12; Italian sample: M = 4.33, SD = 1.90) (see Table 28). However, there were no significant differences in the mean scores of the Math Self-esteem (t = 1.20, p = .231) and the Explicit math gender stereotypes reported by the students in Italy and Croatia (t = .54, p = .587).

Table 28

Mean differences in opinions about mathematics in the 3rd graders by country

Outcome	Country						95% CI for Mean Difference		
	Italy			Croatia					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Attributed value	13.74	1.81	70	11.49	2.90	45	1.29, 3.22	4.67**	113
Perceived ability	8.14	1.59	70	7.40	1.59	45	.14, 1.34	2.45*	113
Perceived difficulty	4.33	1.90	70	5.31	2.12	45	-1.76, -2.09	-2.52*	113

$^*p < .05$, $^{**}p < .01$

When the students attending the 5th grade in two countries were compared, the *t*-test analyses for Independent sample showed significant differences of the math performance on the math calculation tests of math Fluency (t = -4.30, p < .001) and Approximate Calculation (t = -2.45, p = .016). Specifically, the students attending the 5th grade in Croatia performed better on these tests (Fluency: M = 8.23, SD = 2.81; Approximate Calculation: M = 7.85, SD = 1.99) than their Italian peers (Fluency: M = 5.89, SD = 2.01; Approximate Calculation: M = 6.82, SD = 2.93) (see Table 29).

Table 29

Mean differences in math calculation performance in the 5th graders by country

Outcome	Country						95% CI for Mean Difference		
	Italy			Croatia					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Fluency	5.89	2.01	64	8.23	2.81	34	-2.22, -.23	-4.30**	96
Approximate Calculation	6.82	2.93	64	7.85	1.99	34	-3.44, -1.25	-2.45*	96

$^*p < .05$, $^{**}p < .01$

When math self-esteem and opinions about mathematics were considered, there were significant differences in explicit math gender stereotypes (t = -2.16, p = .033) and in math ability that the students of two countries perceived (t = -2.19, p = .031). In particular, the 5th graders in Croatia showed to have higher levels of math gender stereotypes, attributing the excellence at mathematics more to boys than to girls when compared to their Italian peers (Croatian sample: M = 8.97, SD = 1.90; Italian sample: M = 7.92, SD = 2.88). Regarding self-perception of math ability, the Croatian 5th graders perceived their math ability as higher than the Italian 5th graders (Croatian sample: M = 8.18, SD = 1.49; Italian sample: M = 7.37, SD = 2.10) (see Table 30).

Table 30

Mean differences in opinions about mathematics in the 5th graders by country

Outcome	Country						95% CI for Mean Difference		
	Italy			Croatia					
	M	*SD*	*n*	*M*	*SD*	*n*		*t*	*df*
Math gender stereotypes	7.92	2.88	63	8.97	1.90	34	-2.01, -.08	-2.16*	96
Perceived math ability	7.37	2.10	63	8.18	1.49	34	-1.53, -.07	-2.19*	96

$^{*}p < .05$, $^{**}p < .01$

Chapter 6-General Discussion

6.1 Summary of Main Findings and Discussion

The present research has focused mainly on the relationship between math anxiety, general anxiety, math attitudes, cognitive and executive functions, and math performance on calculation and reasoning math tests. According to the main findings in this field, there is a significant impact of emotional variables such as math anxiety and general anxiety on math performance by interfering with cognitive functions and overloading working memory (Aschraft & Kirk, 2001; Miyake & Shah, 1999). Specifically, studies showed that math anxiety interferes with math performance especially in the case of difficult math problems or exercises, and people who are highly anxious tend to rely on inefficient strategies which are less demanding or tend to make mistakes while trying to apply more advanced strategies (Ramirez, Chang, Maloney, Levine, & Beilock, 2016). When students with high and low working memory capacity were compared, those with high capacity perform better at math tests, however, the gap between groups was narrowed by math anxiety (Ramirez et al., 2013). It is also important to mention that high-achieving students are more at risk to experience higher levels of math anxiety than low-achieving students (OECD, PISA, 2012). Furthermore, studies found that highly anxious individuals have some real structural changes in the brain such as modifications in the amplitude of the frontal lobes (Núñez-Peña & Suárez-Pellicioni, 2014, 2015), higher hyperactivity in the right amygdala (Young, 2012), and reduced activity in the dorsolateral prefrontal cortex and posterior parietal lobe (Young et al., 2012). According to studies in this field, there is a significant negative correlation between math anxiety and math performance which is estimated to be between -.29 and -.34 (Hembree, 1990; Ma, 1999). Furthermore, the international PISA research showed that in 63 of 64 education systems students who reported higher math anxiety also displayed lower math performance (OECD, 2013). Regarding gender differences, female students reported higher math anxiety than their male peers in 56 of 64 countries (OECD, 2013). In addition, studies have shown that girls are more likely to be in both high general anxiety and high math anxiety profiles when compared with their male peers (Carey, Devine, Hill, & Szücs, 2017). Regarding the age in which those differences appear, it seems that gender differences in math performance usually develop by the third grade of elementary school. The gender gap observed in many studies is usually explained with the math gender stereotypes which can in some situations foster the stereotype threat and lower performance of female students (Fryer & Levitt, 2010; Penner & Paret, 2008; Robinson & Lubienski, 2011; Spencer, Steele, & Quinn, 1999). In particular, a common agreement is that math anxiety is present at some measure already in the 2nd or 3rd grade children, even though younger children do not usually experience high levels of math anxiety (Wu et al., 2012). Furthermore, studies have shown that math anxiety increases with age, and the attitudes about mathematics also change negatively as children get older (Ma, Kishor, 1997; Dowker, 2005; Mata et al., 2012). One of the possible explanations is that with getting older mathematics becomes more complex, and the experiences of failure in mathematics increase (Dowker, Sarkar, & Looi, 2016). Regarding math anxiety, opinions about mathematics, and math self-esteem, the previous findings showed a significant negative correlation between math anxiety and enjoyment of mathematics (r = -.73), and math anxiety and confidence in mathematics (r = -.82) (Hembree, 1990). Furthermore, people with negative self-rating of math abilities, or in other words those who think that they are bad at mathematics, are more likely to have higher levels of math anxiety when compared with people who have higher self-rating of their math abilities (Goetz et al., 2010; Hembree, 1990; Hoffman, 2010; Jain & Dowson, 2009; Pajares & Miller, 1994). It seems that having negative beliefs and in general negative attitudes about mathematics leads to the reduction of effort, and it becomes a self-fulling prophecy (Klasser & Usher, 2010; Schunk & Pajares, 2009). Interestingly, studies in this field have shown a positive correlation between self-efficacy and math performance which goes from moderate positive correlation (r = .30) to strong positive correlation (r = .50) (OECD, PISA, 2012). Furthermore, self-efficacy differs significantly with respect to gender and socio-economic status. Specifically, 67% of boys and just 44% of girls reported to feel confident about performing a math calculation (OECD, PISA, 2012).

When general anxiety was considered, previous studies found a significant positive correlation between math anxiety and general anxiety which was about .35 (Hembree, 1990). However, this correlation is not strong probably because general anxiety and math anxiety are based on different risk factors, which are in the general anxiety extended also to different life contexts and not just to the math-related situations, which is the case of math anxiety.

One of the possible sources of math anxiety and negative math attitudes that consequently interfere with math performance is a cultural background that a person belongs to. The tendency in small children to like mathematics, and the subsequent deterioration of the attitudes with comes with growing up, seems to be a common phenomenon in different countries (Ma & Kishor, 1997; Dowker, 2005). Levels of math anxiety and opinions about mathematics differ across countries, and that may be because of different social contexts such as higher social pressure to perform well in some societies, but it may also relate to different educational systems and curricula.

In the light of the main findings in this field, the main results of the present research are discussed. Three studies were carried out on the 3rd and 5th graders attending different elementary schools in northern Italy. There were five main goals of the study which were to investigate the relationship between:

1) Emotional variables (math and general anxiety) and math performance
2) Cognitive and executive functions and math performance
3) Self-esteem, self-concept, math gender stereotypes, opinions about mathematics and math performance
4) Emotional variables, cognitive and executive functions, and math attitudes
5) The fifth goal was to compare the findings concerning math attitudes and math performance in two different cultural settings of Italy and Croatia

Regarding the correlation between emotional variables and math performance, differently from the previous studies in this field, and contrary to expectations, the present research did not find a statistically significant difference of the level of neither math or general anxiety when gender and age were considered. In other words, there were no significant differences of mean scores on the AMAS-2 and RCMAS-2 either between male and female students or between 3rd and 5th graders. However, there were significant differences between 3rd and 5th graders when it comes to the relationship between AMAS-2 and RCMAS-2, and math anxiety and math performance. Two measures of anxiety were not significantly correlated in the younger students, and neither the AMAS-2 nor the RCMAS-2 were correlated with math performance. Interestingly, it seems that things drastically change with growing up, and it is stunning that the phenomenon seems to develop in a brief period of time. Differently from the 3rd graders, the 5th graders had a significant positive correlation between math anxiety and general anxiety (r = .47, p < .001), and a significant negative correlation between math anxiety and math performance on both math calculation (r = -.41, p = .001) and math reasoning tests (r = -.26, p = .042). Interestingly, considering the 5th graders, math anxiety had stronger negative correlation with the math tests of calculation than with the math tests of reasoning. In order to understand in which way math anxiety interferes with math performance, it is important to highlight that math anxiety has a major influence on short-term memory, working memory, fact retrieval, and capacity to inhibit irrelevant information (Passolunghi, Caviola, De Agostini, Perin, & Mammarella, 2016). Furthermore, cognitive skills such as WM capacity, processing speed, attention, and inhibition are particularly important in overcoming difficulties in math learning (Fletcher et al., 2007). In addition, previous studies showed that math anxiety can cause the overload of the WM which therefore is responsible for the slow and inaccurate handling of arithmetic problems (Ashcraft & Faust 1994; Ashcraft & Kirk, 2001; Mattarella-Micke et al., 2011; Suarez, Pellicioni et al., 2013), and the impact of math anxiety seems to be greater in the case of complex math problem-solving and reasoning (Owens et al., 2014). Regarding teacher's estimation of the students' emotional and behavioural problems, just in the 5th graders there were significant differences on the mean scores attributed to male and female students (t = .29, p = .015). Specifically, boys scored higher than girls for emotional and behavioural problems (boys: M = 5.48, SD = 3.55; girls: M = 3.51, SD = 3.48). However, even if problems estimated by teachers had a positive correlation with perceived general anxiety (r = .27, p = .031), and a negative correlation with both math self-esteem (r = -.36, p = .003) and academic self-esteem (r = -.29, p = .018), they did not have a significant relationship with math performance on the tests of calculation and reasoning. On the other hand, when the results of the 3rd graders were analysed, the emotional and behavioural problems estimated by their teachers did not significantly correlate with students' self-perception of math ability and perceived general anxiety. However, problems estimated by teachers were a significant predictor of math performance on both calculation (β = .29, t = 2.51, p = .015) and reasoning math tests (β = 2.47, t = 2.09, p = .040). Different findings on the 3rd and 5th grades might be explained by the fact that it is possible that the 3rd graders due to their young age did not have a realistic perception of their math anxiety and general anxiety, which to remind were not significantly correlated either with teacher's estimation of students' emotional and behavioural problems or with their math performance. On the other hand, that was not a case with the 5th graders which seem to have a more realistic perception of their own feelings related to math anxiety and general anxiety which resulted to be significantly correlated with both teacher's estimation of students' emotional and behavioural problems and with their math performance.

Regarding math anxiety and math attitudes which refer to math self-esteem, self-concept, opinions, beliefs, and stereotypes about mathematics, the present research confirmed the findings of previous studies in this field which found a negative correlation between math anxiety and math confidence, and as expected, a positive correlation between math anxiety and negative attitudes towards mathematics. Furthermore, when the entire sample was considered, students with higher levels of math anxiety perceived mathematics as more difficult and their math ability as lower. Math anxiety was also moderately negatively correlated with all the measures of the self-esteem and self-concept measuring math self-esteem, competence of the environmental control, and academic success. Considering general anxiety, differently from the 3rd graders, students attending the 5th grade did not show a significant correlation between general anxiety and beliefs about mathematics.

Overall, regarding Study 1 on the Italian students attending 3rd and 5th grade of elementary school, math anxiety resulted to be a significant predictor of math performance on both math calculation and reasoning tests of the 5th graders. Furthermore, teacher's estimation of students' emotional and behavioural problems was a significant predictor of math performance of the 3rd graders.

The next section of the research or Study 2 was concerned with the relationship between cognitive and executive functions and math performance. Study 2 showed no significant differences of the mean scores on the measures of cognitive and executive functions between male and female students. Even though there are no differences in cognitive abilities by gender, lower performance on cognitive tasks and tasks of executive functions was expected among girls because of their usually higher math anxiety which can interfere with the tasks of cognitive functions by overloading the working memory (Aschraft & Kirk, 2001; Carey, Devine, Hill, & Szücs, 2017; Miyake & Shah, 1999). Furthermore, in the students of both 3rd and 5th, the performance on the tasks of cognitive and executive functions was significantly positively correlated. In other words, higher scores on the cognitive memory tasks of WISC-IV test were associated with higher scores on the NEPSY-2 tasks of executive functions. Interestingly, when the 3rd graders were considered, performance on the tasks of executive functions was significantly positively correlated with math performance on the math calculation tests ($r = .40$, $p = .001$), but not with the math reasoning tests ($r = .23$, $p = .058$). Specifically, the NEPSY-2 Inhibition task was a significant predictor of math performance on the calculation tests ($R^2 = .21$, $F(5, 63) = 3.33$, $p = .010$). Similar results were found on the 5th graders in which the performance on both memory tasks and tasks of executive functions was positively correlated with math performance on the calculation tests. However, it seems that just the performance on the tasks of executive functions is a significant predictor of math performance on the calculation tests ($\beta = .30$, $t = 2.31$, $p = .024$). Interestingly, math performance on the math reasoning tests, such as the Matrix test and the Interferences, was not significantly correlated either with the performance on the tasks of cognitive functions or with the performance on the tasks of executive functions in the students attending 3rd and 5th grade.

Turning to the main findings of Study 3, the results have revealed significant differences about math attitudes when students' gender and age were considered. Specifically, boys showed to have more math gender stereotypes than girls ($t(132) = 3.72$, $p < .001$). That means that male students were attributing mastery in mathematics more to male gender. On the other hand, regarding math self-esteem measured with the Self-esteem Questionnaire, there were no significant differences between male and female students. However, girls got higher scores on the self-concept questionnaires measuring the competence of the environmental control ($t(132) = -2.39$, $p = .018$) and the academic success ($t(132) = -2.73$, $p = .007$). When age was considered, contrary to expectations, the results from Study 3 found more math gender stereotypes in the 3rd graders than in the 5th graders. In other words, younger students were more likely to attribute mastery in mathematics more to boys than to girls. It is possible that these findings are due to the fact that the study measured just explicit math gender stereotypes, and not those implicit. Younger children usually tend to express liberally their opinions without fear of social pressure and social acceptance. In other words, it is possible that the younger students were less aware of the fact that considering one gender worst at mathematics is not socially acceptable. When other beliefs about mathematics were considered, the findings confirmed the results from previous studies. That is, the attitudes towards mathematics get worst with growing up (Dowker, 2005; Ma & Kishor, 1997). Specifically, as hypothesized, the 3rd graders showed higher levels of the self-perceived ability in mathematics, and they also perceived mathematics as less difficult than the students attending the 5th grade (self-perception of math ability: $t(132) = 2.37$, $p = .019$; perceived math difficulty: $t(132) = -2.37$, $p = .019$). Regarding the mean scores on the math tests, math performance did not differ for male and female students, and the only exception was a slight difference in the Matrix logical test in which girls attending the 5th grade outperformed their male peers ($t(62) = 2.31$, $p = .024$). It seems that math attitudes have a significant influence on math performance. Furthermore, that was true just for the 5th grade students, whereas in the 3rd graders there were no significant correlations between math attitudes and math performance. In other words, beliefs, opinions, stereotypes, self-esteem, and self-concept related to mathematics did not have significant correlations with math performance in the 3rd graders. On the other hand, in the students attending the 5th grade both math self-esteem (calculation: $r = .48$, $p < .001$; reasoning: $r = .43$, $p < .001$) and self-perception of math ability (calculation: $r = .54$, $p < .001$; reasoning: $r = .61$,

$p < .001$) were positively correlated with math performance on both math calculation and reasoning tests. On the other hand, the perceived math difficulty was moderately negatively correlated with math performance on both math calculation and reasoning tests (calculation: $r = -.51$, $p < .001$; reasoning: $r = -.46$, $p < .001$). Regarding math gender stereotypes, the finding on the 5th graders found that there is a significant positive correlation with math performance but just for male students. That was true for all 6 math tests measuring calculation and reasoning (calculation: $r = .41$, $p = .001$; reasoning: $r = .32$, $p = .009$). In other words, findings are congruent with previous studies in this field which showed that math gender stereotypes have a positive impact on math performance in the positively stereotyped group (Shih et al., 1999). Fallowing the logic of Stereotype threat theory of Steel and Aronson (1995), other studies showed that even if a negative stereotype can threaten the performance in many fields, a positive stereotype can indeed provide a performance boost (Shih et al., 1999). Overall, predictors of the performance on the math calculation tests of the 5th graders were math gender stereotypes ($\beta = .30$, $t = 2.66$, $p = .010$), and math self-esteem ($\beta = .64$, $t = 3.93$, $p < .001$). The math self-esteem was the only predictor of the math performance on the math reasoning tests ($\beta = .63$, $t = 4.14$, $p < .001$).

The final part of the research was conducted in Croatia and it regarded the administration of the questionnaires and math tests which matched with the Italian Study 3. The Croatian sample was composed of the elementary school students attending both 3rd and 5th grade. The study measured math attitudes, math self-esteem, and performance on the math tests of calculation and reasoning. The difference from the Italian Study 3 was that the test of Number Sense and Written Calculation were not administered because of the time limits and different school programme. There was a positive correlation between the performance on math calculation and reasoning tests in both 3rd ($r = .57$, $p < .001$) and 5th graders ($r = .37$, $p = .030$). When the results of the 3rd graders were analysed, there were no significant differences of math performance by gender, which confirm the finding from the Italian study. Furthermore, boys showed to have more math gender stereotypes, that means that boys were more likely to agree with the statement that boys are better at mathematics than girls ($t = 3.10$, $p = .003$). On the other hand, girls attributed higher value to mathematics than boys did ($t = -2.18$, $p = .035$). In addition, math self-esteem was positively correlated with both values attributed to math ($r = .45$, $p = .002$) and self-perception of math ability ($r = .63$, $p < .001$). In other words, students who were more confident about their abilities in mathematics also perceive themselves with higher math ability. These students were more likely to attribute a higher value to mathematics, which referred to their perception of the importance of mathematics. On the other hand, students who had higher confidence in mathematics perceived it also as less difficult (r = -.39, p = .008). Interestingly, the math self-esteem was the only predictor of the math performance on calculation tests (R^2 = .13, F(2,42) = 3.27, p = .048). Furthermore, when comparing the 3rd and 5th graders, the findings of the present research differ from what one might expect according to previous studies. Specifically, the 5th graders attending school in Croatia showed to have significantly higher levels of math self-esteem than the students in the 3rd grade (t = -2.59, p = .012). Additionally, perceived math ability was also higher in the 5th graders (t = -2.23, p = .029). These findings are particularly interesting because previous studies found a significant deterioration of math attitudes as children grow up (Dowker, 2005; Ma & Kishor, 1997; Mata et al., 2012).

Regarding just the 5th graders attending school in Croatia, math performance on the calculation and reasoning tests resulted to be positively correlated (r = .37, p = .030). These results reflect the same findings of the Italian study. Furthermore, there were no significant differences of math performance between male and female 5th graders, a part from the small difference on the reasoning Interferences test in which girls outperformed boys (t = -2.28, p = .029). Regarding math gender stereotypes, boys had more stereotypes than their female peers, so they showed to agree more with the statement that boys are better at mathematics (t = 2.31, p = .032). The same results were found among the 3rd graders. Furthermore, math attitudes were also significantly correlated. Specifically, math self-esteem was positively correlated with the value attributed to math (r = .46, p = .005) and with the self-perception of math ability (r = .65, p < .001). On the other hand, math self-esteem was negatively correlated with the self-perception of math difficulty (r = -.41, p = .014). Value attributed to math was also positively correlated with the self-perception of math ability, and negatively correlated with the perceived math difficulty. Interestingly, self-perception of math ability was the only predictor of math performance on the reasoning but not on the calculation math tests (R^2 = .071, F(2,31) = 5.88, p = .007). In other words, higher perception of one's math abilities significantly predicted a better outcome on the math reasoning tests, but not on those assessing calculation.

Regarding the fifth goal of the research concerning the cross-cultural comparison of the students attending the 3rd and 5th grade of elementary public schools in two different settings, Italian and Croatian, some results caught a special attention. Students attending the 3rd grade in Croatia scored significantly lower on both math calculation (t = 13.09, p < .001) and math reasoning tests (t = 4.19, p < .001). That was especially true for the Fluency calculation test (t = 10.06, p < .001). On the other hand, the results revealed that their negative attitudes towards mathematics are more enhanced than in the students attending school in Italy. Specifically, students attending the 3rd grade in Croatia had a significantly lower perception of their math ability, and they were also attributing lower value to mathematics. On the other hand, children in Croatia perceived mathematics as more difficult. Negative attitudes towards mathematics seen in the 3rd graders in Croatia should be investigated more in the future, and especially their relationship with math performance that was significantly lower that one would expect.

Considering just the 5th graders attending school in Croatia, the findings significantly differ from the results of the 3rd graders. Croatian students outperformed Italian peers for both math calculation tests which are the Fluency test (t = -4.30, p < .001) and the Approximate Calculation (t = -2.45, p = .016). When math attitudes were considered, students in Croatia showed significantly higher levels of the perceived math ability (t = -2.19, p = .031), but also significantly more math gender stereotypes, therefore, they were more prone to agree with the statement that boys are better at mathematics (t = .2.19, p = .031). Even though the findings confirmed the hypothesis concerning the differences in math attitudes and math performance in two samples, there are greater differences than expected. That might be explained with different social and cultural background of two countries, but also with different educational systems and learning styles. Nevertheless, the future research is needed to investigate more those differences, and to find the plausible explanations. That is especially true for the striking findings concerning more positive math attitudes in the 5th graders than in the 3rd graders attending the school in Croatia. However, given that the findings are based on the small sample size, they should be taken in consideration with caution.

6.2 Limitations and Future Research

In light of the main findings, it is important to underline the limitations of the present research so the problems can be overcome and addressed differently in the future. The research was conducted on the students attending 3rd and 5th grade of elementary school, and the students attending middle school have been left out. Most of the studies in this field were conducted on young adults or children in the early stage of math learning (Ramirez et al., 2013; Wu et al., 2012). Therefore, it is important to study the relationship between math anxiety, general anxiety, math attitudes, cognitive and executive functions, and math performance also in middle school students, especially because their math attitudes might have far-reaching consequences regarding the decisions of their future professional career. Cross-cultural comparison presented in this research enriched the research with significant findings about math performance and math attitudes in two countries, but the problem can be addressed in the more detail way in the future by increasing the number of participants, so they would be more representative of the population. Furthermore, the future research should be conducted in schools which are placed in different regions of the country, therefore, the sample would be more representative to the national sample. In addition, the Croatian study have not deal either with emotional variables, such as math and general anxiety, or with performance on the tasks of cognitive and executive functions. Considering also those variables when observing the relationship between math performance and math attitudes can explain the findings in a more precise way. Therefore, the weaknesses can be overcome in the further work which would increase the generalizability of the findings. The other limitation of the present research was evaluating math attitudes just with the explicit measures. Assessing math attitudes, especially math gender stereotypes, also with the implicit measures would probably give more realistic results. It is possible that when using just explicit measures children were concerned about giving socially acceptable answers on the questionnaire measuring math attitudes. On the other hand, children were assured about the anonymity of their answers, so that might have reduced their possible concerns. However, it would be better that future studies use both explicit and implicit measures of math gender stereotypes, so their relationship can be examined. Furthermore, assessing math anxiety also with the implicit measures would be of special importance for the research. Explicit measures typically assess just the accessible self-representations and they are usually a primary method to obtain information about MA in the school settings. On the other hand, implicit measures of MA would be of profound importance because they typically assess hidden cognitive structures or presentations which are processed automatically. Therefore, future research would benefit of implicit measures of MA such as the Novel Arithmetic-Affective Priming Task (Rubinsten & Tannock, 2010) which uses four types of primes with single-digit arithmetic problems as targets. Furthermore, also the Implicit-Association Test (IAT; Greenwald, McGhee, & Schwartz, 1998) can be used for the same purpose. Additionally, future research may also assess the students' overall cognitive ability and emotionality. Particularly, both overall cognitive ability and emotional and behavioural problems may significantly influence the performance on tasks of working memory and executive functions, and the math performance on the math tests. Therefore, in order to study those variables in a more precise way it would be advisable to use more specific tasks of the WISC-IV test (Wechsler, 2003), NEPSY-II (Korkman, Kirk, & Kemp, 2007) or the emotionality component of the MSCS scale (Bracken, 2003). The other downside regards the research not being able to investigate the cause-effect relationship of the main study hypotheses. The future research may overcome this problem by creating a longitudinal study design.

Finally, it would be particularly interesting and useful in many ways to understand what exactly happens with children between 3rd and 5th grade that their results on the math attitudes questionnaire are so different. Understanding their opinions and beliefs would be of profound interest for science in general, but especially for students' life experiences and life choices. In particular, understanding how and why children's beliefs about their perceived math ability and math self-esteem change negatively as they grow up, would help experts to develop strategies and interventions to positively influence on children's math attitudes. Getting to know better the developmental stages that come in that lifetime period might help in recognizing the triggers that deteriorate math attitudes. The question which arises is what comes to mind to children around the 5th grade so they start to think that their abilities in mathematics are low, and that math is difficult and not useful for their future. Understanding that would be significant not just for researches in that field, but especially for parents and teachers. Understanding better those mechanisms would help in overcoming the problem and developing better interventional strategies. It is particularly important to be aware of the problems concerning math anxiety and negative math attitudes, because it has been shown that those are the one that are significant for children's life choices regarding their future profession and career. Raising the awareness about gender gap in the STEM field which is probably caused by math gender stereotypes and math anxiety induced by stereotypes in female students, requires a special attention. Understanding the profound importance of the problem will consent future researchers to put together the effort to reduce the gender gap and allow both male and female students to improve their life quality and live the life with full potential.

6.3 Educational and Practical Implications

The main findings of the present research showed the importance of the emotional components and math attitudes in defining math performance. Specifically, math anxiety, math self-esteem, and self-perception of math abilities were the main predictors of math performance. That seems to be especially true for the math calculation tests. Therefore, there are different educational and practical implications of the study results. School community and students' families should be aware of the existing problems regarding math anxiety among students, and their negative math attitudes. Raising the awareness of the problem would be the first step in trying to find solutions. It is important to change students' negative math attitudes by displaying the use of mathematics on daily bases in different activities and careers (Perkins & Shiel, 2016). Teachers and parents should be aware of their influences on children's opinions, and they should pay more attention on their own math attitudes and math anxiety. Modelling positive attitudes towards mathematics can be obtained by showing importance of math in different professions and careers, but also in different everyday activities. Furthermore, teachers should provide frequent and short-duration math activities to establish short-term but attainable goals for students. Also, using unfamiliar but easy math problems would boost their confidence in mathematics (Perkins & Shiel, 2016). Different strategies can be implemented in schools and classrooms to enhance same opportunities for all students. Some of them refer to establishing temporary, mixed-ability groups in math classes, so all students would benefit from that, and they can support each other. Ensuring that everyone has same opportunities in math learning with appropriate level of challenge can be obtained also by providing a disciplinary climate in students' learning environments, ensuring that they fully understand the procedural mathematic tasks, their requirements, and underlying math concepts. Monitoring of the effectiveness of engagement strategies in mathematic classes should be implemented. Challenge in math learning can be enhanced by providing students with the contextualised math problems which require them to apply what they learned in a new context, and to understand its relevance. Additionally, cognitive activation strategies and co-operative learning should be applied. Those strategies imply encouraging students to reflect on problems, asking them to explain the answers, supporting them in learning from their mistakes, encouraging them to discuss and reflect on their learning, and to share their insights with peers. Furthermore, the cognitive engagement of student can be raised by allowing them to find their own procedures when solving problems, assigning problems that can be solved in different ways, presenting them in different contexts, giving problems with no immediate solution and encouraging discussion about the solutions (Perkins & Shiel, 2016). Regarding lower-achieving math students, a policy of early diagnosis and intervention should be implemented. Short-term changes and long-term planning are required in those strategies. Furthermore, school community should provide an extra help and support to students who need it most. Raising confidence and mathematical self-concept of lower-achieving students can be obtained by promoting successful learning and providing appropriate feedback. Additionally, setting high expectations for both high and low-achieving students would be of particular benefit to their self-esteem and self-concept.

Finally, encouraging students to participate in mathematics activities outside of the formal classroom, such as math competitions and other extracurricular opportunities, would help in modelling their math attitudes and their math anxiety. Therefore, that would positively influence their math performance and confidence. Students who are confident about math learning are those who are able to reach self-realization, to pursue their dreamful careers, and to have the best life quality.

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