UNIVERSITA' DEGLI STUDI DI MILANO BICOCCA
Facoltà di Psicologia
Corso di Dottorato in Psicologia, Linguistica e Neuroscienze Cognitive

Curriculum Psicologia Sociale, Cognitiva e Clinica
XXIX Ciclo

THE INTERACTION BETWEEN HIGH COGNITIVE ABILITIES, LEARNING AND CULTURE

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Anno Accademico 2015/ 2016

ABSTRACT

Uno degli obiettivi della psicologia cognitiva riguarda la comprensione dei fattori cognitivi legati all'intelligenza umana, con lo scopo di formulare modelli il più possibile esplicativi del funzionamento della mente. Nella mia tesi ho tentato di dare una definizione del concetto di intelligenza, intesa come l'insieme dei processi consci e inconsci che determinano la nostra conoscenza, in associazione con specifiche abilità cognitive come ragionamento e problem solving. Mi sono inoltre proposta di investigare l'interazione tra intelligenza, apprendimento e cultura, considerati come fattori esogeni che concorrerebbero alla manifestazione delle differenze individuali. A tal fine sono stati condotti tre studi. Il primo studio riguarda la valutazione dell'insight problem solving nell'infanzia, in interazione con le capacità pragmatico-interpretative del linguaggio, che si svilupperebbero grazie all'apprendimento nelle situazioni sociali. Il secondo studio si focalizza ancora sui problemi insight, ma in età adulta: la performance in questo tipo di problema è valutata in relazione alle differenze culturali e in interazione con specifici fattori cognitivi come la capacità inibitoria e la Mindfulness. Nel terzo studio, l'intelligenza e la capacità di ragionamento, in un gruppo di studenti di scuola secondaria superiore, vengono analizzate in relazione a specifici contesti di apprendimento. Le ricerche dimostrano la necessità di trovare una definizione maggiormente soddisfacente del concetto di intelligenza e il coinvolgimento della cultura e dell'apprendimento nella sua evoluzione.

ABSTRACT

One of the purposes of Cognitive Psychology is the comprehension of the cognitive factors related to human intelligence, in order to formulate explanatory models of the mind processes. In my thesis I tried to define the concept of intelligence as the sum of conscious and unconscious processes linked to our knowledge and related to specific cognitive abilities, such as reasoning and problem solving. I also investigated the interaction between intelligence, learning and culture, considered as exogenous factors which would be involved in individual differences. Three studies were, therefore, conducted. The first study concerns the insight problem solving in childhood, in interaction with the pragmatic-interpretive skills of the language that would develop through learning in social situations. The second study is still focused on the insight problems, but in adulthood: the performance in this kind of problems would be influenced by the cultural differences and by the interactions with specific cognitive factors such as the Inhibitory Ability and Mindfulness. In the third study, intelligence and reasoning skills are analyzed in a group of secondary school students in relation to some specific learning contexts. Results underlie the need to better define the concept of intelligence and the involvement of culture and learning in its evolution.

SUMMARY

INTRODUCTION

One of the purposes of the Cognitive Psychology is the comprehension of the cognitive factors linked to human intelligence and their interaction, with the aim to formulate models that are the most possible explanatory of the operations of the human mind.

Despite the amount of research conducted on the Cognitive Ability, it is still unclear by which factors it is composed, so that we are far from being able to give a good definition of this construct. It is also not yet clear whether the concept of Intelligence overlaps with that of Cognitive Ability and if they therefore measure the same object. In the literature there are many examples of studies in which some cognitive functions are associated with intelligence ((Frey & Detterman, 2004; Higgins, Peterso, & Lee 2007; Singh-Manoux, Ferrie, Lynch & Marmot, 2005), although, the latter is often categorized and analyzed in a different way (Ackerman, Beier & Boyle, 2005; Friedman, Miyake, Corley, Young, DeFries & Hewitt, 2006; Miyake, Friedman, Emerson, Witzki, Howerter, & Wager, 2000).

The terms Cognitive Ability and Intelligence are mostly used interchangeably, although the former appears to be more frequently used in the epidemiologic literature, for the cognitive impairment, and the latter in the psychological literature, for the measurement of performance. Cognitive psychologists have disagreed on the exact nature of intelligence for over a hundred years, with some favoring one general construct underlying all intelligence and others believing in multiple factors (Lubinski, 2004). The modern psychological theory views Cognitive Ability in a multidimensional way with many different abilities themselves positively correlated. This positive correlation across abilities has led most psychometricians to accept the reality of a general Cognitive Ability that is reflected in the full scale score on major tests of cognitive ability or IQ. Moreover, general Cognitive Ability seems an important predictor of a wide range of life outcomes, with similar predictive validity across groups with different average levels of ability.

Adult differences in cognitive ability appears also influenced by genetic, but despite the large role played by genetic differences in explaining adult variance in cognitive ability, there is considerable evidence that intelligence is highly malleable and the life outcomes are influenced by intelligence even more so (Dickens, 2005).

In my thesis the concept of Intelligence is identified with that of Cognitive Ability as the set of conscious and unconscious processes which coordinate our knowledge. I tried to analyze this construct, in association with the specific thinking abilities that influence Reasoning and Problem Solving in the life cycle.

Moreover, I propose to investigate the interactions of Cognitive Ability with learning contexts and different cultural environment, considered as exogenous factors that may contribute to individual differences. I therefore considered appropriate to divide the work into five parts.

In the first part I described the theories, the most significant approaches and recent positions formulated to understand and explain the functioning of Intelligence and its relationship with specific cognitive abilities in reasoning and problem solving.

In the second part, I tried to include the previous contributions in a more integrated vision of higher cognitive skills: these last which develop in multilayered and complex environmental contexts, in which culture and learning help to explain a large part of the variance of the cognitive factors considered.

After this theoretical part, I collected and reworked the experimental research conducted in these three years of PhD. The studies mean to analyze the interaction between some components of Cognitive Ability, such as reasoning skills and insight problem solving with learning and culture.

The first study concerns the insight problem solving in children and the interaction with interpretive-pragmatic factors of language that would develops thanks to learning and exercise in the social environments. Recently, a broad discussion has developed around the study of insight problem solving (Gilhooly, 2009, 2010; Gilhooly, Ball & Macchi, 2015; Sio, Ormerod, 2013), but this discussion has not yet extended to considering the characteristics of problem solving in children, except in limited cases (Bermejo & Sternberg, 1996; Sternberg & Davidson, 1984, 1998). In fact, research on problem solving during the developmental period has focused on divergent thinking, on the one hand (Defeyter, 2003), or on the so-called move problems (Garber, 2002; Kaller, 2004), on the other hand. We therefore attempted to explore the mechanisms by which children solve the insight problem to test the hypothesis that difficulties in resolution are linked to pragmatic factors, improved by communicative exchanges at school and home, and not necessarily to cognitive difficulties. We hypothesized that it is possible that a greater exercise of pragmatic interpretive skills, and not just analytic-mathematical ones, during school time, may improve performance in insight problem solving.

The second study focuses again on insight problem solving, but in adulthood. The role of learning and culture is discussed further in the performance in this kind of problem in interaction with the specific cognitive factors, that are assumed to be involved in the resolution. The study starts from the research of Hattori and Sloman (2012, 2013) that have tried to analyze the relationship between the unconscious and conscious cognition in insight problem solving, using the implicit hints. They showed that these suggestions facilitate the resolution of the problem, and shortened solution time. The results attained by the two authors, however, suggested that there are some aspects that interfere with the effectiveness of the hint as the conscious control or the metacognitive awareness (Radel, 2009, Castoldi & Nishida, 2015). Through a parallel study conducted in Italy, in Bicocca University-Milan and in Japan at the Ritsumeikan University-Kyoto, we further explored the reduced hint's efficacy from two cognitive factors, the Inhibitory Capacity and Mindfulness, that we supposed to be involved in insight problem solving. In addition, by comparing two samples of different nationalities (Italian-Japanese), we analyzed the influence of culture on the metacognitive skills and performance through insight problem solving. We expected the a possible interaction between cognitive and inter-cultural factors in insight problem solving.

In the third study reasoning skills are considered in a sample of adolescents, in relation to the different evolutionary pathways of learning that may predispose to the use of higher cognitive skills. The starting point is identified in the studies of Stanovich and West (1998, 2008) who observed that Intelligence measured with the Scholastic Aptitude Test (SAT) is related to reasoning ability in a variety of tasks. We assumed that the SAT does not measure the pure Cognitive Ability because it is too widely dependent on learning and there isn't direct relationship between reasoning ability and performance on SAT.

Overall, my intent, through these studies, was to define the concept of Cognitive Ability and its evolution, to analyze in detail some cognitive components in reasoning and problem solving, and their link with culture and learning. The analysis of the different theories, the assessment and the learning/culture interactions allowed me to further support the hypothesis that Intelligence seems the result of a complex system of relationships between the individual and the environment, that cannot be separated from the analysis of the context in which subjects are placed, in an "ecological" perspective.

CHAPTER 1.
HIGH COGNITIVE ABILITY: THEORETICAL APPROACHES COMPARED

1.1 Cognitive Ability

With Cognitive Ability we means the set of processes and mental activities that may be conscious or unconscious, such as problem solving, reasoning, thinking, deductive reasoning that coordinate our knowledge, or mental representations of principles, procedures and theories of a set domain-specific knowledge.

Cognition or cognitive processes are analyzed differently from different perspectives and in different contexts such as linguistics, neurology, psychiatry, psychology, philosophy, anthropology, systemic and with the emergence of fields of study such as artificial intelligence, it has expanded the concept of cognition is therefore now also studied by fields such as informatics.

During the execution of a task or activity there is always a comprehensive and integrated combination of different cognitive abilities. For this reason, in the presence of a change in cognitive functioning and behavior it is needed a specific evaluation to identify the nature of the disorder and the possibilities of intervention, to facilitate the acquisition of more adaptive capacity.

Historically, theories of intelligence have focused on the identification of a single factor, the "g", that has been shown to gather performance on tests of mental capacities (Spearman, 1927). The theory of single-factor explains that the various subtests of IQ measures correlate positively. Spearman demonstrated that a general factor was shared by specific measures of cognitive ability (Spearman, 1904). He noted that even though tests contained many different kinds of items (verbal, mathematical, etc.), scores on these factors tended to be highly correlated and that a considerable portion of variance in test scores could be attributed to a "general factor" or g (Spearman, 1927). Spearman proposed the hypothesis of a general factor giving some contribution to success in different forms of cognitive activity. Factor analysis was used to show which tasks were most correlated with “g” and were the best measures of general intelligence. Next empirical evidence suggests that all tests of cognitive ability, as Raven’s Progressive Matrices, share common variance (Kranzler, 1997; Neisser, Boodoo, Bouchard, Boykin, Brody, Ceci, & Urbina, 1996; Oberauer, Schulze, Wilhelm, Süß, 2005; Schmiedek, Lövdén, & Lindenberger, 2010; Süß, Oberauer, Wittmann, Wilhelm, & Schulze, 2002).

Several major theories agree that there are somewhat more specific abilities such as verbal ability, mathematical ability, spatial ability, and so on, that also exist (Bull, & Scerif, 2001; Engle, 2002; Yilmaz, 2009). They are usually considered the second level of constructs that load on “g”. However, there is considerable debate about the names and nature of these more specific abilities (Blair, 2006; Lubinski, 2004). There are thought to be much more specific mental abilities (e.g. short term memorization) at the base of cognitive ability. There is considerable support for such a conceptualization of mental ability (Ree & Caretta, 1995). Currently accepted models of cognitive ability appear to share some features. Although several alternative interpretations exist, it seems assured that a single mathematically derived factor can be extracted from tests of different mental abilities (Carroll 1993; Jensen 1998; Sternberg & Grigorenko 2002). Jensen (1998), using the method of correlated vectors, provided a summaries of research on “g”, proving the evidence for “g” and the relation of “g” to various outcomes in the real world.

However, there are numerous questions about “g” described by ongoing research and scientific dialogue: questions about the unitary nature of “g”, the biological bases of “g”, and the extent to which “g” is itself reducible. As a mathematically defined entity with large explanatory power, the general factor has been pervasive in the psychological literature for over one hundred years. However, it is important to remember that psychometric “g” is not a factor in itself but a demonstration of some undefined properties structure and function of the brain. It is only in the last two decades that the processes and functions, underlying "g", have begun to be analyzed in any detail (Duncan, Seitz, Kolodny, Bor, Herzog, Ahmed & Emslie, 2000; Gignac, 2014; Gignac, G. E., & Watkins, M. W. 2015; Morgan, Hodge, Wells, & Watkins, 2015; Nisbett, Aronson, Blair, Dickens, Flynn, Halpern, & Turkheimer, 2012). For example, a *general speed-of-processing* hypothesis (Edwards, Wadley, Vance, Wood, Roenker & Ball,2005; Kail, 2000; Leonard, Weismer, Miller, Francis, Tomblin & Kail, 2007) has been examined, using measures of inspection time and reaction time. The conceptual relation of these measures to "g" is known, but a number of studies have shown that their empirical relation to "g" goes to be small (Crawford, Deary, Allan & Gustafsson, 1998; Luciano, Wright, Geffen, Geffen, Smith & Martin, 2004). At the same time, the solid *general synaptic plasticity* thesis has been proposed as an underlying basis for "g" (Benfenati, 2007; Garlick 2002; Silva, 2003; van Hemmen, 2001). However, the synaptic plasticity argument doesn't propose a clear relation between brain plasticity and intelligence and It is not able to measure individual differences in plasticity that could correlate with psychometric "g". In apparent contrast to the previous explanations for "g", work on *fluid cognitive* functions – those associated with general reasoning and problem solving processes and referred to working memory (WM), executive function (EF), considered as fluid intelligence (gF) – offered another contribution to the study of cognitive abilities. WMC is defined by the ability to retain information during short periods of time while performing a concurrent and interfering processing. WMC relates to reasoning, problem solving, language comprehension, or learning, among other mental activities (Colom, Abad, Rebollo, & Chun Shih, 2008; Mogle, Lovett, Stawski & Sliwinski, 2008; Engle, Tuholski, Laughlin, & Conway, 1999; Miyake, Friedman, Rettinger, Shah, & Hegarty, 2001). It is a cognitive system implicating the simultaneous temporary storage and processing of any given information. Working memory shows a strong connection to fluid intelligence: working memory capacity and fluid intelligence reflect the ability to keep a representation active, particularly in the face of interference and distraction. It seems there is also a relationship of this capability to controlled attention, and the functions of the prefrontal cortex (Engle, Tuholski, Laughlin, & Conway, 1999). There are two major schools of thought on this issue in order to set the coding of various constructs. The major theories, as said before, affirm there is a common factor underlying human cognitive abilities, the “g”.

An alternative hypothesis, originally proposed by Thomson (1940), has also caught a lot of consideration. According to this hypothesis, any task receives contributions from a large set of component factors or information-processing functions. There isn’t a common reason in the universal positive correlation of factors, but simply any two tasks are likely to share at least some components. As Thomson showed, tasks with high apparent “g” correlations will be those sampling the total set of cognitive functions. For this reason, an alternative hypotheses from correlational data it is made impossible by the indeterminacy of factor analysis.

There is considerable debate about the names and nature of these more specific abilities. Current theories diverge in how to conceptualize and analyze “g” and its sub-factors. As seen, one school suggests that “g” should be conceptualized and analyzed as a higher order factor (e.g., Jensen, 1998). These researchers extract the first order factors (verbal ability, mathematical ability) and then estimate the loadings of the first order factors on “g”. A second approach suggests that “g” is the primary factor that accounts for mental functioning (Ree & Carretta, 1998; Ree, Carretta & Steindl, 2001). These theorists suggest that the "general factor" should be extracted first and then more specific abilities such as verbal ability, mathematical ability, spatial ability should be allowed to account for residual variance in cognitive ability scores. Both theoretical approaches suggest there is a hierarchy of abilities with “g” (or general mental ability) at the top (Neisser, Boodoo, Bouchard Jr, Boykin, Brody, Ceci & Urbina, S1996; Ree & Carretta, 2001; Vernon,1979).

Bartholomew, Deary, and Lawn (2009) provided a description of how uncorrelated underlying abilities might be combined by different test items, producing a “g” factor. As in the other models of “g” the underlying abilities are assumed to be uncorrelated. A “g” factor emerges because any test item shares multiple abilities. Thus there will be a tendency for items that fit some of the same abilities to be correlated, resulting in a correlation matrix between test items having all positive elements. This kind of matrix yield a first principal factor that loads positively on all test items. One problem is that, in the Bartholomew model, the correlation of “g” loadings and the heritability of different abilities are unaddressed.

In terms of the hierarchy, Vernon (1979) and Carroll (1993) both suggest a *3-stratum theory*. Stratum III (the top) contains “g”, and Stratum II contains cognitive abilities such as verbal ability, or mathematical ability. Stratum I contains about 70 tight and specific abilities such as inductive reasoning and memory span. This theoretical structure has important implications for the study of ethnic group differences on cognitive ability - both in terms of hypotheses and methodological strategies. Methodologically, this structure suggests a substantial commonality between intelligence tests and achievement tests. According to Jensen (1980), there is little distinction between the two types, and no clear operational distinction can be made because some form of achievement often are used to measure “g”. One implication is that a general aptitude test that is designed to measure how much knowledge a student has acquired (e.g., the SAT) is measuring the same latent constructs as “g” tests designed to measure general mental ability (Neisser et al., 1996). A second implication is that there are a series of related constructs in the area of cognitive ability. Although the construct of “g” is at the top of the three strata, some selection systems use only verbal or mathematical abilities. Thus, a better comprehension of standardized ethnic group differences on these other level constructs is also important.

Robert Sternberg and his colleagues (Sternberg, 1999, 2006) have moved away from traditional studies on intelligence, considering also a different kind of cognitive ability, not necessarily analytical-abstract ones. They have studied practical intelligence, which they define as the ability to solve concrete problems in real life that require searching for information and for which many solutions are possible, as well as creativity, or the ability to offer novel solutions to problems and to originate useful questions. Sternberg and his colleagues affirm that both practical intelligence and creativity correlate only moderately with analytic intelligence, measured by IQ tests, and predict significant amounts of variance in academic and occupational achievement above what can be predicted by IQ measures alone. Early Sternberg theories were disputed by other intelligence researchers (Brody, 2003; Gottfredson, 2003). Subsequent work by Sternberg (2007) improved on the original evidence and showed that nonanalytic aspects of intelligence could significantly improve the predictive power of intelligence tests, as it demonstrated later also (Hunt, 2011; Willis, Dumont & Kaufman 2011).

Recently, neurobiological theories (Duncan, Seitz, Kolodny, Bor, Herzog, Ahmed & Emslie, 2000; Gray, Chabris & Braver, 2003; Holroyd & Coles, 2002) investigated the neural basis for “g” in the light of Spearman’s and Thomson’s interpretations. One possibility - more close to the Spearman view - is that “g” may reflect some relatively confined set of neural functions, broadly contributing to success in diverse cognitive tests. In recent years, in particular, similarities have been noted between some effects of frontal lobe lesions and the normal behavior of people from the lower part of the “g” distribution, suggesting that frontal functions may be particularly central to “g” (Krawczyk, 2002; Roca, Parr, Thompson, Woolgar, Torralva, Antoun, & Duncan, 2009). Though frontal functions are not well understood, processes such as executive control, strategy formation, or monitoring the contents of working memory (Fuster, 2000; Miyake et al., 2000) are important in a wide diversity of behavior, as a major role in “g” would imply. According to this hypothesis, tasks with high “g” correlations should be characterized by specific involvement of prefrontal cortex. The alternative, implied by the Thomson hypothesis, is that increasing “g” correlations should be associated with an increasingly different pattern of neural activation, reflecting bigger sampling of all major cognitive functions.

Clearly, a neural system associated with Spearman's "g" should be recruited by many different forms of cognitive demand. Future research will then develop more detailed models of "g" in terms of frontal functions and their interactions.

Several recent papers have suggested how a "g" factor could arise despite the independence of its components, but influenced by the environment in which it develops (Bartholomew, Deary, & Lawn, 2009; Dickens, 2007; van der Maas, Dolan, Grasman, Wicherts, Huizenga & Raijmakers 2006). Dickens (2007) showed that a general intelligence factor would appear because people who show higher cognitive skill are more likely to grow in environments that cause them to develop a wide range of skills. He tied to describe the important facts about "g" without considering any underlying physiological base for the abilities correlation. So people may have physiological advantages for one or more cognitive skills, but Dickens showed that, even if these skills are initially largely independent of one another, after people interact with their environments, these skills will no longer be independent. Someone who is good at any intellectual skill is more likely to be in environments where all skills will be practiced, which will lead to the development of all skills.

This short survey highlights the fact that, despite the progress of scientific experimentation and the presence of new measuring instruments, it seems that we are still far from an unambiguous and precise definition of the concept of intelligence. It is still unclear what are the constituent factors and to what hierarchical form, if it is present, these are related to each other. This awareness has to push again the research to find new hypotheses and explanations to adequately understand the attributes of this construct.

1.2 Reasoning

Reasoning plays a vital role in all human activities, from those specifically cognitive, such as learning, development, training and development of knowledge, to creative and social ones. Inferences, that allow us to derive new conclusions from information available to us, are the means by which we can make use of the vast body of knowledge that we possess, and we have developed in the course of our existence, either implicit or aware. In this sense, the reasoning connects naturally to the more general dimensions intelligence, decision making and problem solving.

The solution of the diverse range of problems that we face on a daily requires reasoning: we use it to apply our knowledge to particular situations and improve them, in our favor. In fact, the relationship between reasoning and knowledge is ambivalent; on the one hand, the better is our knowledge, the more accurate are the inferences we make, so we can get results; on the other, our knowledge and beliefs have the power to interfere with the reasoning, giving rise to errors and misunderstandings.

Both in the scientific reasoning and that of everyday, we employ different types of reasoning. Those used primarily by humans are identified in deductive, inductive and probabilistic.

The deduction is a process where are known the requirements and the rules and it necessary to draw a conclusion (go from the general to the particular). It begins with a general rule (implication relation), applies it to a specific fact (antecedent) and draws a certain outcome (result). The conclusion will make explicit information that is present only implicitly in the premises. It is used in mathematical reasoning, while in ordinary reasoning and it is used very rarely because of the difficulty of having certain general rules.

Induction is a process where you know the premise and the conclusion, and you want to rebuild the rules (goes from the particular to the general). It starts from a specific case (the antecedent), it connects to another fact (the consequent), and draws an uncertain outcome, a general rule likely (implication relation). At last, the probabilistic reasoning is the way whereby, from individual data, we come to make generalizations, categorizations and prevision.

Logical reasoning tasks measure the ability to work flexibly with unfamiliar information and solve problems. Each test question displays a series of shapes/objects. The aim is to identify the underlying logical rules of each series and use this information to select the missing shape from a number of options or to give directly the right solution.

So, think rationally means being able to put in place of the mental expedients that potentially should be able to lead individuals to reach the correct resolution of reasoning tasks. But it is not necessarily so. There are numerous types of errors, in literature called “biases”, which may distort the reasoning appropriate for a just resolution of the problems and lead to a different solution. Often these errors are due to the use of "mental heuristics" that instead of helping, distracting solvers.

In the late 1960s and early 1970s, a series of works by Amos Tversky and Daniel Kahneman has revolutionized academic research on human reasoning. The central idea of the *Heuristics and biases* program was that the judgment under uncertainty is often based on a limited number of heuristics than an algorithmic processing identified by academic psychology. Moreover they affects the theory and research in a wide range of disciplines including economics, law, medicine, and political science. The message was revolutionary since at the same time questioned the normative adequacy of the ideals of judgment, and has offered an alternative cognitive explaining of human error without considering alleged irrationality. The initial evidence and a variety of related activities were collected in a volume of 1982 “Uncertainty judgment: Heuristics and biases” (Kahneman, Slovic, and Tversky, 1982). They developed their own perspective on bounded rationality. While recognizing the role of complexity of applications and limited processing capabilities in erroneous judgment, Kahneman and Tversky were convinced that the processes of intuitive judgment, were not more simple than rational models, but they were categorically different. They described three general heuristics: availability, representativeness, and that underlie anchoring. The first describes the tendency to attribute similar characteristics to similar, often ignoring information that should suggest otherwise. With the second people tend to estimate the probability of an event based on the liveliness and emotional impact of a memory, rather than on objective probability. Frequency of information is a key element in drawing conclusions. It is particularly used in the formation of projections and is the key to inductive. Humans with their "samples" of the memory uses the information such as a frequency index, which is prone to several types of bias. With heuristic anchor if you have to give an estimate of the probability of an event, which has systematically affected by a comparison. This type of heuristic describes the common human tendency to rely too heavily on the first information found when trying to make a decision. That is, the man appears to intentionally use the information made available in the decision-making process, according to the distance (mediation reduction strategies) as announced, although objectively not relevant to the problem.

In the first experiments that have defined this work, each heuristic has been associated with a number of prejudices: by using the availability heuristic, for example, leads to a tendency to try to remember the dramatic cases or trends of the wider world to call attention on examples of a particular type of restrictions. Some of these prejudices were defined as deviations of some true or objective value, most of the violations of the fundamental laws of probability. Kahneman and Tversky's work is critical to the development of the psychology of reasoning because it gave a birth for a critical discussion between different researchers.

Insights in this field have shown that. even if the heuristics are distinct from the reasoning of regulatory models prejudices, heuristic processes are sensitive estimation procedures that have to be no irrational measure. Then, even if the heuristics produce incorrect solutions, suggesting the underlying processes (for example, the matching function, of recovery of memory), they are highly sophisticated. Finally, these heuristics are no answers to the problems of complexity and excessive overload of information, but the normal intuitive answers to even the simplest questions of probability, frequency and forecasting.

Kahneman and Tversky's experience in teaching statistics and in research has led them to conclude that people often fail to anticipate regression to the mean, fail to give importance to the size of the sample and fail to consider the base rates when making predictions. Their three heuristics have been offered as an explanation of such errors. Heuristics are often described as something similar to strategies that people use deliberately in order to simplify the activities of judgment considered too difficult for the typical human mind. In this perspective, prejudices documented in the heuristics and biases tradition are the product of minds incapable. This conclusion is unfortunate and potentially misleading, because the biases identified in this tradition have not been significantly reduced full cognitive resources (Camerer and Hogarth, 1999 ; Grether and Plott, 1979; Wilson, Houston, Etling & Brekke, 1996). Camerer and Hogarth (1999) concluded that incentives can reduce the self-presentation effects, increase attention and effort, and reduce rash response. Tversky and Kahneman (1983) related heuristics to "natural feedback" raised from the task and that influence the judgment without being used deliberately and strategically. Research on existing anchorage, also, makes it clear that many of anchoring effects occur in the absence of any explicit adjustment (Mussweiler & Strack, 1999; Chapman & Johnson, 2002).

Sloman (1996) discusses the closest form approach heuristics and biases with the most modern conception of the mind as a connectionist computer, characterized by parallel processing and computation based coherence.

The heuristics and biases message also fits well with the pragmatic program in the field of social psychology (Tajfel,1982; Abrams, 2006). Social psychologists have had a lasting interest in social problems and their reduction. Research on topics such as persuasion, compliance and cognitive consistency has been increased by a concern with political propaganda, mindless conformity, and the distortions which arise rationalization.

The Dual Process theory (Evans, 2003) deepened the predictions of Heuristics and Biases program. The two systems view is consistent with the idea of rapid, automatic assessments that may or may not be overridden by deliberate processes, and the emergence of such a perspective should provide the explanation of how heuristics work. And follow it did, as the heuristics and biases program has reshaped both explicit and implicit assumptions about human thought in all of these areas and a few more.

Recently Gigerenzer (2001) has proposed the use of an ecological rationality according to which heuristic is rational if it fits the structure of the environment in which it is applied. Every human being has a "toolbox" in which lie the heuristics received a gift genetically and exhausted in its environment. Whenever people will find in the state to implement a choice under uncertainty, they are automatically the rescue without his cognitive system should make any effort.

Cosmides and Tooby, (1996) which are considered two of the founders of evolutionary psychology, have associated the modularity of the human mind to that of the “Swiss boxcutter”, who owns several tools each suitable for solving a specific problem. But the human mind is more flexible because it can deeply than boxcutter combine the use of various functions.

It seems that heuristics are useful for human survival; In fact, in hard environments where homo sapiens has acquired the transformation of prey into predator, and where the brain has evolved, decisions had to be quick and effective.

In many situations people could not afford to stop and think about the best strategies to achieve a certain purpose, it was necessary to act, taking heuristic decisions.

Although the heuristics are no longer needed to survive in today's world, however, they continue to act, viscerally, in human behavior with a feature that we could name intuition. The important decisions in the life of a person are not taken with the logic but with intuition, and prove accurate most of the time.

Even for less important daily activities people use little time to decide what to do, or create an instant opinion of the situations in which they are, that is, of taking decisions heuristics. In fact, every decision has a big energy cost, because mental processes are expensive, and mind tries continuously to optimize the relationship mental costs/opportunities. Humans have an ecological brain, created by evolution to adapt to the environment, trying not to sustain costs that exceed the benefits.

1.3 Problem Solving

In the previous section I introduced the concept of "intuition"; besides referring to the way of reasoning, this concept has a lot to do with problem solving. We encounter a wide variety of problems and problematic situations daily, of varying levels of complexity and importance. A problem can be defined as a situation in which a gap exists between a current state and a goal state. Thus, problem solving refers to a process by which the solver develops plans within a range of constraints in the attempt to move from the current state towards the goal state (Newell & Simon, 1972) or, more generally, to a goal-directed sequence of cognitive operations (Anderson, 1993).

The concept of a problem solving state is probably the most basic in the Newell and Simon characterization of problem solving. A problem solution can be characterized as the solver beginning in some initial state of the problem, traversing through some intermediate states, and arriving at a state that satisfies the goal. An exemplification of this kind of problem is the *Tower of Hanoi* problem, in which subjects bust reach a specific configurations of disks and pegs. In addition to these paradigmatic problems, most mathematics and mathematics-related problems can be classified as procedural problems (Greeno, 1978) which consist, as the previous ones, of an initial state, a goal state, and right problem solving operators. These problems can be solved using search techniques such as means-ends analysis which involves attempting to reduce differences between each problem state encountered and the goal state, using the operators.

Though it seems that procedural problems are resolved everyone equally, not all problem solvers use the same strategy. Larkin, McDermott, Simon, and Simon (1980) and Simon and Simon (1978) using physics problems, found that the strategies used by expert and novice problem solvers differed. Novices used means-ends analysis. They worked backward from the goal setting sub-goals. This procedure continued until equations containing no unknowns other than a desired sub-goal were encountered. Experts in contrast, eliminated the backward working phase; they are able to work forward immediately by choosing appropriate equations leading to the goal because they recognize each problem state from previous experience and know which moves are appropriate. The cognitive structures which allow experts to accurately recall the configuration of a given problem is defined as a structure which allows problem solvers to recognize a problem state as belonging to a particular category of problem states that normally require particular moves (Sweller, 1988). This means, in effect, that the problem solver knows that certain problem states can be grouped in part, by their similarity and the similarity of the moves.

However, there is a particular type of problem for which there are not used the step by step procedures and is not clear the role of experience: the insight problem. Bergson (1902), first, differentiated between an analytical mode to solve the problems, just described, and an intuitive mode of inquiry. Many other theorists have similarly emphasized the importance of a method of direct apperception, variously called restructuring, intuition, illumination, or insight (Adams, 1979; Bruner, 1966; Davidson & Sternberg, 1984; Dominowski, 1981; Duncker, 1945; Ellen, 1982; Gardner, 1978; Koestler, 1977; Levine, 1986; Maier, 1931; Mayer, 1983; Polya, 1957; Sternberg, 1986; Sternberg & Davidson, 1982; Wallas, 1926).

The introduction of the study of insight into modern psychology is generally credited to the Gestalt psychologists: most importantly, Kohler's (1925) work on intelligent problem solving in chimpanzees, Wertheimer's (1959) studies of the role of restructuring in productive thinking, and Duncker's (1945) program of experiments on insight problems. This pioneering work was followed by a relatively long rest that, judging by the resurgence of interest, has now ended (Sternberg & Davidson, 1995; DeYoung, Flanders & Peterson, 2008; Gilhooly, 2005, 2009, 2010, 2015; Knoblich, 1999; Macchi & Bagassi, 2012, 2014; Qiu, Li, Yang, Luo, Li, Wu, & Zhang, Q., 2008, 2010). A common theoretical thread that runs through some contributions is that insight requires the removal of one or more unnecessary constraints imposed by the solver on the actions that they take in attempting to solve the problem (Davidson, 1995; Gick & Lockhart, 1995; Ohlsson, 1992; Smith & Blankenship, 1991). The traditional Gestalt explanation for the insight problem solving is that solvers impose an implicit constraint (Scheerer, 1963). More others explanations (Lung & Dominowski, 1985; Weisberg & Alba, 1981; Mayer, 1995) point to different constraints but share the view that the locus of problem difficulty is centered on the solver's constrained representation of the problem.

Knoblich, Ohlsson, Haider and Rhenius (1999) and Ohlsson (1992) proposed that past experience biases the initial representation of the problem in a manner that hind to find the solution and leads a change in the problem representation. Ohlsson's (1992) general work on insight has been developed by Knoblich et al. (1999) into a more precise and testable theory that proposes key roles for both constraint relaxation and chunk decomposition, in which we find a particular type of re-encoding, for insightful moves. Knoblich Ohlsson and Raney (2001) argued that the probability that the constraint of particular problem is relaxed is inversely related to its scope, that is, how much of the problem representation is influenced by the constraint. At the same time, they supposed that the probability of re-encoding by decomposition any particular information of the problem is an inverse function of the tightness with which the information is chunked in the present representation. Chunks are lost if they can be decomposed into constituent elements that themselves are recognizable as chunks, whereas they are tight if the elements cannot be encoded as chunks. Modern *impasse-based* theories in general, and the theory of Knoblich et al. (1999) in particular, resemble earlier Gestalt approaches to insight in a different aspect.

Other approaches suggests that an impasse consists not only of one but of two essential characteristics: a constraint and a dynamic component that drives problem solving activity against the constraint. Ormerod et al. (Chronicle, Ormerod, & MacGregor, 2001; MacGregor, Ormerod, & Chronicle, 2001, Ormerod 2004, 2002), developed a model to explain behavior in insight problem solving that included a dynamic component. These bring subjects to approach the goal by the most apparently direct way: if the resultant move satisfies a criterion of progress, it will be selected. When it does not, criterion failure come and we have an impulse to seek alternative moves, which may lead to the relaxation of constraints.

Researchers seem agree when, with problems that require ‘insight’, there is a lack of clarity regarding the goal state and the steps to be taken, and the solver frequently reaches an impasse in which he or she is very uncertain just how to proceed in approaching the problem. For insight problems, solver is easily uncertain by the initial interpretation of the problem situation below to poor organization of goal-directed behaviors (Fleck, 2008); if the solver want success, he has to adaptively restructure the problem, reinterpreting the initial problem situation, revisiting the goal state, and anew searching for effective operations to reach the new goal state. Chrysikou (2006) also proposed that solving insight problems with success stays under goal-directed processes, particularly an implicit process named ‘goal-categorization’ in which is needed to generate combinations of various elements that already exist in memory to find relevant properties of various elements of the problem and dynamically organize those elements in goal-derived categories so as to satisfy the given goal. The generation and coordination of goals is central to both fluid reasoning and executive function. In a series of experiments, Duncan, Emslie, Williams, Johnson and Freer and Duncan, Parr, Woolgar, Thompson, Bright, Cox and Nimmo-Smith (1996, 2008) found that goal neglect – involving a failure to act in accordance with one or more of the requirements of a task – was more frequent in individuals who scored lower in the Cattell Culture Fair (CCF) Test of fluid intelligence. In contrast to crystallized intelligence, which primarily reflects acquired skills and knowledge, fluid intelligence particularly catch an individual's ability to cope with novel situations (Horn, 1982; Sternberg, 2008), and fluid intelligence thus measures reasoning, abstracting, and analogical problem solving ability (Wen, Butler & Koutstaal, 2013). Macchi and Bagassi (2012, 2014) offer an original contribute to the research on insight problem solving, considering that the solution to these problems is not attained by abstraction, but only by a pertinent interpretation of the context in the light of the goal, allowing the problem solver to abandon the default representation. They therefore propose the concept of interpretative heuristic, inherent to all insight problem solving processes and, more general, is adaptive characteristic of the human cognitive system. In this view, insight can presumably be seen as a dynamic process of interaction between the information provided by the text and the reader's knowledge.

Recent research has also focused on the relationship between insight problem solving and other cognitive and neuro-cognitive factors. It has been demonstrated that Mindfulness have potential in facilitating the creative responses needed for solving insight problems but not for non-insight problems (Ostafin & Kassman, 2012). For Practitioners mindfulness involves a non-conceptual awareness that does not get hung up on ideas or memories but instead 'just observes everything as if it was occurring for the first time (Gunaratana, 2002). That is, an aim of mindfulness is to limit the ability of automatically activated verbal–conceptual content derived from past experience to bias thought and behavior.

Relatively few studies of individual differences in insight have been reported, but two patterns are emerging (Ansburg, 2000; Ash & Wiley, 2006; Baker-Sennet & Ceci, 1996;

Davidson & Sternberg, 1986; Gilhooly & Fioratu, 2009; Jacobs & Dominowski, 1981; Schooler & Melcher, 1995). First, performance on procedural problems, including those that make up standard IQ tests, is associated with performance on insight problems (Davidson, 2003; Schooler & Melcher, 1995). Thus, people who are more intelligent also tend to be more insightful. Second, insight is associated with a set of interrelated abilities that involve using loose or remote associations, analogies, and pattern recognition (Ansburg, 2000; Baker-Sennett & Ceci, 1996; Jacobs & Dominowski, 1981; Schooler & Melcher, 1995). The fact that insight problem solving is associated with standard analytic problem solving and IQ indicates that it may involve some of the same processes. This does not mean that insight cannot be distinguished from standard intelligence, because insight may require additional processes not shared with standard problem solving and IQ, but it produce an issue for the individual differences approach, which has not been adequately addressed (DeYoung, Flanders, & Peterson, 2008). Demonstrating that insight problems are distinct from non-insight problems has been an important aim in insight research, largely because of claims to the contrary (Chronicle, MacGregor, & Ormerod, 2004; Gilhooly & Murphy, 2005; Weisberg & Alba, 1981). DeYoung et al. (2008) demonstrated that that the ability to solve insight problems is like the ability to solve well-defined or non-insight problems (i.e., to think convergently) plus the ability to break frame and to think divergently. This is consistent with the idea that all problems may require logical operation within an appropriate problem formulation. The ability to break frame may be necessary to avoid perseveration with an incorrect problem formulation, while divergent thinking may be necessary to generate elements of a novel formulation. Convergent thinking allows effective application of logical operators, when a problem is well-defined, but it may also contribute to identification of flaws in existing problem formulations or to validation of novel formulations. Moreover correlating verbal intelligence with insight problems, he found that only “flexibility” was linked to insight problem solving ability. This suggests that flexibility, the ability to switch repeatedly between categories or perspectives, may be particularly important in divergent thinking.

The type of cognitive ability characterized by divergent thinking and pattern recognition has usually been emphasized as the key contributor to insight (Ansburg, 2000; Duncker, 1945; Fiore & Schooler, 1998; Schooler & Melcher, 1995). Restructuring should require convergent logical analysis to help determine the inadequacy of the initial formulation and to falsify new formulations when they are generated. Once an imperfect formulation has been lost, restructuring should require divergent thinking to find new elements and structure of new formulations. The two types of thinking are complementary, and divergent processes seem likely to be necessary but not sufficient to produce insight (Fiore & Schooler, 1998). Even together, however, convergent and divergent thinking do not appear sufficient to encompass all of the abilities that might contribute to insight.

An important share on the interaction between Insight problem solving and Cognitive Ability was provided by Sternberg and Davidson: "We propose that a distinctive characteristic of the intellectually gifted is their exceptional insight ability (Sternberg & Davidson, 1983). In their opinion, the continuity of intelligence assumed by IQ tests may be masking a particularly important set of skills that distinguish the intellectually gifted from the intellectually average or sub-average. gifted children might be seen as being superior to average children in their level of general intelligence or in their levels of major mental abilities such as verbal comprehension, reasoning, or spatial visualization. Sternberg and Davidson proposed a three-process view of insight constituting what we believe to be a well-specified theory of insightful information processing: Selective Combination, Selective Encoding, Comparison. The three kinds of insights constitute three distinct sources of individual differences; the three processes are not executed in simple serial order. Rather, they continually interact with each other in the formation of new ideas. Although the model is very interesting, it emerges from the studies that the problems used are not necessarily categorized as insight, therefore it is difficult to verify the real interaction between intelligence and insight problem solution rate.

Despite the big amount of research, the findings of modern brain research have not been incorporated into research on creativity. Current neuroscientific explanations of creative achievements remain focused on hemispheric asymmetry (Carlsson, Wendt, & Risberg, 2000; Katz, 1986; Martindale, 1999). The prefrontal cortex contributes highly integrative computations to the conscious experience, which enables novel combinations of information to be recognized as such and then appropriately applied to works of art and science. Once an insight occurs, the prefrontal cortex can bring to bear the full arsenal of higher cognitive functions to the problem, including central executive processes such as directing and sustaining attention, retrieving relevant memories, buffering that information and ordering it in space–time, as well as thinking abstractly and considering impact and appropriateness. Innumerous insights turn out to be incorrect, incomplete, or trivial, so judging which insights to pursue and which to discard requires prefrontal cortex integration. The prefrontal cortex must implement the expression of the insight and orchestrates action in accordance with internal goals (Dietrich, 2004; Miller & Cohen, 2001).

Unfortunately, we are aware of the product of neural computations but not what produces it (Gazzaniga, 1998). Consequently, neither processing mode, deliberate or spontaneous, offers an explanation to the mechanism of how knowledge is computed. However, if intuition is the ability to arrive at a solution without aware reasoning (Shirley & Langan-Fox, 1996), intuition can be conceptualized as knowledge obtained while the frontal attentional system does not control the content of consciousness, which would result in a mental state in which knowing occurs without intentional reasoning.

In the light of the above considerations, the understanding of the processes involved in insight problem seems far from being achieved. The study of the relationship between conscious and unconscious thinking is still at a preliminary stage, since even neurology and neuropsychology are struggling to find discrete neural circuits within which to place the cognitive processes. The association between neuroimaging studies and cognitive psychology is far from providing a concrete answer on the activation of certain brain areas using the insight problems. Furthermore research on insight problem solving, is still anchored to the inferential methods, with which we can only deduct procedures used, without ever being able to define them completely. Anyway it seems that its elusive appearance makes the understanding of insight problem so interesting and compelling.

CHAPTER 2.
INTERACTION BETWEEN COGNITIVE ABILITIES, CULTURE AND LEARNING

2.1 Culture, learning and the development of brain's functions

In an ecological perspective, culture appears as the use of alternative possibilities that guarantee a greater evolutionary success. In this perspective, man is the more cultural animal, since he has committed the development of culture on evolutionary chances, without any comparison with other species. The cultural ability of other species is much more limited and controlled, while in humans it has become not only new dimensions, but also auto-productive and self-reflexive.

Without culture, the hominid or proto-human would find more difficulties for environmental adaptation; with the invention of culture, survival became easier, beginning in this way to another type of evolution.

The 4 or 5 million years that separate the first presence of hominids, who manipulated rudimentary tools (e.g. Australopithecus), from modern type of human as Homo sapiens sapiens, constitute a period of time, huge from the human point of view, in which the changes that have characterized the evolution of hominids have been driven by cultural advancements. The advantages of bipedalism, leaving hands free for the transport of food and objects for manipulation of tools, are placed in types of life where the cultural order solutions appear decisive (Klein, 1995). Homo erectus, which thanks to its motor apparatus and the control of fire was able to spread beyond Africa, in Eurasia, has deployed an unprecedented capacity for colonization of new environments. His brain, however, is smaller than Homo sapiens; The same Neanderthal that will be replaced by more modern forms of Homo sapiens, is the proof of the evolutionary trend towards brain growth. It is supposed that the Neanderthal Man did not have the full range of sounds typical of modern man, and it is conceivable that his anatomical limit has affected his communication skills. The most recent summary of paleoanthropological data shows that organic evolution, from which come Homo sapiens sapiens, was not uniform and the brain was the last outcome. The long periods of time when hominids and early forms of humans were already relying on specific behaviors and cultural solutions have been marked by the coexistence culture and small cranial capacity (Kurtén, 1971). In the long history of Homo erectus it is possible to collect a significant progress and accelerations, which could be linked under certain cultural innovations: manual, articulate language, use and control of fire as the stimulus factors for the expansion of the cranial capacity. With Homo sapiens still appears a modern type of brain; and it is not only an increase in size, but a greater development of both hemispheres is the cerebral cortex and association areas.

The human brain, which functions as the great coordinator of behavior, activities and fundamental functions of culture is brought to use over a very long process, which takes place for the most part outside the boundaries of the organism. Among all the animals, man is the species whose small know the longest period of dependency and aging, during which they must learn how to properly use the lower limbs to walk, hands to manipulate objects and bring food the mouth, verbal emissions to talk and communicate in a meaningful and effective way. But between cultural activities and maturation of the brain there is a circularity: if it is essential for the brain to learn and act culturally, just as indispensable are learning and cultural action to ensure the proper development and maturation of this organ. The operation of both the brain and the nervous system in general requires a social and cultural environment. The brain works only within a cultural habitat if from the point of view of organic it is inserted and secured in the skull, from a functional point of view operates in a much wider context, not organic but social (Dreyfus & Dreyfus, 1987).

The brain is undoubtedly the organ most significant of human culture. As noted by Klein (1995), a cultural evolution must be attributed to the modern type of human brain with incredible development that has quit to accompany the organic evolution. Thereafter the Homo sapiens sapiens were able to more and more shorten the times of their cultural achievements. Human culture, supported by a brain completely human, seems grown on itself, acquiring the ability to self-productivity and self-reflexivity, with art and language, that separate it from any other animal.

The recent migration of homo sapiens sapiens also allowed to disrupt the whole range of skills acquired with the evolution in the more specific capabilities that distinguish, no more men from animals, but human beings of different cultures and learning context.

2.2 The role of culture in cognition

We can affirm that intelligence develops in a cultural context, and that the cultural processes significantly affect the functioning of the human mind. Still, the experimental psychology fields went on, as if the study of the mind and culture were simply separated, (Sperber, 1995).

Most psychologists argued that universal cognitive processes might seem to be independent of cultural and historical modifications, and even some anthropologists believe that the outset of cultural life can be comprehended not to regard with the properties of human minds that lead to collective manifestation, while the analysis of the higher mental processes, culture and learning could be an indispensable factor in the psychology of individual consciousness. In fact, many cognitive processes, also basic, are highly affected by cultural variations. One example is shown by the way in which religious beliefs are created: it demonstrate how specific theories domain provide the foundation of culture, and constrain its variation. Most religious beliefs seem to develop the psychological expectations on theories of the mind, biology and physics, in specific and systematic ways. Pascal Boyer (1993, 1994) has described some ways in which religious beliefs can be made by systematic violations of the presumption of these theories. These domain-specific theories give the cognitive elements of religious belief and also can define what beliefs are likely to be common or rare in the cultural point of view. In this way, the theories put constraints on the range of possible changes in religious beliefs.

It's assumed there are also primitive basic processes by which the child is born. People all over the world are likely to present cognitive functions such as those who make categorization based on exemplary, inductive and deductive reasoning, long-term memory, the covariance detection, etc. However, if we don't refuse the existence of these basic processes, there are at least three major ways through which cognition is shaped by cultural/learning variations (Nisbett, Peng, Choi & Norenzayan, 2001): the differences on cognitive accessibility, differences on how cognitive process sort and face a problem and the differences in the cultural creation of complex cognitive functions from universal primitive cognition. Maybe There is a cultural differences in cognitive availability of thinking processes. Different people change in usual cultural practices, promoting diverse skills in the use of a cognitive strategy, or knowledge of a different domain. For this reason, a specific cognitive process may also be accessible, but not equally in different cultures and different environment (Nisbett, et al., 2001). Different cultural experience with a particular cognitive process or familiarity with a given domain, can produce cultural change in cognition: usually people can rely on cognitive strategies that are qualitatively different to solve the same problems of everyday life. Thus, although each person has essentially the same basic cognitive tools, their choice can be very different for the same problem.

Along the history of psychology, a ceaseless question regarded the relevant roles of nature and culture for individual and group differences in cognitive abilities (Degler, 1991; Loehlin, Lindzey, & Spuhler, 1975). The scientific debate begun in the middle of 19th century (Galton 1869; Nott & Glidden, 1854). Starting with the pervasive use of standardized mental test for the rating of IQ in the First World War, racial and ethnic group differences were found.. There is a question that stay on also now: if the average IQ of group differences is social, economic and cultural or genetic factors are also involved. The hereditarian position (Flint, 1999; Jensen, 1973, 2005; Plomin, DeFries, McClearn, and McGuffin, 2001; Zhang, Meaney, 2010) originated in the work of Charles Darwin (1859, 1871) and later developed by Galton (1869) supposes that a substantial part (50%) of both individual differences and group on human behavioral traits is genetic. The cultural position affirm (De Waal, Tyack, 2009; Furnham, 2001) is no need to assume any genetic causality, asserting that the differences between the groups in IQ would disappear if the environments for all individuals could be considered. On the contrary, Hereditarians use the methods of quantitative genetics, and seek to identify the environmental components of group differences observed. Culture position, in hereditarian opinion, only consider the environmental factors that rely on intellectual differences and discover the existing test bias. Hereditarians include the international model of the IQ test scores, g-loaded test components, heredity, brain size and cognitive ability relationships, Transracial adoption, regression to the mean, miscegenation, and behavior matrix race (Jensen, 2005).

The *Heuristics and Biases* movement of Kahneman and Tversky (1974) and their colleagues in social psychology (Nisbett & Ross, 1980) encouraged the view that procedures such as judgment of probability by the representativeness heuristic, and judgment of frequency by the availability heuristic, were primary, universal, genetically determined, and difficult to alter. They support the idea that some cognitive abilities are universally delivered. There is increasing evidence that beliefs or ways of creating the world are possible for humans. It emerges that there are considerable regularities in the ways that people organize the perceptual and conceptual worlds, and that these typical patterns are observable from a very early age. The most convincing evidence concern the infants' understanding of the physical world and of mental life, but there is also a good evidence that popular theories of society and religion are constrained by universal cognitive structures. Folk Theories about the nature of the world suggests that the human infant born with theories about the natural and psychological worlds. Theories of mechanics and physics (Baillargeon, 1995; Carey & Spelke, 1994; Spelke, 1991, 2007), theories of biology (Atran, 1999, 2005; Berlin, Breedlove, & Raven, 1973; Gelman, 1988) and theory of mind (Bering, 2002; Meltzoff, 1999; Greenfield, Keller, Fuligni & Maynard, 2003) appear so early that it seems probable that they have substantial innate components. But at the same time, universal content puts constraints on the diversity of human thought as the set of possible cultures. Moreover cultural differences in cognitive processes are so linked to cultural differences in primary theories about the world so that the traditional distinction between content and process seems now arbitrary.

We can say that cultural practices and cognitive processes create one another. Cultural practices sustain some kinds of cognitive processes, which then last the cultural practices.

As said above, the idea that culture profoundly influences the contents of thought through knowledge structures has been a central theme in modern cognitive Psychology (Fiske & Taylor, 2013; Goode, 2000) that has provided a set of concepts that are useful for describing these knowledge structures. Schema, for example, refers to knowledge structures that rule selective attention, retention, and use of information about a particular aspect of the world. Schemas can be about people, situations, objects, events or sequences of events. About this concept, D'Andrade (1992; 1995) has introduced the idea of cultural schemas, patterns of basic schemas that compose the meaning system of a cultural group. Those cultural schemas that are shared inter subjectively in a group are known as cultural models (D'Andrade, 1995; Holland & Quinn, 1987; Shore, 1996) that control the ways by which people read their experiences and guide action in a huge set of life domains. An important kind of cultural model is a "script" (Schank & Abelson, 1977). A script is an event schema that people suit to appropriately take part in the event, to use the objects, to play the social roles, to engage in specific sequence of actions. We can see how scripts are crucial to everyday cultural life, such as the functioning of institutions, the performance of rituals, and playing games.

These differences seem ethnographic: across cultures, people live in different social and physical environments in different cultural framings, and have different experiences, beliefs, concepts, and desires. However, going beyond these differences, researchers have analyzed the effects of cultural variation on cognitive processes, personality, and perception (Cohen & Kitayama, 2007). Particularly, some authors have assigned the role of linguistic differences in producing psychological differences. The anthropologist Edward Sapir and the linguist Benjamin Whorf proposed that the syntax and the vocabulary of different languages promote different patterns of thought: this theory is known as the famous *Sapir-Whorf hypothesis* (Whorf, 1964). Similarly, Soviet psychologists, particularly Lev Vygotsky, argued that languages as social activities constitute tools that allow children to develop symbolic thinking (Vygotsky, 1986).

Some theories and findings centered on two proximal causes of cross-cultural psychological diversity: an authoritative approach, the *extended cognition*, insist on the social and physical environment in which cognition takes place, such as routines and formal education, as well as physical artifacts (Hutchins, 2005, 2008; Clark, 1999). Because practices and artifacts vary across cultures, their effect on the mind is a potent source of cross-cultural diversity. Solid evidence has been found for the cognitive effect of linguistic differences in the coding of spatial location (Levinson, 1996), number marking (Lucy, 1997), and color categorization (Roberson, Davidoff, Davies & Shapiro, 2005). Language is one of the social practices that can potentially affect cognition to differ across cultures. Since the 1990's, a cross-cultural work in linguistics and psychology has revived interest in the *Sapir-Whorf hypothesis* (Gentner & Goldin-Meadow, 2003; Gleitman & Papafragou, 2005; Chiu, Leung, Kwan, 2007). Levinson and colleagues have shown that languages encode spatial orientation in a variety of ways (Levinson, 2003; Pederson, Danzinger, Wilkins, Levinson, Kita, & Senft, 1998). They identify three main ways of indicate the location of objects. People who use an intrinsic frame of reference locate objects by describing the relations between these objects. Speakers who use a relative frame of reference locate objects by describing the position of these objects in relation to themselves and others. Speakers who use an absolute frame of reference locate objects by using cardinal directions. Pederson et al. (1998) found that Dutch and Japanese subjects, whose languages use a relative frame of reference, preserved the relative orientation of the objects, while Mayans, whose language uses an absolute frame of reference, preserved the absolute orientation of objects. Levinson and colleagues used this and other findings to support the *Sapir-Whorf hypothesis*.

Another well-known experiment to test a linguistic relativity hypothesis is Alfred Bloom's (1981) work on counterfactual or hypothetical reasoning. Bloom noticed that the English language has an explicit linguistic device to code counterfactuals ("If I were rich, I would buy a big house") but it was not so in the Chinese language, which instead expresses counterfactual meaning by relying on context, arranged with the use of if-then statements.

Chinese are indeed less likely to engage in hypothetical or counterfactual reasoning than Westerners (Nisbett, 2001), primarily for cultural factors rather than differences in grammatical categories. The previous finding on relation between language and thinking have, however, been criticized (Gallistel, 2002; Li & Gleitman, 2002). Li and Gleitman (2002) have shown that when a salient object is present in their physical environments, American subjects can be primed to replicate the first array in an absolute manner. Since subjects who replicated the array of objects in a relative manner and those who replicated it in an absolute manner speak the same language (English), it would seem that the linguistic differences between Dutch and Japanese do not explain Pederson et al. original findings (Levinson, Kita, Haun, & Rasch, 2002). Li and Gleitman propose that the task description of the Pederson experiment, was ambiguous, because there are different ways to reproduce the original array of objects. So currently it is still difficult to prove with certainty a causal relationship between these functions.

The work supporting linguistic relativity has huge implications for psychology, and also for the cultural mediation of thought. To the extent that societies have diverged in their linguistic conventions, so cognitive processes would do. More research is needed to analyze the influence of language on thinking. Furthermore, the tools of experimental psychology can be used to examine in more detail the cognitive processes that mediate the linguistic control of thought. Finally, it is important to distinguish linguistic effects from other cultural effects on thought, for example effects due to social practices, epistemic beliefs, or expertise in a domain. These questions are particularly difficult to discuss because non-linguistic cultural patterns and linguistic conventions that correlate with the same cognitive orientations tend to occur together in societies.

A second approach to the proximal origins of cross-cultural differences (Berman, Jonides & Kaplan,2008; Gifford, 2007; Miyamoto, Nisbett & Masuda, 2006) notes that people typically show various processes and strategies for performing psychological function as categorizing, reasoning inductively, making decisions under uncertainty, etc. In any environment, these strategies do not equally well execute their functions. For instance, the different types of spatial orientation do not work equally well in all environments. As a result, people can learn to rely on the processes and strategies that are most efficient in their environments. It is therefore important that social and physical environments vary across cultures. Indeed, culturally transmitted norms directly model social environments, and cultural practices can modify al lot people’s physical environments. Culture is thus a source of diversity in social and physical environments; hence, across cultures, people might come to learn to trust different processes and strategies, because these are the best ways to fill the relevant functions in the environments where they live.

It is important to say that the idea that artifacts and social experiences influences people's cognitive processes implicates that specific cognitive processes could exist in some cultures, but not in others. In contrast, the idea that people learn to rely on the strategies and processes that are most efficient in their environment indicates that the same processes are present in all cultures, but are differently spent. Recent work on cultural differences in attention and reasoning provides a good example of the second type of cross-cultural psychological diversity (Nisbett et al., 2012).

Nisbett (Nisbett et al. 2001; Nisbett, 2003; Norenzayan, Choi, & Peng, 2007) distinguish two cognitive styles: The *analytic cognitive style* that involves detaching focal objects from their context (field independence), focusing on the properties of objects in contrast to relations between objects and by contrast, the *holistic cognitive style* that involves paying attention to the context, focusing on the relations between objects, and relying on similarity to classify and reason. Nisbett and colleagues showed that Westerners exhibit an analytic cognitive style, while East Asians display a holistic cognitive style. Westerners' attention abstracts objects from their context, while East Asians' attention relates them to their context. Using an eye-tracking method, Chua, Boland, and Nisbett (2005) have shown that Chinese and American students have different patterns of visual exploration of a scene, Americans focusing on the main object of the scene, and Chinese paying greater attention to the background. They propose that the differences between Westerners' and East Asians' attentional patterns might result from the differences between the visual scenes that are characteristic of the two cultures. Westerners and East Asians also think differently in a large number of contexts. According to Norenzayan, Smith, Kim, and Nisbett (2002), when asked to assess the similarity between an object and members of two different categories, East Asians refer on the family similarity of the object to the members of each category, while Euro-American search properties that are necessary and sufficient for belonging to one of the categories.

Work by Choi, Nisbett, and Smith (1997) indicates that Koreans make less use of categories for purposes of inductive inference than Americans. For example, they were less influenced than Americans by coverage of the category, unless the category was made salient in some way. Categories are apparently less spontaneously salient for Koreans and, hence, are less available for driving generalizations. Work by Norenzayan et al. (2000) suggests that it might be more difficult for them to learn how to classify objects by applying rale systems. The results of cited studies indicate that East Asians rely less on rules and categories and more on relationships and similarities in organizing their worlds than do Americans. East Asians preferred to group objects on the basis of relationships and similarity, whereas Americans were more likely to group objects on the basis of categories and rules. Americans were more likely to rely spontaneously on categories for purposes of inductive reasoning than were East Asians and found it easier to learn and use rule based categories.

Many differences between different cultures, mostly from East and West, also, were found in the deductive reasoning because people often find typical arguments to be more convincing than atypical ones (Sloman, 1993). Norenzayan and coll. (2000) asked Korean, Asian American, and European American participants to evaluate the convincingness of a series of such arguments. The responses of participants who received only typical arguments were compared with those who received only atypical arguments. As expected, Koreans showed a large typicality effect, being more convinced by typical than by atypical arguments. European Americans, in contrast, were equally convinced by typical and atypical arguments. Asian Americans' responses were in between those of European Americans and Koreans. In another study, Norenzayan and colleagues (2000) presented participants with syllogisms that were either valid or invalid and that had conclusions that were either plausible or implausible. In addition, some arguments were presented in abstract form. Koreans and Americans were instructed to evaluate the logical validity of each argument and decide whether the conclusion followed from the premises. Results showed that, overall, there was an effect of logic as well as of knowledge, consistent with past research (Chapman & Chapman, 1959). Thus, participants correctly judged valid arguments to be more valid than invalid ones, and incorrectly judged arguments with plausible conclusions to be more valid than arguments with implausible conclusions. As predicted, Korean participants showed a stronger "belief bias" for valid arguments than did American students, more inclined to judge valid arguments as invalid if they had implausible conclusions. Importantly, this difference cannot be attributed to cultural differences in the ability to reason logically, since both cultural groups showed equal performance on the abstract items. The results indicate that when logical structure conflicts with everyday belief, American students are more willing to set aside empirical belief in favor of logic than are Korean students.

Congruent with the "*extended cognition*" perspective described earlier, the adaptive significance of cultural information suggests that natural selection can be expected to have exercised the human mind so as to maximally exploit this resource.

Through this small "review" about cognition and culture, we tried to explore the extent to which cultural information shapes cognition, and to examine how the acquisition of cultural information may be underlain by evolved psychological mechanisms of varying degrees of domain specificity. This may give the impression that cultural information is a static feature of the environment. However, because culture exists in the minds of individuals, the relationship between culture and cognition is bidirectional, and thus dynamic. Specifically, because culture is instantiated through processes of the transmission, retention, and application of information, the composition of culture is subject to the influence of actors' minds, as information that is more likely to be transmitted, retained, and applied will come to predominate, while information for which this is less true will become rarer, and may disappear entirely (Fessler, Machery, 2012).

2.3 The role of learning in cognition

As was the case for culture, experimental psychology also often underestimated the relationship between the different learning contexts and the development of specific cognitive abilities. Learning is a process in which people discover a problem, invent a solution, produce the solution, and evaluate the outcome, thereby leading to the discovery of new problems Argyris (2003).

Widespread conception of learning and reasoning claims intelligence largely as a property of the individuals minds. This belief is prevalent in educational setting, which are largely affected by lonely intelligence. However, it's possible to affirm that mind rarely works alone. Intelligences are distributed across mind, persons and the symbolic an physical environment, both natural and artificial (Pea, 1993). Research has provided significant information and understanding of conditions in which learning has general effects in human cognitive performance (Singley & Anderson, 1989). For instance, the contextual approach has contributed studies of transfer between practices, proving that people with previous experience in different practices learn and perform in new practices in ways that reflect those previous activities both at school and out of the school (Anderson, Greeno, Reder, & Simon, 2000; Beach, 1995; Lave, Smith, & Butler, 1988; Saxe, 1990).

In this view cognition is built on the existing knowledge and beliefs that people already have and are established in experiences (Piaget 1978; Vygotsky 1978). When people learn, the previous knowledge is integrated with the new skills (Fraser, 2015; Lage, Platt, & Treglia, 2000; Meyers, & Jones, 1993). Reviewing the empirical relationship between learning and intelligence, Jensen (1989) concluded that whatever intelligence (g) is found among the parameters of the learning curves derived from a number of different learning tasks is essentially the same general factor, g, that is found among any large number of diverse tests of mental abilities. Moreover, Jensen pointed affirmed the same information-processing components are implicated in both learning and intelligence with the variable of speed being the most important for individual differences.

Kyllonen and Christal (1990) reported that general reasoning ability and general working memory are highly correlated factors. They concluded that individual differences in working memory, rather than speed of processing, may be the central components underlying individual differences in reasoning: attentional resources support general reasoning ability. According to this view, general ability predicts performance during early learning, where working memory and attention resources are most critical; the influence of general ability on learning reduces with practice.

The fact that cognitive ability tests predict academic performance is well-documented (Chamorro-Premuzic, 2007). Indeed, academic performance has been the criterion for validating IQ tests for a long time, and researchers barely refer to these tests as intelligence measures if they did not correlate with academic performance. However, IQ tests rarely account for more than 50% of the variance in academic performance (Chamorro-Premuzic & Furnham, 2008; O'Connor & Paunonen, 2007), suggesting that other factors than ability contribute to individual differences in academic performance.

Cause seems students' approaches to learning. Biggs (1987) distinguished between three major approaches, namely *deep*, *achieving*, and *surface*. *Deep* learners are intrinsically motivated and enjoy exploring the subject matter as much as they can. On the other hand, *achieving* students are extrinsically motivated and want to do well because of the prizes involved to high performance. Finally, *surface* learners are interested in learning only the indispensable elements and pay minimum effort to achieve this (Chamorro-Premuzic, Furnham, & Lewis, 2007). Wilding and Valentine (1972) found that achieving learning predicted exam success. Snelgrove and Slater (2003) found that deep learning was positively related to academic performance, whereas surface motive was negatively related to exam results. Duff (2004) on the other hand, found that deep and surface learning correlated negatively with assignments grades on an MBA, while strategic approach was a positive correlate.

As well as the readiness to learn, the data suggest that much of the causal pathway between IQ and schooling direct the importance of the quantity of schooling people attains. Schooling bring up the development of cognitive processes that fortify performance on most IQ tests. In Western nations, schooling conveys this influence on IQ and cognition through practices that appear unrelated to systematic variation in quality of schools. If correct, this could have implications for the meaning one attaches to IQ screening and prediction as well as for efforts to influence the development of IQ through changes in schooling practices (Ceci, 1991).

Although cognitive ability remains the best single predictor of scholastic outcomes (Sattler, 1992), the construct has not demonstrated sufficient utility for educational intervention. This would appear that the qualities underlying intelligence are inseparably linked to complex networks of genetic and environmental factors that are essentially unalterable in the lives of most children. It isn’t already known how to improve noticeably the cognitive abilities of students, and intervention programs that are sure by such expectation have shown little positive merit (Glutting & McDermott,1990; Ysseldyke, Dawson, Lehr, Reschly, Reynolds & Telzrow, 1997; Spitz, 1987). Although striking technical validity for prediction, intelligence tests tend to offer very limited treatment validity (Neisworth & Bagnato, 1992; Ysseldyke & Christenson, 1988). Keogh and Becker (1973) have argued that assessment activities should not be designed solely to document or confirm deficits, but to provide intervention information that would prevent future problems.

For these reasons, it is necessary to consider the interaction between learning and cognitive skills through a larger perspective. The reconceptualization of cognition as a social phenomenon has been proposed by researchers in ethnomethodology, conversation analysis, and discursive psychology (Edwards and Potter 1992; Maynard and Clayman 1991; Molder and Potter 2005; Schegloff, 2006). Cognitive, affective, and other exhibitions, versions and descriptions, are built on social context.

Traditional instruction (mostly science) has tended to exclude students who need to learn from contexts that are real-world, graspable, and self-evidently meaningful. There are also calls for students to learn complex cognitive, social, and communication skills as part of their middle and high-school experiences to help them develop cognitive practices. In addition, there is a need for students to learn in ways that allow them to put it into practice solving problems and making decisions, rather than just store collections of abstract facts. Deep and effective learning would best promoted by situating learning in purposeful and engaging activity (Collins, Brown, & Newman, 1989).

Cognitive training (Collins et al., 1989) suggested that learning focus on implementation of important skills in real contexts of use and that the content that needed to be learned could be learned in that context. It also suggested putting the teacher in the role of modeler and coach and articulator of process, gradually having students take over these roles. Anchored instruction (Zech, Vye, Bransford, Goldman, Barron, Schwartz, & Mayfield-Stewart, 1998), knowledge integration (Bell, Davis, & Linn, 1995), and *cognitive flexibility* theory (Spiro,1988), Constructionism (Harel & Papert, 1990; Kafai, 1996) suggested that students engage in more than one challenge and with a wide variety of resources to learn skills and knowledge a wide enough variety that will allow them to lean the richness of each targeted concept and skill. All of these approaches suggested that under these circumstances, learners could learn to ask important questions, carry out investigations, interpret data, and apply what they had learned, therefore, trying to build their intelligence.

The Literature (Bransford et al., 1999) suggests that considerable time is needed for learning, that learners need to feel accomplished along the way, that much time should be spent on practice (Ericsson, Krampe, & Tesch-Romer, 1993) that includes monitoring one's learning and experience of learning; the students should have the opportunity to see the transfer implications of what they are learning (Anderson, Reder, & Simon, 1996; Klahr & Carver, 1988). They need to both experience the concreteness of particular problems and learn the abstractions and principles (Singley & Anderson, 1989) and that transfer can be improved by helping students become aware of the reasoning of learning (Palincsar & Brown, 1984). Such practices engage students actively in focusing attention on critical issues, critical features of problems, and critical abstractions and principles and on evaluating their own understanding.

The scientific reasoning literature (Dagher, 1998; Kuhn & Pearsall, 2000; Mintzes, Wandersee, & Novak, 2005; Monk & Osborne, 2001; Morris, Masnick, Zimmerman, & Croker, 2012) is rich in descriptions of scientific reasoning, suggesting reasoning skills students should have learn. An essential part of this development of scientific reasoning skills includes learning to distinguish theory from opinion (Kuhn & Pearsall, 2000) and opinion from evidence (Zimmerman, 2012). These scientific reasoning skills, as well as skills for planning, communication, and independent learning.

A complete cognitive theory will include more specific explanations of differences between learning environments, considered as effects of different contexts. It is sometimes asserted that the cognitive perspective ignores the relation between learning in school and activities of work and other social participation outside of school (Kolodner, Gray, Fasse, 2003). Research has provided significant information of conditions in which learning has general effects in human performance. simplifying, the cognitive approach has provided analyses of information structures in a lot of tasks that explain amounts of transfer between tasks in reckonable detail (Singley & Anderson, 1989). The "*situative*" approach has added studies of transitions between practices, showing that individuals with previous experience in different practices learn and perform in new practices in ways that reflect those previous activities, both from school learning to non-school learning and from non-school to school learning (Beach, 1995; Lave, Smith, & Butler, 1988; Saxe, 1990).

The contemporary view of the relationship between learning and cognition in accordance with the constructivist theory is that knowledge is based on the existing knowledge and beliefs we already have and are grounded in experiences (Piaget 1978; Vygotsky 1978). People learn by doing. And when they learn, the previous knowledge does not go away; it is integrated with the new knowledge (Fraser, 2015; Lage et al., 2000 Meyers et al., 1993). The implication of current theories is that good instructional practice consists of designing learning environments that stimulate students to construct intelligence. This involves activities that provide students many opportunities to think, reason and reflect on their learning, as well as discussing and reflecting with their peers. According to this latter approach, the teacher is like a coach, a co-learner, a facilitator, rather than as a conduit of knowledge in a teacher-centered classroom, through lectures. A student-centered approach is more effective in helping students build a deeper understanding of reasoning and to be able to transfer what they have learned in subsequent classes or in the real world.

Clearly the learning and development of cognitive skills can not only be attributed to the different learning environments, but can also relate to individual differences, such as motivation, interests, preparation. With International demands to raise academic standards for all students, educators and researchers are searching for ways to maximize performance while considering individual differences. Therefore, research efforts (Schunk & Zimmerman, 1998, 2012) have focused on how self-regulated learning can facilitate achievement. By definition, self-regulated learners engage in academic tasks for personal interest and satisfaction and metacognitively and behaviorally activate participants in their own learning. Therefore, self-regulated learners are typically high achievers (Zimmerman & Martinez-Pons, 1990). Students scoring in the top 1 % on an achievement test more frequently use specific self-regulated learning strategies that optimize personal regulation (organizing and transforming information), catching the instant environment (reviewing notes, seeking peer assistance, and seeking adult assistance). Although high achievement is related to the use of self-regulated learning strategies, there is substantial variation in self-regulated learning among high achievers (Zimmerman & Martinez-Pons, 1990). Given that high self-regulated learners can actively facilitate their academic progress, variation in self-regulated learning among high achievers suggests that some of these students will continue to excel, while others may be at risk for underachievement (Risemberg & Zimmerman, 1992). Individual variation in self-regulated learning among high-achieving students may be related to differences in advanced reasoning, differences in achievement goals, and gender, (Mills, Ablard, & Gustin, 1994) but presumably also for exogenous causes. For example, the Scholastic Aptitude Test (SAT) is often used to distinguish among high-achieving middle-school students for selection into challenging summer courses. It could be argued that students with the highest advanced reasoning are more aware of self-regulated learning strategies and use them to a greater degree than students with lower reasoning. Moreover some students have performance goals, focusing on performance and believing that poor performance indicates low academic ability (Dweck, 1986). Therefore, students with this view avert the risk of appearing intellectually incompetent by avoiding challenge.

The development of educational interventions should be informed by the growing bodies of research in cognitive and social science. This kind of research is increasing the understanding of processes of learning, conceptual development, problem solving, reasoning, communication, and social participation. Alternative educational practices, including prospective innovations as well as currently prevalent practices, should be evaluated and analyzed using appropriate methods that are developed in conjunction with that research (Garfield, & Ben-Zvi, 2009).

CHAPTER 3.
THE INSIGHT PROBLEM SOLVING IN THE DEVELOPMENTAL AGE: AN INTERPRETATIVE-PRAGMATIC APPROACH TO LEARNING

3.1 Introduction

Despite the wide interest researchers have recently shown in insight problem solving, contributions examining children remain relatively scarce (Bermejo, Sternberg, 1996; Davidson, Sternberg, 1984, 1998). Research on problem solving during the developmental period has focused primarily on so-called *move problems* (Bull, 2004; Defeyter, 2003; Garber 2002; Sikora, Haley, Edwards & Butleret, 2002), for which solution process would not involve restructuration, as the reconfiguration of the problem space. A classic example is the test of the Tower of Hanoi or London, which is used to evaluate executive functions, particularly the planning of a course of action (Anderson & Anderson, 1996; Culbertson, 1998; Darryn, Sikora, Haley, 2002; Fierman, 1996, Kaller, 2004). This test involves the use of a strategy to solve a procedural-type problem with an overall objective that can be deconstructed into specific hierarchical sub-objectives and for which the process of obtaining the appropriate solution is provided default and includes a limited number of moves.

Additionally, in relation to childhood, strategies for solving *arithmetic word problems* were investigated (Brissiaud, Sander, 2010; Geary, 2004; Hegarty, 1995; Passolunghi, 2004); these kind of problem contains real-world situation that requires a mathematical solution. The resolution of *arithmetic word problems* involves several distinct cognitive processes: comprehension of the problem, which is characterized by the complex activity of syntactic processing (Mayer & Mayer, 1998), representation of the problem, planning and supervision, and identification of individual sub-goals. In all these cognitive processes, the role of executive functions and in particular of the working memory are relevant (Passolunghi, 2004).

Even in this type of problem, however, it does not seem that the restructuration plays a decisive role for resolution because, as the model shows, the process is primarily procedural in nature.

3.2 Pragmatic factors in insight problem solving

Research on insight problem has focused mainly on adults presumably because of the poor performance that has been observed in this population (Ghilooly, 2005, 2015; Knoblich, 2001; Metcalfe, Wiebe, 1987; Newell & Simon, 1976; Schooler, 1995; Segal, 2004; Sio and Ormerod, 2013; Weisberg, 2014); among the different approaches adopted to study insight problem solving in adulthood, there is the *psycho-rhetoric* approach, that refers to pragmatic factors (Carpendale, McBride & Chapman, 1996; Mosconi 1973,1974,1990) according to which the skills of interpretation and understanding seem crucial for problem solvers. In this view, restructuration would depend on the ability to disambiguate the format of the problem to discover the relevant meaning to solve the task. Context, appears to enhance cognitive processing by increasing the specificity of inference (Chaigneaua, Barsalou, Zamani, 2009). In the study of classical reasoning tasks the intention of the speaker and the aim of the task, have usually been considered as an obstacle to the solution. According to pragmatic view however, this interpretative processing is instead the core of thinking, a way of functioning shared by both language and thought.

Thinking and speaking could be considered two sides of the same cognitive process, which is close to the concept of effective communication. Linguistic mechanisms are deeply connected with interactive thinking, and communicative heuristics fills the mind (Levinson, 1983, 1995). The presupposition of this hypothesis is that a context is always predominant and the heuristics may also be used when rules are applied to abstract tasks (Stanovich, 2009). Restructuring in insight problems, therefore, could be a form of overcoming the default interpretation, and productively re-interpreting the relationship between data and the aim of the task, guided by the principle of relevance. Hence, overcoming fixation is not achieved by abstracting from the context, but contextualizing further and in greater depth. If this is true, then a relevant reformulation of the problem should produce an increase in restructuring and in the solutions.

The use of pseudo-parallel versions method provides valid evidence to test this hypothesis. The pseudo-parallel version of an insight problem is the reformulation of the problem without changing the objective data but only clarifying the meaning of the message. Deciphering the text of a problem using insight and understanding/interpreting the message, in fact, seem to be prerequisites for being able to obtain solutions (Mosconi, 1990). In fact, the formulation of insight problems would be crucial to the solution because some expressions may hide the solution itself; this is could due to the cognitive meanings that they assume at the moment of formulation.

Moreover, insight can presumably be seen as a dynamic process of interaction between the information provided by the text and the reader's knowledge. In fact, understanding cannot depend only on the characteristics of the text; it also relies on the subjective aspects of the problem-solver relative to the content of the text. Precisely for this reason, understanding is an active process of meaning that also involves inferential mechanisms that are useful for processing the context and the information implied in the text, including non-insight problems (Bunch, Halford, Graeme, 2007; De Beni, 1995; Lynch, van den Broek, 2007; Passolunghi, 2001, 2004; Vista, 2013), thus allowing a correct interpretation of the meaning contained in the delivery format (Grice, 1975; Levinson, 1983, 1995, 2013; Sperber & Wilson, 1986, 2012).

If the pragmatic approach has only involved the adult population in the study of insight problems, on the contrary it has been used with children to study the resolution of the classic Piagetian problems.

3.3 Pragmatic factors in children

The importance of pragmatic emerges in studies of the development of the reasoning, in particular, those relative to the classic Piagetian tasks. Criticism commonly made of Piaget's experiments is that understanding is not the same thing as task completion.

Experiments, where the different aspects of the tasks have been manipulated and that have received positive answer from children who had failed the Piagetian tasks, are numerous (see Donaldson, 1978 for a review). For example, egocentric responses obtained in the three mountains experiment seemed to be due mainly to the way in which the task was presented, rather than an inability to conceive of different perspectives (Hughes and Donaldson, 1979). The latest research was not intended to undermine the theory of Piaget but to recognize that self-centeredness or pre-logical reasoning is typical of the pre-operative period.

However, these studies showed that misleading conditions might not bring to correct performance. Also, the merit of this research is that it has drawn attention to the child's role (Camaioni, 1994). In the original tasks, in fact, the pragmatic interpretation given by the children did not correspond to the semantics interpretation of the investigator, and this discrepancy gave rise to mistakes apparently attributable to the incomplete development of some cognitive operations (Hall, 2006). The structure of the task used to lead the children to attribute to the experimenter different intentions from the ones implied (McGarrigle and Donaldson, 1975; Politzer, 1993; Politzer & Macchi, 2000; Rose & Blank, 1974).

Some experiments derived from Piaget (McGarrigle & Donaldson, 1975; Politzer, 1993; Rose & Blank, 1974; Setti & Caramels 2007), relating to conservation and the judgment of inclusion in classes, have already shown that children 8-9 years old are capable of solving these tasks if the experimental conditions allow them to understand the purpose of the experimental question posed to them. Another interesting contribution, considering pragmatic competence as an indispensable factor in the study of reasoning in children of the same age, was provided by research into the acquisition of scalar implicatures belonging to a linguistic scale (Sala, Macchi & Bagassi, 2006; Bagassi, D'Addario, Macchi, Sala, 2009). The latter contains terms that adhere to the same grammatical category, ranked according to the degree of information and a principle of inclusion that the stronger term also contains the weaker term, but not vice versa (Gazdar, 1979; Horn, 1973).

The scalar implicature is inferred from the violation of the Maximum Gricean Quantity (1975), when the interlocutors must make appropriate contributions to the context, without being more informative than necessary. The quantifiers (some/all), the logical connectives (or/and), some adjectives (beautiful/gorgeous), and modal words (can/must) are examples of such scales. From the pragmatic point of view, the use of a less informative term, as in the case of "some" instead of "all", implies the exclusion of the more informative term. This process should not, however, occur in accordance with the principles of logic that, in contrast, consider quantifiers interchangeable.

Research with children has shown that their initial representations of scalar terms were relatively weak because the adjective "some" seemed logical in nature before the children surrendered to their emerging pragmatic interpretations. It seemed that the children would consider the terms of a relatively weak scale as logical, before becoming aware of their pragmatic potential (Chierchia, Crain, Faults, Gualmini and Meroni, 2001; Olsen, & Crain, 2000). Recent studies (Bagassi et al., 2009; Sala, Macchi & Bagassi, 2006; Feeney, 2004) have instead disproved this hypothesis: if the intention of the experimenter and the request of the task are adequately communicated, children of eight years old use scalar implicatures like adults.

The pragmatic laws therefore seem to play a key role in determining the inferences from children, in their interpretation and in understanding of the conversation, just as they do for adults. Replies that are apparently compatible with the rules of classical logic can actually be attributed to a misunderstanding of the application of the task.

3.4 Insight problem solving in children

As told before, the pragmatic approach has not been used in the study of insight problem solving in childhood and, at the same time, few researches have been performed with this population on insight problems.

The Gestalt school was the first to explore experimentally and systematically, even in children, the phenomena of insight and restructuration and the processes that occur in solving new problems. Wertheimer (1945) called these processes "productive" to distinguish them from mere repetition or imitation or a combination of what has already been learned. According to the Author, in fact, there are two types of thinking: structurally blind thinking, which is recognizable by the reproduction of the thought processes performed in other situations without awareness of their inadequacy and *productive thinking*. Wertheimer (1945) distinguished the functions performed by logic from the functions allowed by *productive thinking*. In this perspective, creativity has been considered an important component of the solving process, understood as a particular mode of thought that involves originality and fluidity, which breaks with the existing models and introduces something new.

Guilford (1959) developed the concept of *divergent thinking*, or the ability to produce a range of possible solutions to a given problem, in particular for a problem that does not have a single correct answer. In contrast, through what Guilford called *convergent thinking*, solvers converge on the only possible solution to the problem. The limit of traditional tests of intelligence and reasoning given to children would be identified by their mainly being designed to assess *convergent thinking*. What Guilford and others (Cattell, 1987; Gilhooly, 2015; Gardner, 1989; Runco, 1992; Sternberg, 1984) have attempted to show is that, by emphasizing *convergent thinking*, *divergent thinking* has been completely neglected and thus penalized in educational contexts: the study of thought, in fact, has involved logical-mathematical intelligence. In this paradigm, creativity has often been regarded as the ability to perform surprisingly rapid analysis, deductions and inductions, thus being identified with high intellectual endowment and the ability to score highly on mental tests that aim to measure general intelligence (Antonietti, 2013; Barron, 1969).

In addition to the Gestalt school, the nature of insight in children was also investigated by Sternberg (1984, 1985, 1995). According to this author, insight consists of three psychological processes: selective coding (a selection of relevant information rather than irrelevant information); selective combination (combination of what originally appears to be isolated information); and selective comparison (comparing newly acquired, related information with that already held). Insight is not conceived as an extension of the normal acquisition of knowledge but rather as the exploitation of intuitive processes and originality in how these processes are applied.

In this perspective, Sternberg & Davidson (1984) and Bermejo & Sternberg (1996) studied performance through insight problem-solving in children in relation to the level of IQ, understood as the inter-dependence between so-called *fluid intelligence* - the ability to think logically and to solve problems in new situations independently of acquired knowledge - and more specific cognitive functions, such as attention and memory, which are involved in executive processes. These authors also attempted to show a relationship between the results obtained on insight problems with verbal and mathematical content. According to the authors, in agreement with the model of insight previously discussed, subjects with high IQs would select the most important information more quickly than children with normal intelligence. The specific element of insight involves the coding of the selection process that makes it possible to choose the data that can help to solve the problem. Individuals with average intelligence would derive greater benefit from cues than those with high IQs, who do not need any kind of help. This difference would suggest that the peculiarities of selective coding represent one of the features of insight into thinking (Sternberg & Davidson, 1984; Sternberg, 1985). Regarding the relationship between verbal and mathematical problems, the Bermejo’s study (1996) did not reveal a significant difference because both types of problems appeared to offer the same measurement of the construct of insight and the processes involved in it.

The research and studies mentioned above overlooked some essential components, considered for example in arithmetic word problems, including pragmatic-interpretative skill. An effort toward the involvement of understanding in problem solving was undertaken by Howard, McGee, Shin, Shia (2001), who intended to determine whether the three types of intellectual skills - analytical, creative, and practical- that Sternberg had previously assumed in his Triarchic theory (1984), predict factors such as understanding content and problem solving. The results indicate that a greater use of practical skills to implement and apply problem solving processes to concrete problems and daily life would predict greater comprehension and problem-solving skills. High analytical skills instead explain understanding but not the ability to problem solving. Finally, high creative abilities would predict the ability to solve problems but not understanding.

Although very interesting, the results of this study is based on a population of adolescent, whose cognitive skills are more like those of adults than those of children. Moreover, as previously claimed, in our perspective insight problem solving could be strictly connected with pragmatic factors also in childhood, but no studies has already been run to test this hypothesis.

3.5 THE EXPERIMENT

In our study we wanted to test the hypothesis that pragmatic factors influences insight problem solving also in childhood; with children attending the 5th grade of primary school, we attempted to prove that a relevant understanding of the text would promote the resolution of this particular type of problem. This choice was justified, as already mentioned, by the lack of studies in childhood and the need to complete the results of research conducted in adulthood (Ghilooly, 2005, 2015; Knoblich, 2001; Metcalfe, Wiebe, 1987; Newell & Simon, 1976; Schooler, 1995; Segal, 2004; Sio and Ormerod, 2013; Weisberg, 2014). If there is an insight, even in children, according to our hypothesis, restructuration would depend on the change in the understanding of the terms of the problem, associated with the change in the coding, according to which the child would read the message given (Mosconi, 1990).

So, we hypothesized that the difficulty in insight problem solving resided in the formulation of the text. We used five well known insight problems (Dow & Mayer, 2004; Frederick, 2005; Gilhooly, 2005) and we created two pseudo-parallel versions for each problem arranged in ascending order of comprehensibility. We proposed a control version, consisting of the original text of the problem and two experimental versions. In the latter two, were removed those discursive items that could hinder interpretation relevant to the purpose of the task but did not contain any implicit suggestion of the responses, and all of the other components were left unchanged.

3.5.1 Method

Participants

The subjects were 144 children[1] (mean age 10.45 years old, SD = 0.49; Male = 66, Female= 78) attending the fifth class of one primary schools in Milan and two primary school in Sesto San Giovanni near Milan. The three schools were similar in terms of demographics. All the children, tested in Italian, were Italian speakers. The participants didn't have a learning disability certificate. All of the students were enrolled in full-time education services.

Eight teachers and eight classrooms volunteered to participate. People in each classroom were randomly assigned to one of three experimental conditions: a control group

[1] Signed parental consent was obtained for all participants. Information about parental education was not required for this study.

(N = 47; mean number of student per classroom = 15.6; SD = 4.16 ; Male = 22, Female = 25), the first experimental group (N = 29; mean number of student per classroom = 14.5; SD = 6.36; Male = 16, Female = 13) and the second experimental group (N = 68; mean number of student per classroom = 22.6 ; SD = 2.08; Male = 28; Female = 40).

Materials

Below are listed the problems used in our study, containing discursive ambiguity that, according to our hypothesis, impedes a correct interpretation. We will also present a depth of the reformulation used with the Bat and the Ball problem in light of the particular importance that this problem has encountered in the Literature - see the experimental manipulations of the other problems in Appendix A.

1) *Zoo* problem:

Yesterday I went to the zoo and I saw the giraffes and ostriches. Altogether they had 30 eyes and 44 legs. How many animals were there?

In this problem, the critical issue resides in the inability to inhibit irrelevant information (in this case, the 44 legs), thus preventing the proper achievement of the solution.

2) *Ancient Invention* problem:

There is an ancient invention still used in parts of the world today that allows people to see through walls. What is it?

Regarding the second problem, it seems that the expression “ancient invention” is semantically binding and does not allow the subject to expand the network of possible associations to find a connection between this expression and the object of the solution (the window).

3) *2 Coins* problem:

In my pocket I have two Italian coins that together are 70 cents, but one is not 20 cents. How is possible?

In the third problem, the use of “but” seems to exclude the existence of 20 cents in the pair of coins, while a functional interpretation to the solution would make it possible to report the previous indication as valid only for one of the two coins, leaving the other available to the correct attribution.

4) *Lake* problem:

Someone walked for 20 minutes on the surface of a lake without sinking but without any form of flotation aid. How?

In the fourth problem, the impossibility of the event would seem to influence the answers of the subjects, who would focus on only one of the two elements of the problem, namely the person. In contrast, the consideration of the different states of water makes it possible to understand the circumstances in which such an event could occur, for example, when the water reaches the solid state.

5) *Bat & Ball* problem

A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?

Of course, the wrong answer that immediately comes to mind is 10 cents because, in this case, the difference between 1$ and 10 cents is only 90 cents, not 1 $, as the problem stipulates. The correct answer is 5 cents. Generally, the physiognomy of the number and the plausibility of the costs are held responsible for this type of error (Frederick, 2005; Kahneman, 2003). In this question, the rhetorical structure of the text and its demand would lead one to believe that the price of the bat is already known (1$), so the ball (mistakenly) should costs 10 cents. For this reason, we produced two experimental versions that would reduce the probability of interpreting the text as expected.

- First experimental version:

A bat and a ball cost $1.10 in total. The bat has a higher price of $1.00 than the ball. How much does the ball cost?

- Second experimental version:

A bat and a ball cost $1.10 in total. The bat has a higher price of $1.00 than the ball. How much does the ball cost? How much is the bat?

In the first experimental version, we attempted to disambiguate the term "the bat costs 1 $ more than the ball," which is usually interpreted as "the bat costs 1 $ " (Frederick, 2005), explaining that the bat has a higher price than the ball. In the second test version, in addition to the previous reformulation, we added the question "How much is the bat?" to emphasize further that the cost of the bat is not yet known.

Procedure

Each child was randomly assigned to one of three conditions: control, experimental version 1, or experimental version 2. Each child received only one version of each problem to be solved individually. The experiment occurred in a silent classroom that was purposely prepared. All the children had access to paper and a pencil to perform calculations and to answer the question. There were no time restrictions.

3.6 Results

Although the five problems have unique solution in Literature (Dow & Mayer, 2004; Frederick, 2005; Gilhooly, 2005), we proceeded with inter-rater reliability analysis.

Two judges evaluated the accuracy of the answers in all problems. Inter-observer agreement with Coehn's Kappa was almost total. In *Zoo problem* K is > .80 (K = .993 p < .01); in *Ancient Invention* problem K is > .80 (K = .978 p < .01); in *Two Coins* problem K is > .80 (K = 1.000 p < .01); in *Lake* problem K is > .80 (K = 1.000 p < .01); in *Bat and Ball* problem K is > .80 (K = .993 p < .01). The few doubtful cases were resolved through verbal agreement.

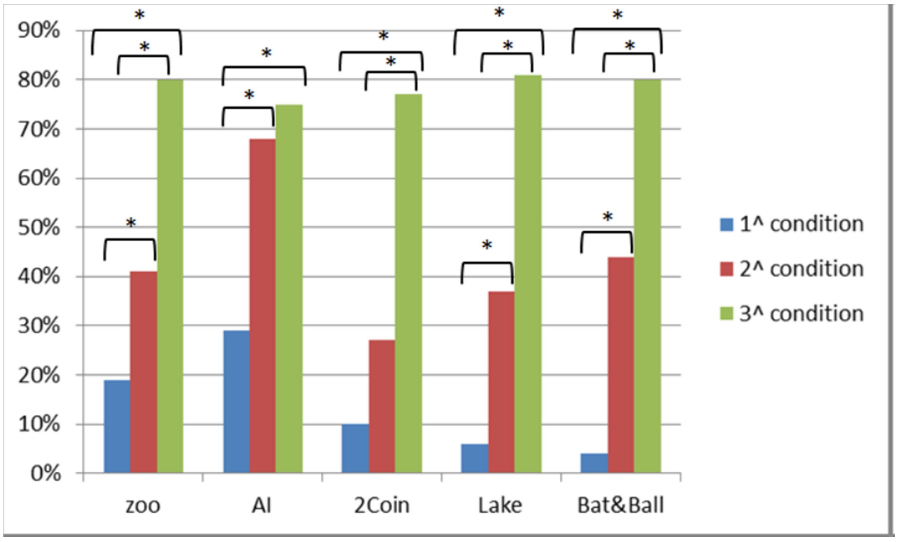
After the previous analysis we conducted *chi square* test. As shown in table 1, in both experimental conditions, the subjects showed an increase in the percentage of problem resolutions. In each problem, the children experienced significant improvement: *Zoo* (x^2 (2) 30.248 p <.01; η^2 .522 p<.01), *Ancient Invention* (x^2 (2) 18.860 p <.01; η^2 .416 p<.01), *Two Coins* (x^2 (2) 39.709 p < .01; η^2 .598 . p<.01), *Lake* (x^2 (2) 47.016 p <.01; η^2 .657 p<.01), and *Bat and Ball* (x^2 (2) 46.737 p <.01; η^2 .680 p<.01).

Table 1. Solution rate in the three conditions

	Controls	Condition 1	Condition 2
Zoo	18%	41%	77%
Ancient Invention	29%	66%	75%
Two Coins	10%	26%	71%
LaKe	6%	36%	84%
Bat & Ball	4%	44%	80%

In particular, the effect was evident for the second experimental condition, compared with the controls (Graph 1). The graph shows the percentages of each problem solved in the three conditions. The *Zoo* problem showed a significant improvement between the first condition and controls (x^2 (1) 4,432 p <.05; η^2 .241 p=.035) with 19% (N = 9 of 47) of the solutions for controls and 41% (N = 12 of 29) for group 1; between group 2 and controls, the condition (x^2 (2) 29,999 p <.01; η^2 .605 p<.01) with 80% (N = 28 of 35) of solutions in group 2, and between conditions 1 and 2 (x^2 (1) 10.093 p <.05; η^2 .397 p=.001). For the *Ancient Invention* problem, there was a significant improvement between the first condition group and the controls (x^2 (1) 9.320 p <.05; η^2 .350 η^2=.002) with 29% (N = 14 of 47) of solutions for the controls and 68% (N = 20 of 29) for group 1, between condition 2 and the controls (x^2 (1) 16.339 p <.01; η^2 .453 p<.01) with 75% (N = 25 out of 35) of solutions of group 2, while not significantly difference between the two experimental conditions (x^2 (1) .786 p = .375). The problem of the *Two Coins* did not show a significant difference between the first condition and the controls (x^2 (1) 3,633 p = .057) with 10% (N = 5 of 47) of solutions for controls and 27% (N = 8 of 29) of group 1, while there was a significant improvement between condition 2 and the controls (x^2 (1) 37.287 p <.01; η^2 .674 p<.01) with 77% (N = 27 out of 35) of solutions for group 2, and between conditions 1 and 2 (x^2 (1) 15.718 p <.01; η^2 .496 p<.01). In the problem of the *Lake*, we saw a significant improvement between condition 1 and the controls (x^2 (1) 11.878 p <.05; η^2 .395 p=.001), with 6% (N = 3 of 47) of solutions for controls and 37% (N = 11 of 29) in group 1, between condition 2 and the controls (x^2 (1) 47.072 p <.01; η^2 .767 p<.01) with 81% (N = 27 of 35) of solutions of the group 2, and between conditions 1 and 2 (x^2 (1) 12.531 p <.01; η^2 .450 p<.01). The problem of the *Bat and Ball* showed a significant improvement between the first condition and controls (x^2 (1) 18.636 p <.01; η^2 .495 p<.01), with 4% (N = 2 to 47) solutions for controls and 44% (N = 13 of 29) of group 1, between condition 2 and the controls (x^2 (1) 47.736 p <.01; η^2 .814 p<.01), with 80% (N = 20 of 25) of solutions in group 2, and between conditions 1 and 2 (x^2 (1) 8.835 p <.05; η^2 .404 p=.003).

Graph 1. Percentage of solution for each problem



3.7 DISCUSSION

Our experiment, trying to give a contribution to the scarce amount of research on insight problems during childhood, investigated the influence of pragmatic factors on the ability to solve insight problems. We focused on insight problem solving to determine whether there is a correspondence between the attribution of meaning to a sentence and the discovery of the solution through a restructuring process. The results seem to confirm the hypothesis that even in childhood, insight problems can be solved by rephrase the text to make it more understandable.

Comparing the control group with the first experimental group and the control group with the second experimental group, we found a significantly greater percentage of solution in both experimental groups compared with the controls. There was also significant improvement between the first and the second experimental conditions, presumably because the degree of clarity was even greater in the third version of the problem. In fact, the two experimental versions were formulated according to an ascending order of comprehensibility. With this procedure, we attempted to place problems along a continuum: at one extreme laid the original problem; at the intermediate level, the problem was presented without one of the elements of discourse that was assumed to hinder a relevant interpretation of the task but the other characteristics were left unchanged; and at the other extreme was the second test version of the problem, in which all potentially unclear elements were disambiguated while the logic of the configuration was preserved.

The progression from the original problem to the two reformulations is certainly of great interest from the epistemological point of view, because the insight problem gradually lose its connotative characteristics. The resolution of the problem would depend on the use of decoding to understand the implicit message. Once the latent meaning is disambiguated, the problem loses its original properties, and the solution requires mainly executive skills or calculations (Mosconi, 1974,1981,1990).

The improved performance that occurred after the two reformulations shows that the difficulty in problem solving could arose from difficulties understanding the text. Consider the *Bat and ball* problem (Frederick, 2005): only 3% of children were able to solve the original version - in adult is 10% - while 44% solved the second version, and 80% solved the third. Since the other aspects of the problem were unchanged, the difference in performance could be traced back to the reformulation of the text.

Therefore, it seems plausible that when a problem is presented, difficulties might arise primarily from the interpretation/understanding of the message. Muth (1984) demonstrated the crucial role of reading skills in *arithmetic word problems*, suggesting that along with computational ability, they play an important role in achieving the solution. Cornoldi (2003, 2013) have often examined the relationship between reading comprehension and related disorders and problem solving but always restricting the field to procedural problems.

The studies that have examined problem solving in children have rarely included insight problems (Bermejo & Sternberg, 1996; Sternberg & Davidson 1984, 1995, 1998), presumably considering them too complex, without assuming that children, like adults, often find themselves in new situations in which they must restructure the surrounding context to be able to negotiate it adaptively. Often, too, these situations require children to use their creativity and apply alternative or unconventional thinking. Insight problem solving, given its nature, can be considered to encourage *productive/divergent* thinking to a greater extent than procedural tasks do (Gilhooly, 2015; Guilford, 1959; Wertheimer, 1945). Unfortunately, at school, we tend to develop mainly *convergent thinking*, rewarding correct answers and penalizing wrong ones; instead, teachers should be prepared to act in an atmosphere in which creative effort is encouraged and rewarded, rather than in an educational atmosphere in which only exact solutions gain praise.

The teaching practices implemented in classes play an essential role in the nature and quality of students' learning (Dupriez & Dumay, 2009; Good & Brophy, 1972; Slavin, 2009). We should wonder how adults can simultaneously promote children's creativity and develop the interpretive skills necessary for comprehend problems, taking advantage of the many opportunities offered by educational situations.

Future studies could investigate if a pragmatic approach in teaching practices could alleviate many of the difficulties that students, especially those pertaining to science (Bergeron & Herscovics, 1983). It is in these subjects, especially in mathematics (Bull, 2001), that people show greater uncertainty because, problem coding is more laborious.

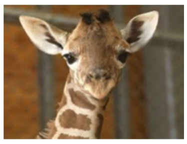
The need to encourage pragmatic-interpretative skills also seems to be linked to the need for action in metacognition; in fact, many students with learning disabilities, particular those with comprehension difficulties, have important gaps in metacognition (Cornoldi and Oakhill, 2013; Haertel and Walberg, 1993; Palinscar & Brown, 1987). Precisely for this reason, future studies should explore the relationships among metacognition, pragmatic-interpretative abilities and problem solving.

Given their important contributions to problem solving skills (Lucangeli and Passolunghi, 1995; Miller, 2013; Miyaki, 2000; Zelazo, 2008), it would also be useful to evaluate the relationships among executive functions, with their specific components, and pragmatic skills through insight problem solving. In fact, is known that the executive functions aid in predicting school-age math skills and the results in the sciences and the humanities, even apart from IQ (Blair & Razza, 2007; Gathercole & Alloway, 2008; Holmes et al., 2008; Scerif & Bull, 2001; St Clair-Thompson & Gathercole, 2006). Precisely for this reason, it would be interesting to examine the influence of executive function on insight problem solving and not strictly in the procedural tasks, commonly used in schools. It would also be advisable to determine the level at which pragmatic skills and the specific components of executive functions are possibly integrated and to determine which skill type is most strongly correlated with insight problem solving. A more integrated model, in which problem solving is not only conceived in an analytical and procedural context, could then be formulated.

3.8 Appendix A

ZOO PROBLEM

1) Yesterday I went to the zoo and saw the giraffes and ostriches. Altogether they had 30 eyes and 44 legs. How many animals were there?

2) Yesterday I went to the zoo and saw the owls  and giraffes  Altogether they had 30 eyes and 44 legs. How many animals were there?

3) Yesterday I went to the zoo and saw the giraffes and ostriches. Altogether they had 30 eyes and 44 legs. How many animals were there? Try to use the data contained in the text of the problem, you deem important to decide how many animals were

ANCIENT INVENTION PROBLEM

1) There is an ancient invention still used in parts of the world today that allows people to see through walls. What is it?

2) There is a very very old invention still used in parts of the world today that allows people to see through walls. What is it?

3) There is an ancient invention still used in parts of the world today that allows people to see outside through walls. What is it?

TWO COINS PROBLEM

1) In my pocket I have two Italian coins that together are 70 cents, but one is not 20 cents. How is possible?

2) In my pocket I have two Italian coins that together are 70 cents, but one of the two is not 20 cents. How is possible?

3) In my pocket I have two Italian coins that together are 70 cents; one of the two is not 20 cents. How is possible?

LAKE PROBLEM

1) Someone walked for 20 minutes on the surface of a lake without sinking but without any form of flotation aid. How?

2) Someone walked for 20 minutes on the surface of a lake without sinking but without any form of flotation aid. What conditions have allowed man to walk on the surface of the lake?

3) Someone walked for 20 minutes on the surface of a lake without sinking but without any form of flotation aid. What environmental conditions have allowed man to walk on the surface of the lake?

CHAPTER 4.
THE INTERACTION BETWEEN CONSCIOUS AND UNCONSCIOUS THOUGHT IN INSIGHT PROBLEM SOLVING: AN INTER-CULTURAL STUDY

4.1 Introduction

Researchers in thinking and reasoning have proposed recently that there are two distinct cognitive systems underlying reasoning: *System 1* and *System 2* (Sloman, 1996; Evans, 2003, 2005, 2008). *System 1* is old in evolutionary: it comprises a set of autonomous subsystems that include both innate input modules and domain-specific knowledge acquired by a domain-general learning mechanism.

System 2 is evolutionarily recent and distinctively human: it permits abstract reasoning and hypothetical thinking, but is constrained by working memory capacity and correlated with measures of general intelligence (Evans, 2003). These two systems are usually described as *System Implicit 1* and *System Explicit 2*. Dual-process theorists generally agree that *System 1* processes are rapid, parallel and automatic: only their final product is posted in consciousness. *System 2* is believed to have evolved much more recently and is thought by most theorists to be uniquely human. *System 2* thinking is slow and sequential in nature and makes use of the central working memory system (Baddeley, 2000).

Contemporary interest in the dual-process accounts of reasoning is evidenced by the wider application to related fields such as decision making and problem solving, especially the insight one. Some researchers see the apparently unconscious nature of solution discovery as evidence that the processes required to achieve insight in problem-solving are qualitatively different from those used to tackle problems that do not require insight (Sio, & Ormerod, 2009). From early in the history of psychology, theorists have argued about whether insights are initially unconscious or whether they are conscious from the start (Siegler, 2000). It seems that unique insights often results from a process whereby some initial conscious thought is followed by a period during which the problem is put to rest. Subsequently, after this period without conscious thought, a solution or idea presents itself (Dijksterhuis & Meurs, 2006). Also studies that compare the resolution of insight and not insight problems highlight a solution pathways, characterized by different processes. Metcalfe and Wiebe (1987) found that solution comes differently for insight as against non-insight tasks. These last would involve a procedural process to reach the solution but conversely in insight problems, solution might come suddenly, through the restructuration of the problem space (Wertheimer, 1945), suggesting that unconscious implicit processes underlay insight solutions as against non-insight solutions.

Schooler, Ohlsson and Brooks (1993) also found a separation between insight and non-insight problems in that concurrent thinking aloud verbalisation interfered with insight problem solving but not with the non-insight problem solving. This result was interpreted as indicating that insight problems normally involved unconscious non-verbal processes which were overshadowed by concurrent verbalisation. Ohlsson (1992) and Schooler Ohlsson, and Brooks (1993) argued that insight solutions result from automatic, implicit, non-executive processes.

Further evidence of the presence of unconscious thinking in insight problem solving is provided by incubation studies (Dorfman, Shames & Kihlstrom, 1996; Hélie & Sun, 2010; Ormerod, MacGregor & Chronicle 2002; Segal, 2004). During incubation, covert mental processes work to select what were considered by the conscious to be irrelevant or unusual cues in solution achievement. The unconscious then would matches these ideas randomly, because the unconscious might not have as strict filters as the conscious. The solution may emerge from these mental processes s such as spreading activation (Chu & MacGregor, 2011).

These views stressing the role of automatic, unconscious, implicit processes in insight problem solving, suggest that Type 2 processes would not be as heavily implicated in insight problem solving as in non-insight problem solving. Solvers, indeed, usually cannot report the processing that enables them to reinterpret the problem and overcome the impasse. Insight often occurs when people are not even aware they are thinking of the problem. Persistent questions about insight concern whether unconscious processing come before reinterpretation and solution and whether the apparent suddenness of insight solutions reflects truly sudden changes in cognitive processing. Unfortunately, consensual ways of observing and analyzing such putative unconscious processes are not already known, but some experimental efforts were proposed for an explanation.

4.2 The use of subliminal priming in the study of insight problem solving

A rife methods to study the insight, due to the presence of predominantly unconscious processes, is subliminal priming. Researchers used subliminal priming to explain some psychological phenomena; for example Strahan, Spencer and Zanna (2002) suggest that subliminal priming can be used to enhance persuasion, and Karremans, Stroebe and Claus (2006) assessed whether subliminal priming of a brand can affect people’s choices for it.

Regarding insight problem solving, Yaniv and Meyer (1987) proposed a model of priming effects in semantic memory which offers a mechanism by which intuition and incubation can occur in problem solving. In their view, presentation of the definition activates relevant nodes in semantic memory. Even before the threshold for conscious awareness is crossed, subthreshold levels of activation can sensitize the problem solver to new information pertinent to the solution.

According to Yaniv and Meyer, this sensitization, revealed by priming effects in lexical decision, underlies “feeling of knowing” and other meta-memory judgments. Shames (1994) imported the RAT into Yaniv and Meyer's priming paradigm. The subjects showed significantly shorter response latencies when making lexical decisions about targets primed by unsolved and solved RAT items. In his view, the priming effect occurred during the incubation period, after the problem has been posed, but before the solution has arrived in consciousness.

The priming effect uncovered by Shames (1994) may underlie the ability of subjects to judge which RAT items are coherent (Bowers, Regehr, Balthazard & Parker, 1990; 1994) compared to controls. Before Shames studies, always within the context of an associative theory of creativity, (Mednick, Mednick, & Mednick, 1964), studied the effect of specific associative priming upon incubation of creative performance and demonstrated that performance on a remote-associate task was enhanced by specific priming.

In another test of the activation hypothesis, Dorfman (1990) examined the effects of external primers on metacognitive judgments in problem solving. In one experiment, subjects were more likely to solve coherent problems when they received a greater number of primers, so that the incremental presentation of primers promoted discovery of insightful solutions.

With another perspective Slepian, (2010) investigate whether insight could be catalyzed by a cultural artifact about which it was learned the meaning - in this case a lightbulb, an iconic image of insight –before or during insight problem solving. He found that it enhanced insight problem solving in three different domains (spatial, verbal, and mathematical), but did not enhance general (non-insight) problem solving.

Marsh, Bink and Hicks (1999) explored how participants solved an open-ended generative problem-solving task. They found that when the features were related to certain concept, participants' creations contained features connected to that concept. These results suggest that conceptual priming of generative cognitive tasks could influence the cognitive aspects of the creative process.

Experiments with subliminal priming included also the use of emotions (Isen, Daubman & Nowicki 1987) demonstrated that positive affect, induced by means of seeing a few minutes of a comedy film or by means of receiving a small bag of candy, improved performance on two insight tasks (Duncker's candle task and Mednick, Mednick & Mednick's

Remote Associates Test), contrary to negative affect that failed to produce comparable improvements in creative performance.

Recently, consistent with *activation* theories, especially the Ohlsson's (2011) one, Hattori and Sloman (2012, 2013) tried to analyze the relationship between unconscious and conscious cognition in insight problem solving, using subliminal hints as primers. They have shown that hints facilitate solving the problem, and it shortened the solution time: exposing to a hint could activate insight without awareness, increasing the probability using the appropriate strategy or avoid using the wrong one falling into an impasse. They presented a hint a few minutes after participants started tackling the problem to make them receptive to priming. Waiting a few minutes allowed them to set their goals, because incubation periods in creative thinking could involve such goal setting. Sloman and Hattori's data once again suggest insight could be an unconscious process, after which the solution become aware.

4.3 The interaction between conscious and unconscious thought in insight problem solving

As already mentioned above, unconscious processes might be involved during insight problem solving. Despite research on the subliminal hints have shown an influence of the latter on unconscious thought and then to the performance, we can assume that conscious thought can still interfere.

Is known that conscious verbal processes can interfere with unconscious processes in insight problem solving (Schooler, Ohlsson, & Brooks, 1993) and intentional activities can reduce unconscious processes. The same was found by Schooler and Engstler-Schooler (1990) with the verbal overshadowing in the faces recognition, that is reduced by their previous description.

Macchi and Bagassi (2012) in the context of psycho-rhetoric theory showed whether verbalization could hamper insight problem solving. The percentage of solutions showed that the participants in the verbalization condition were significantly less successful in solving the problem than those in the no-verbalization condition.

In Maier (1931) research subjects were asked to retrospectively report their insight problem solutions for which they had been given a hint by the experimenter. Subjects who reported the solution as an insight experience seemed not to be aware of the hint.

So regarding to subliminal priming, other studies demonstrated that there are several aspects that could interfere with the effectiveness of hints, such as metacognitive control or Mindfulness (Radel, 2009); moreover conscious attention seems to eliminate priming effects on social perception (Dijksterhuis & Van Knippenberg, 2000).

Hattori and Sloman (2012) investigated the role of metacognition in his interaction with unconscious thought. Participants had to solve a problem exposed to a subliminal hint with metacognitive control instructions. They found that respectively hint and metacognition increased solution rate, but the effect disappeared when both were introduced. The results suggest that the relationship between subliminal hints and conscious thought is not so clear and had to be more inquired. These evidences may suggest that there are aspects of conscious thought that might be a hindrance or decrease the effectiveness of subliminal hint. In fact, if the subliminal stimulus had always an effect, we would expect that all or most of the subjects in subliminal hint -condition solve the problem, because of the effect of hint on the unconscious though. But this does not happen, or better happens only for some of these persons. We therefore wondered if there are a particular individual differences that may explain the variance effect of hint. Research findings that relate conscious and conscious thought in insight problem solving tell us that the involvement of conscious awareness could be an explanatory key. Moreover, since it has not been specified by Hattori and Sloman in their inter-cultural research, one wonders if individual differences in insight problem solving and in the effectiveness of subliminal hint could be influenced by culture and education. Much has been said on reasoning and cognitive processes, but research on intercultural predisposition is less extensive. We can hypothesize that people of different culture and education would solve differently reasoning task and could have develop to a greater or lesser particular specific cognitive functions linked to consciousness (Choi, Nisbett, and Smith,1997; Nisbett, Aronson, Blair, Dickens, Flynn, Halpern, Turkheimer, 2012; Norenzayan, Choi, & Peng, 2007; Yama, Manktelow, Mercier, Henst, Soo, Kawasaki & Adachi , 2010; Yama, Nishioka, Horishita, Kawasaki & Taniguchi , 2007). This procedure could be useful to understand if the relationship between conscious and unconscious thought in insight problem solving could also depend on culture and learning.

4.4 Mindfulness and Inhibition: two factors of conscious thought

There are some individual differences in conscious thought that should be explored more about the effectiveness of hints in insight problem solving. As told before, conscious awareness could contain the effect of hints. So we focused on the role of Mindfulness, and Inhibitory Ability, considered two representative factors of conscious thought.

Consciousness encompasses both awareness and attention. Awareness is the system that detect consciousness, continually monitoring the inner and outer environment. One may be aware of stimuli while they aren't at the center of attention. Attention is a process of focusing conscious awareness, providing enhanced sensitivity to a limited range of experience. Awareness and attention are intertwined: Mindfulness can be considered an enhanced attention to and awareness of current experience or present reality (Brown & Ryan 2003).

Mindfulness

Mindfulness is one attribute of consciousness that has been much discussed and is commonly defined as the state of being attentive to and aware of what is taking place in the present (Shapiro, 2003). the concept of Mindfulness comes from the teachings of Buddhism, Zen meditation and the practice of yoga, but only at the end of the twentieth century this model has been assimilated and used as a stand-alone paradigm in some disciplines psychotherapeutic Italian, European and overseas (Langer, 1989)

Mindfulness is therefore a way of paying attention, moment by moment, here and now, in a non-judgmental and intentionally, in order to solve (or prevent) the inner suffering and reach an acceptance of self through greater awareness of their own experience which includes: feelings, perceptions, impulses, emotions, thoughts, words, actions and relationships. So mindfulness is the ability to work flexibly, a detachment from the mental contents, allowing you to observe more clearly. This detachment- detached mindfulness – (Wells, 2005) decreases automatic responsiveness that every human being leads a lavish rapid efforts.

Mindfulness represents a unique practice that may have potential in facilitating the creative responses needed for solving insight problems.

Inhibition

Inhibition is part of attention that concerns one’s ability to deliberately inhibit dominant, automatic, or prepotent responses when necessary (Mayake et al, 2000). This type of Inhibition is commonly labeled an executive function and linked to the frontal lobes (Jahanshahi, Profice, Brown, Ridding, Dirnberger, & Rothwell 1998; Kiefer, Marzinzik, Weisbrod, Scherg, & Spitzer, 1998). The concept of inhibition is not necessarily a controlled process and usually is linked to a decrease in activation levels due to negative activation. Conversely Inhibition is seen as a process that is actually intended. Although under the two conception of inhibition could be some underlying commonality, in this research we will refer to the deliberate, intended inhibition of responses.

Inhibition is involved in the control of response processes, even when motor activations are triggered by stimuli that are not accessible to conscious awareness. Inhibition seems crucial in the studying of subliminal hints as primers, because sometimes occurs a ‘‘reactive inhibition’’, such as that seen with negative priming (Tipper, 2001). Eimer and Schlaghecken (2003) has investigated with behavioral, electrophysiological, and functional imaging methods how subliminal primes would influence response-related processes. It was found an initial response activation, triggered by these primes, followed by an inhibition of this response tendency. This provided that the initial activation was strong enough to overcome an ‘inhibition threshold’. They suggested that this pattern would reflect the presence of self-inhibitory circuits in motor control. Contrary to endogenous response inhibition, seen when response-relevant signals were consciously perceived, this exogenous way of response inhibition seems mediated by corticostriate mechanisms.

4.5 The correlation between Mindfulness and Inhibition

Regarding the relation between Mindfulness and Inhibition, Alexander, Langer, Neman, Chandler, and Davies (1989) have found that mindfulness trainign is associated with improvements in cognitive flexibility (e.g., lower Stroop interference scores). Thus, Mindfulness training might be associated with improvements in executive processes, particularly at the level of stimulus selection. Bishop Lau, Shapiro, Carlson, Anderson, Carmody and Devins, (2004) have proposed the first formal definition of its cognitive mechanisms as part of a two-component operational definition of mindfulness involving: (1) the self-regulation of attention so that it is maintained on immediate experience and (2) the adoption of an open, curious, accepting awareness of experiences in the present moment.

Specifically, Bishop et al. (2004) proposed that Mindfulness involves sustained attention to maintain awareness of current experience, attention switching to bring attention back to the present moment when it wanders, inhibition of elaborative processing to avoid ruminating on thoughts or feelings that are outside of the present moment and non-directed attention to enhance awareness of present experience, unfiltered by assumptions or expectations. Mindfulness training entails extended practice of these attentional control abilities, and practice generally improves attentional control (Cepeda, Kramer, & Gonzalez de Sather, 2001; Halperin, Sharma, Greenblatt, & Schwartz, 1991; MacLeod, 1991).

4.6 THE EXPERIMENT

As the previous researches suggested (Hattori, 2012, 2013; Redal, 2009), people with high Mindfulness and metacognitive ability could mitigate subliminal hints because of the presence of higher conscious control. Given these circumstances, with this study we attempted to prove that some individual differences like Mindfulness and Inhibitory Capacity can hamper the effectiveness of subliminal hint. We hypothesize that people with high level of Mindfulness and Inhibitory Capacity, as increased activation of the awareness, could less assimilate subliminal hints to solve the problem, because they would be more able to reject exogenous stimuli. The second aim of our study was to explore cultural differences in insight problem solving and in the use of subliminal hint. Since Hattori and Sloman didn't consider this factor in their studies (2012, 2013), not comparing two samples of different nationalities (Japanese vs Americans), we analyzed the influence of the latter on the metacognitive skills and performance through insight problem solving (for a discussion on cultural diversity in cognitive abilities, refer to the Chapter 2). This need arises from the fact that in the Literature there are no studies on cultural differences that used implicit stimuli during insight problem solving. If we assume that we could find any differences in conscious though, identified in

Mindfulness and Inhibition capacity, between Italian and Japanese, we could also assume that the culture could be an important factor in assessing the effectiveness of hints.

Therefore, with our study we evaluated the performance of the two groups in Mindfulness, with self-test report FFMQ (Bear, 2006), and the Inhibitory Ability with the Flanker Task (Eriksen & Eriksen, 1974). For assessing the performance through insight problem solving, , in the control group an insight problem with withe interspersed screens was administered on a PC, while the experimental group was given the same problem, with interspersed screens containing geometric figures that hide the design of the solution.

4.6.1 Method

At first participants had to fill a Mindfulness questionnaire the FFMQ (Baer, 2006), then they had to solve one insight problem on PC within 8 minutes. We created two experimental condition of this problem:

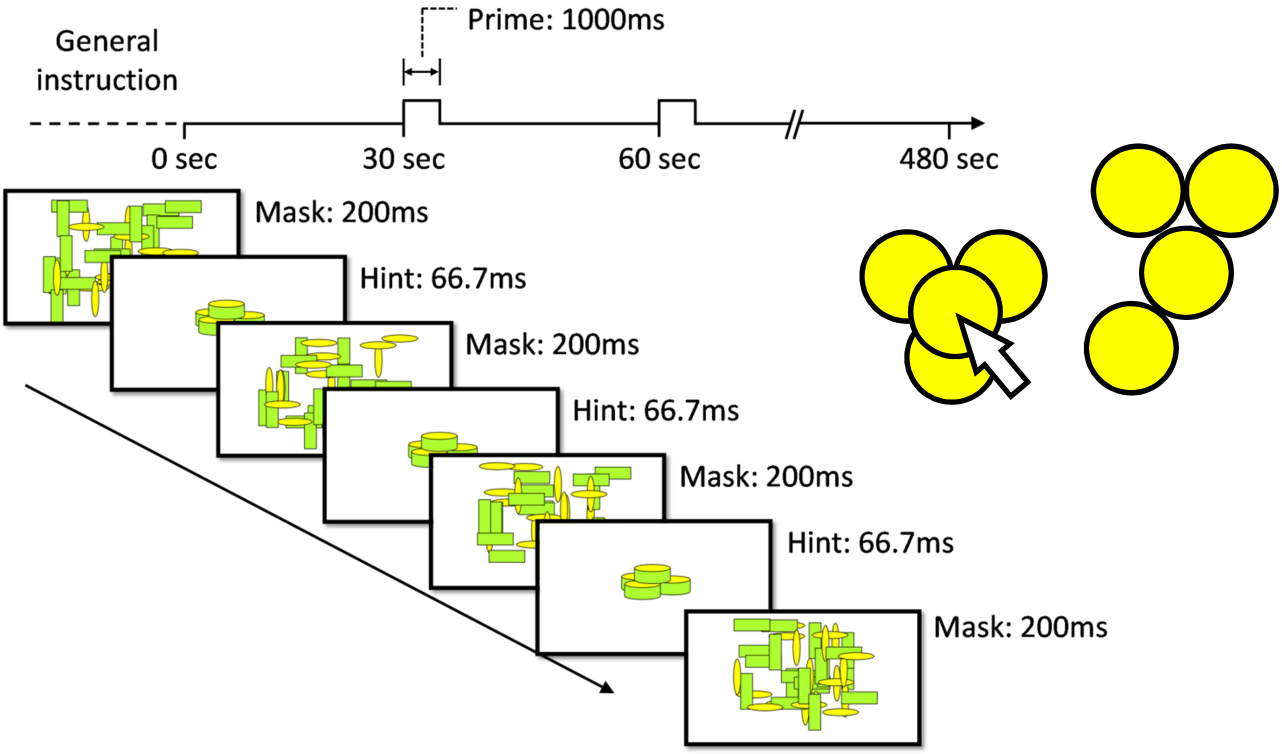
- Hint condition: every 30 seconds a hint on the screen was presented, covered with a mask made up of geometric shapes
- No-hint condition: every 30 seconds a white screen was presented

At the end of the task, after a minute break, subjects was given an inhibition task, the Flanker Task (Eriksen & Eriksen, 1974) which lasts 4 minutes.

Materials

<u>Insight problem</u>

8 coins Problem (Ormerod, 2002, 2004): *Moving only two coins, make an arrangement which ensure that every coin touches exactly three other coins*



The problem was administered on PC in the laboratories. All the operations, including receiving the hint and answering postquestions, will be carried out on the device.

Mindfulness

A self-report assessment with the Five Facet Mindfulness Questionnaire (Bear, 2006) was administered to assess Mindfulness. The FFMQ is a 39-item self-report measure of five facets of mindfulness derived from a factor analysis of five existing mindfulness measures. Items are rated on a Likert scale from 1 (never or very rarely true) to 5 (very often or always true). The five subscales reflect tendencies towards: Observing one's experience (observe); describing or putting words to one's experience (describe); acting with awareness in everyday life (act with awareness); not-judging of experience (not-judgment); and not-reactivity towards internal stimuli (not-reactivity).

Inhibition

Participant was given Flanker task in which it was asked to indicate by button-press the orientation of a briefly presented left- or right-facing arrow. The target arrow is flanked by a set of distractor arrows, two on each side. On compatible trials, these point in the same direction as the target arrow; on incompatible trials, they face in the opposite direction. The Flanker task involves both conflict and selection-for-action, in particular on incompatible trials. On these trials the combined influence of the target and Flankers leads to conflict in the form of competition between correct and incorrect responses, an effect that is reflected in prolonged reaction times.

Outliner & factor's score

Flanker task

We excluded the incorrect or no responses in the flanker task and calculated the mean, SD, plus/ minus 3 SD of each participant. Then we excluded the outliner of each participant (out of the range of plus/ minus 3 SD) and calculated the inhibition score.

FFMQ

We calculated Cronbach's coefficient alpha for each factor of FFMQ (making 0.7 a criterion) we and calculated the average FFMQ of each participant.

Participants and Design

We tested a sample of 55 students both of Ritsumeikan University and 60 of Milano-Bicocca University. They were randomly assigned to a hint or no-hint condition.

In Japan we collected the data of 55 participants (Man 22, Woman 33, Mage= 20.5, SD= 4.0), and in Italy 60 participants (Man 17, Woman 43, Mage= 26.3, SD= 3.4).

In Japan, on 55 participants, 5 participants were excluded from the analysis because the correct response rate was lower than the average correct response rate for -3SD (1 participant) or figured out the answer in the first 30s (4 participants).

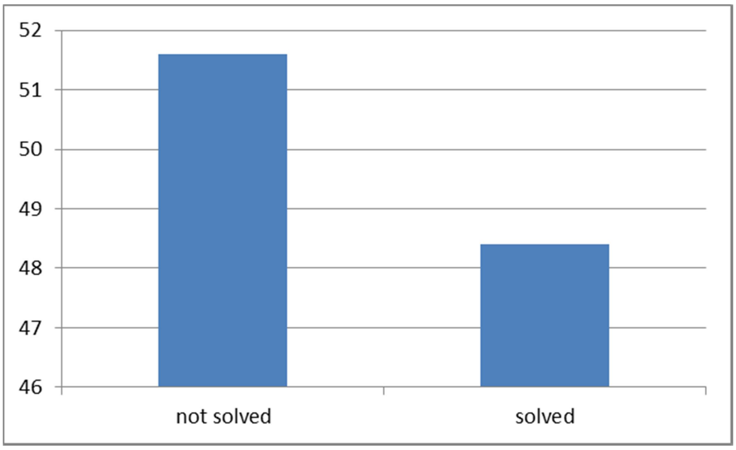
In Italy we collected the data of 60 participants, but 19 participants were excluded from the analysis because the correct response rate was lower than the average correct response rate for -3SD (3 participant) or figured out the answer in the first 30s (8 participants) or had known 8-coin problem (5 participants) or didn't complete item of FFMQ (3 participants).

4.7 Results

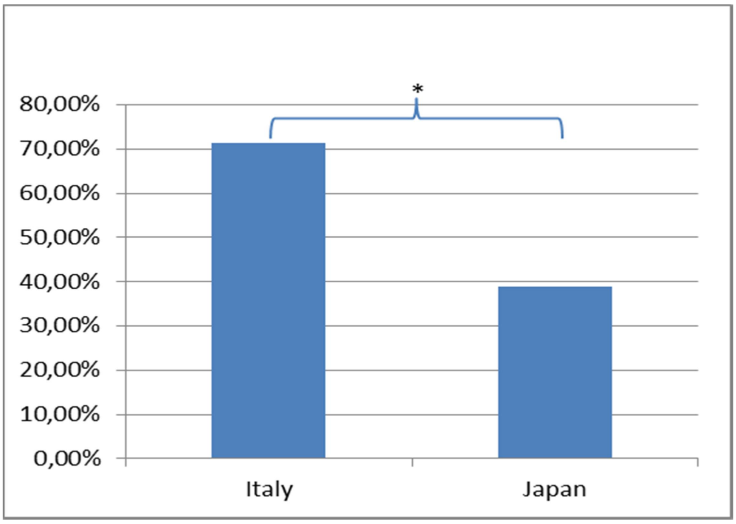
First result – general differences

First of all, we found the percentage of solution of the *8 coins Problem* in the total sample (44 on 91, 48,4%, see Graph. 1) and then we conducted a *Chi square* analysis to check the different results in solution rate for Italian sample and Japanese Sample (Graph. 2). There is a significant difference in solution rate between Italian (71,4%) and Japanese (38,9%) subjects in both condition with more solution for the first sample ($\chi 2$ (1)=10.964, p<0,01).

Graph. 1: Total solution rate of 8 Coins Problem



Graph. 2: Percentage of solution rate in each sample

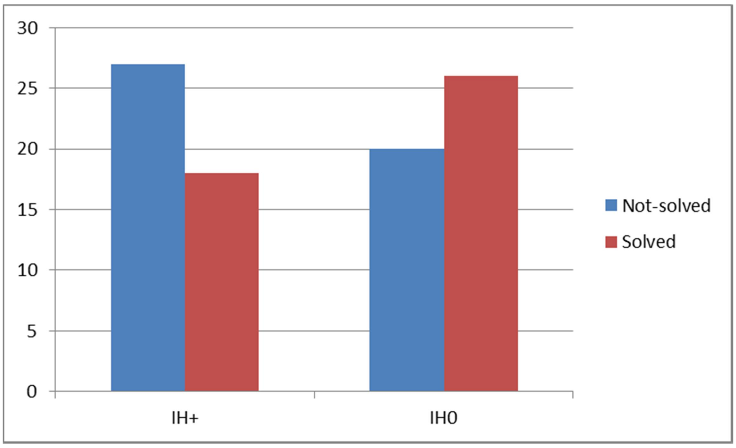


We didn't find a difference in solution rate between Hint condition (HI+) and no-Hint (HI0) in the total sample ($\chi2(1) = 2.486$, $p=.086$) (Tab.1 and Graph. 3).

Tab. 1 Percentage of solution in Hint/No-Hint condition for total sample

	Not solved	Solved
IH+	57,40%	40,90%
IH0	42,60%	59,10%

Graph. 3 Percentage of solution in Hint/No-Hint condition for total sample

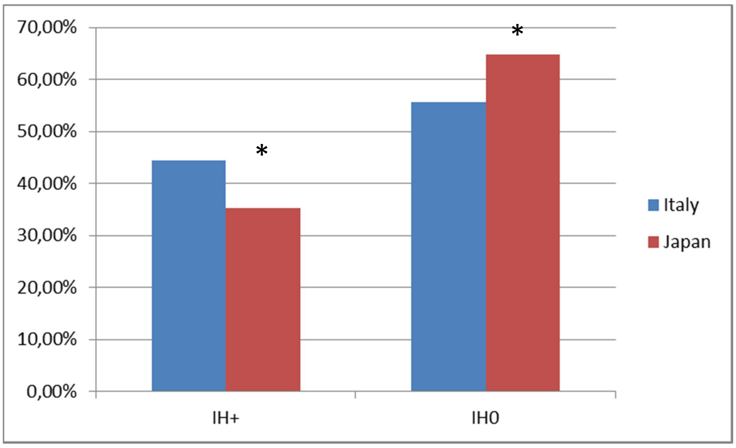


Then we conducted a *Chi square* analysis to check the different results in *8 coins Problem* solution rate in Hint/No-hint condition for each sample. For Italian sample ($\chi2$ (1)=.114, p=.496) we didn't find significant difference in solution rate between hint and no-hint condition. Japanese sample shows a weakly significant difference ($\chi2$ (1)=3.818, p=.051), by which there are fewer solutions in the hint condition (Tab. 2 and Graph. 4).

Tab. 2 Solution rate for Italian and Japanese samples in Hint/No-Hint condition

	IH+	IH0
Italy	44,40%	55,60%
Japan	35,30%*	64,70%*

Graph. 4 Solution rate for Italian and Japanese samples in Hint/No-Hint condition



Mindfulness and Inhibitory ability

After the previous procedure, our aim was to control the association of the other two factors of our study, Mindfulness (FFMQ) and Inhibitory Capacity (Flanker Task) with solution rate in Hint/No-Hint condition. So participants were divided in High/low group for each factor and we run a *Chi square* analysis.

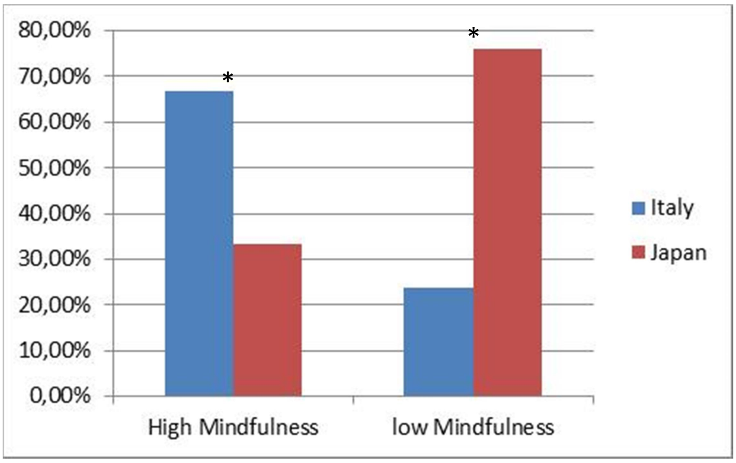
Regarding Mindfulness, Italian sample shows higher level Mindfulness (Tab. 3 and Graph. 5) and Japanese show lower Mindfulness ($\chi 2(1) = 16.796$, p <0,01):

Tab. 3 Level of Mindfulness in Italian and Japanese samples

	Italy	Japan
High Mindfulness	66,70%***	33,30%***
Low Mindfulness	23,90%	76,10%

P<0.01***

Graph. 5 Mindfulness in Japanese and Italian sample

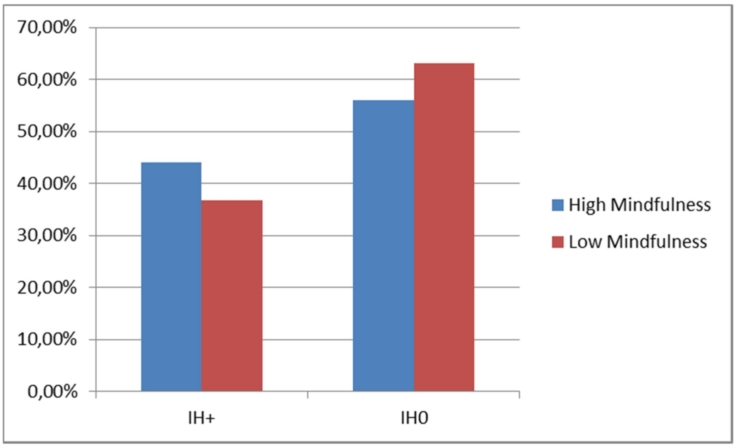


We didn't find any association for the total sample in Hint/No-Hint condition between FFMQ and solution rate in *8 coins problem* ($\chi 2(1) = 2.486$, p=.086, see Tab. 4 and Graph. 6):

Tab. 4 Association between Mindfulness and solution rate in Hint/No-Hint Condition

	IH+	IH0
High Mindfulness	44,00%	56,00%
Low Mindfulness	36,80%	63,20%

Graph. 6 Association between Mindfulness and solution rate in Hint/No-Hint Condition

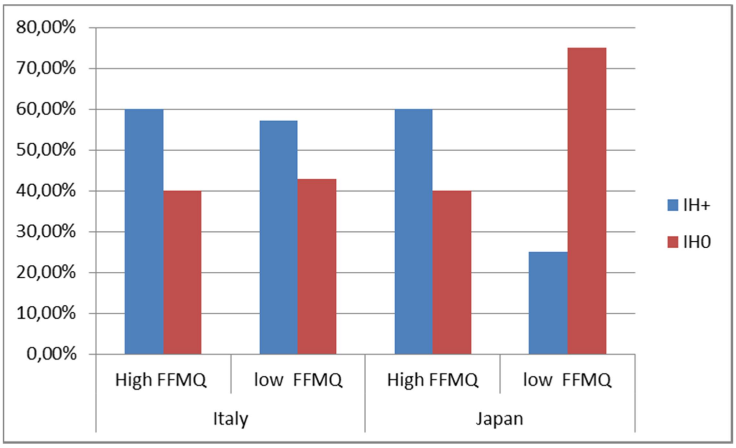


The same was for Italian sample ($\chi 2(1) = .114$, p=.735) and Japanese sample ($\chi 2(1) = 2.880$, p=.090) separated (Tab. 5 and Graph 7):

Tab. 5 Association between Mindfulness and solution rate in Hint/No-Hint Condition for each sample

		IH+	IH0
Italy	High FFMQ	60,00%	40,00%
	Low FFMQ	57,10%	42,90%
Japan	High FFMQ	60,00%	40,00%
	Low FFMQ	25,00%	75,00%

Graph. 7 Association between Mindfulness and solution rate in Hint/No-Hint Condition for each sample



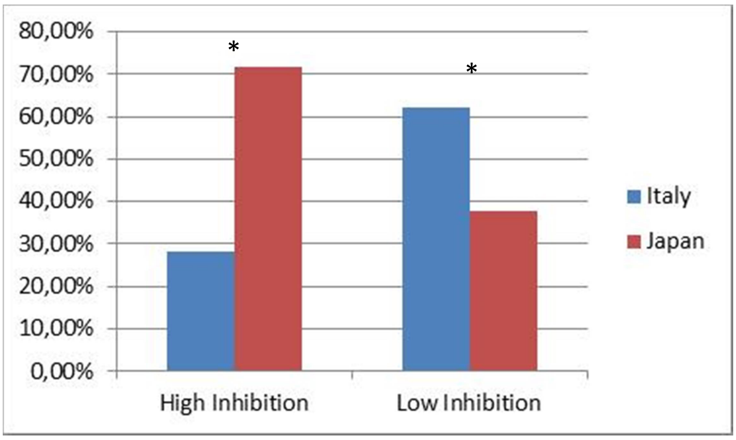
For Inhibition, we used the same way: we divided subjects in High/Low groups and we run a *Chi Square* analysis. First of all, the test showed that Japanese participants have higher levels of Inhibition than Italian ones ($\chi2(1) = 10.598$, p <0,01, see Tab. 6 and Graph. 8)

Tab. 6 Level of Inhibitory ability in Italian and Japanese sample

	Italy	Japan
High Inhibition	28,30%***	71,70%***
Low Inhibition	62,20%	37,80%

P<0.01***

Graph. 8 Level of Inhibitory ability in Italian and Japanese sample

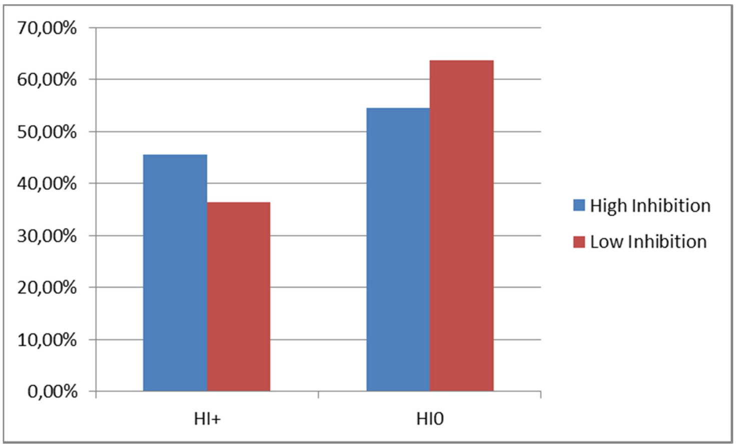


There isn't any association between Inhibitory ability and solution rate in *8 Coins Problem* for the total sample in Hint/No-Hint condition ($\chi2(1) = 2{,}486$, p=0.86, see Tab. 7 and Graph. 9)

Tab. 7 Association between Inhibition and solution rate in Hint/No-Hint Condition

	IH+	IH0
High Inhibition	45,50%	54,50%
Low Inhibition	36,40%	63,60%

Graph. 9 Association between Inhibition and solution rate in Hint/No-Hint Condition



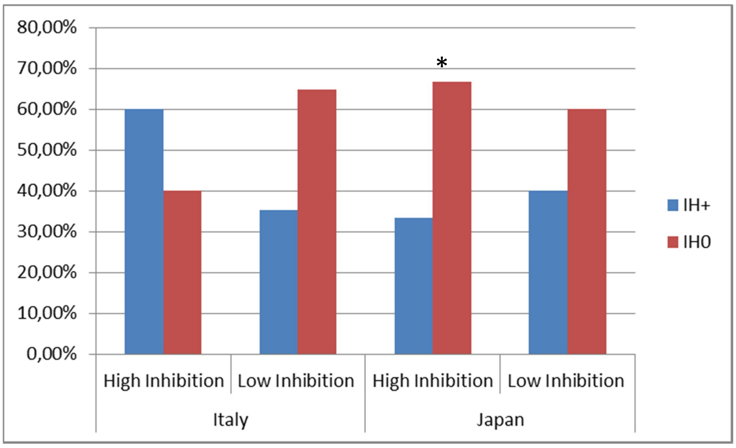
However, we found a interaction between Inhibition and percentage of solution in Japanese participants: The high inhibitory activity in Hint condition was associated with a decrease in resolution in the *8 coins Problem*, only with Japanese subjects ($\chi 2(1) = 4.537$, p <0,05, see Tab. 8 and Graph. 10). Moreover we can observe an opposite trend, although not significant, for the two sample: in the Hint condition Italian subjects with high inhibitory ability show a higher percentage of solution than in the No-Hint condition. For Japanese participants is the opposite.

Tab. 8 Percentage of solution in high inhibition group for each Italian and Japanese sample

		IH+	IH0
Italy	High Inhibition	60,00%	40,00%
	Low Inhibition	35,30%	64,70%
Japan	High Inhibition	33,30%**	66,70%**
	Low inhibition	40,00%	60,00%

**p<.05

Graph. 10 Association between Inhibition and solution rate in Hint/No-Hint condition for each sample



After previous analysis, also the *T-Test* was conducted to control the mean of each factors in the total sample (Tab. 9) and to control the differences between Italian sample and Japanese sample. Factors were used as continuous variables, with the solution rate considered as the degrees of constraint relaxation (Ratio 3D), that are the number of three-dimensional movements/number of all movements. We found no difference in solution rate between Hint-condition and No-Hint together in Japanese sample (*t* (89) 1.83 *p*= .073) and in the Italian one (*t* (39) -0.11 *p*= .914), but there is a significant difference between Italian and Japanese in Ratio 3D (*t* (89) -4,84 *p*<01). Moreover Italian participants present higher levels of Mindfulness (*t* (89) -4,84 *p*<01), while Japanese participants show higher level of Inhibition ability (*t* (89) 3,00 *p*<01) - (Tab.10 and Graph. 12).

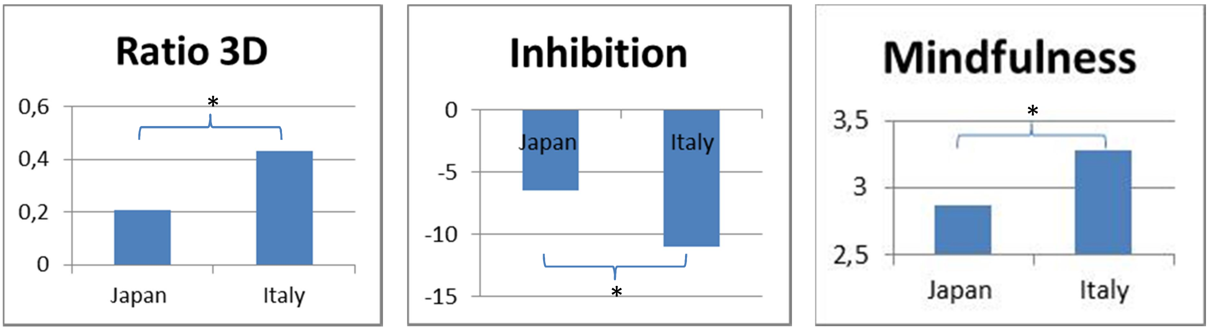
Tab. 9 Mean of each factor in total sample

	Min	Median	Mean	Max	SD
Ratio 3D	,00	,22	,31	1,00	,24
Inhibition	-6,23	26,78	26,58	65,24	13,14
Mindfulness	2,02	3,02	3,05	4,09	,46

Tab. 10 Summary statistics for each sample, such as Japan and Italy (n = 50 + 41)

	Japan					Italy					t-test (No-Hint vs Hint)		
	Min	Median	Mean	Max	SD	Min	Median	Mean	Max	SD	t	df	*p*
Ratio of 3D	,03	,18	,21	,71	,14	,00	,42	,43	1,00	7,84721	-4,84	89	,000***
Inhibition	-16,43	-8,13	-6,44	11,54	6,49	-39,23	-11,7658	-10,9604	11,54	11,97	3,00	89	,003***
Mindfulne:	2,02	2,81	2,87	3,66	,35	2,03	3,33	3,28	4,09	,49	-4,63	89	,000***
n			50					41					

Graph. 11 Solution rate and level of Mindfulness and Inhibition



Then we repeated the same analysis separating the Hint from No Hint-condition to verify the differences in each sample in both condition (Tab. 11 and Tab. 12). In No-Hint condition there is a significant difference in Ratio 3D (*t* (44) -2,70 $p< 0.05$) between Japanese sample and Italian sample with more solution for Italian one. We found the same pattern also in the Hint condition (*t* (43) -4,13 $p< 0.01$). In the No-Hint condition there is a significant difference between Italy and Japan in Inhibition (*t* (44) -2,63 p< 0.05), but not in the Hint one (*t* (43) 1,42 p= .162).

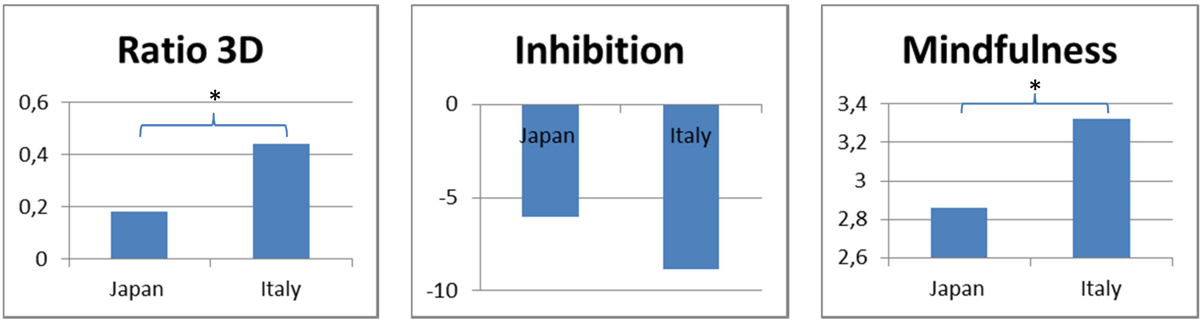
Regarding Mindfulness, Japanese sample shows a significant difference from Italian sample both in Hint (*t* (43) -3,56 p<0.01) and No-Hint condition (*t* (44) -2,95 p< 0.05).(Graph 12 and 13).

Tab. 11 Summary statistics for Hint condition in each sample

Hint condition (n = 26 + 19)

	Japan					Italy					t-test (Japan vs Italy)		
	Min	Median	Mean	Max	SD	Min	Median	Mean	Max	SD	t	df	*p*
Ratio of 3D	,03	,14	,18	,71	,13	,00	,45	,44	,87	,28	-4,13	43	,000***
Inhibition	-16,43	-8,13	-6,05	3,41	5,75	-18,43	-10,43	-8,82	11,54	7,30	1,42	43	,162
Mindfulne:	2,43	2,74	2,86	3,56	,33	2,03	3,45	3,32	4,09	,53	-3,56	43	,001***
n			26					19					

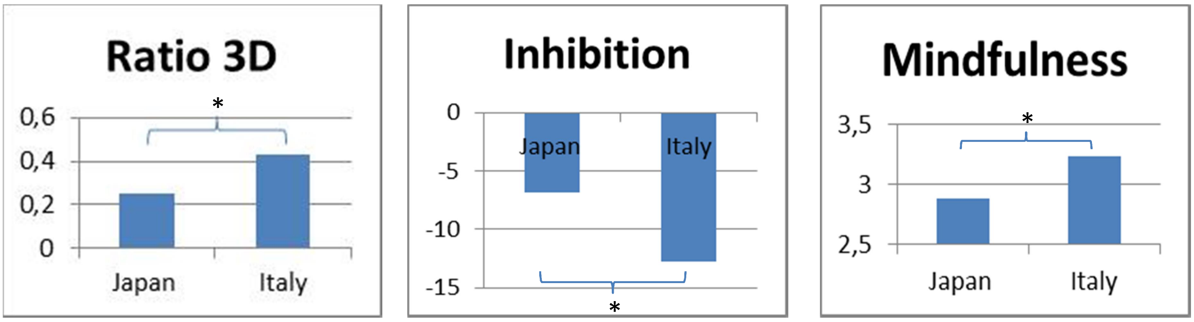
Graph. 12 Solution rate and level of Mindfulness and Inhibition in Hint condition



Tab. 12 Summary statistics for No-Hint condition in each sample

No-Hint condition (n = 24 + 22)	Japan					Italy					t-test (Japan vs Italy)		
	Min	Median	Mean	Max	SD	Min	Median	Mean	Max	SD	t	df	*p*
Ratio of 3D	,05	,22	,25	,57	,13	,00	,41	,43	1,00	,30	-2,70	44	,010 **
Inhibition	-16,43	-8,13	-6,87	11,54	7,30	-16,09	-12,94	-12,80	-9,52	7,98	-2,63	44	,012 **
Mindfulne:	2,02	2,82	2,88	3,66	,38	2,39	3,29	3,24	3,93	,46	-2,95	44	,005 ***
n			24					22					

Graph. 13 Solution rate and level of Mindfulness and Inhibition in No-Hint condition



Second result: Interaction between factors

Finally we conducted a multifactorial ANOVA with “Ratio of 3D” as dependent factor, and “Hint/No-Hint condition” “Country”, “Inhibition”, “Mindfulness” as independent, to control the interaction of factors and verify the main factor of variability (Tab. 13 and Graph 14).

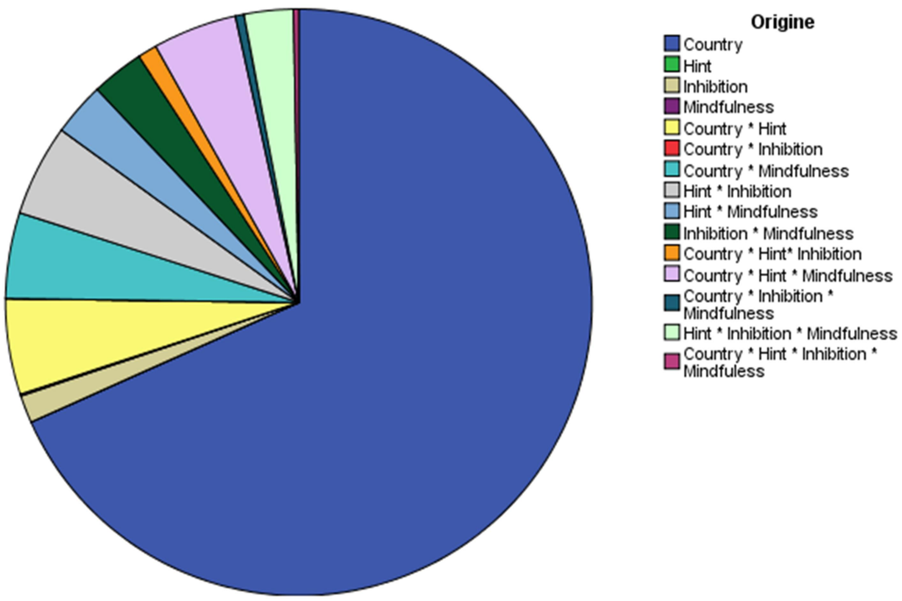
Tab. 13 Multifactorial ANOVA (Factors x Ratio3D)

Source	df	F	P
Country	1	17,008	0,000***
Hint	1	0,001	0,975
Inhibition	1	0,377	0,541
Mindfulness	1	0,026	0,873
Country * Hint	1	1,314	0,255
Country * Inhibition	1	0,001	0,981
Country * Mindfulness	1	1,179	0,281
Hint * Inhibition	1	1,255	0,266
Hint * Mindfulness	1	0,734	0,394
Inhibition * Mindfulness	1	0,72	0,399
Country * Hint * Inhibition	1	0,264	0,609
Country * Hint * Mindfulness	1	1,155	0,286
Country * Inhibition *Mindfulness	1	0,118	0,733
Hint * Inibizione * Mindfulness	1	0,676	0,414
Country * Hint * Inhibition * Mindfulness	1	0,071	0,79
Errore	75		
Totale	91		

**p<.05 ***p<.01

We didn't find any interaction. The only factor that explains the greater variability in solution rate (3D Ratio) in the *Problem of 8 coins* is "Country" ($F(1, 75)=0.86$ $p<.01$):

Graph. 14 Between-subjects ANOVA: interaction and main effect on Ratio3D



4.8 DISCUSSION

Exposure to a hint can activate insightful ideas without awareness, increasing the probability of producing a corresponding strategy and of deactivating inappropriate ones to escape from the impasse.

One critical condition to the effect of subliminal priming is preparedness (Moss, Kotovsky, and Cagan 2007). Open goals set in a task (unsolved problems) promoted acquisition of hints implicitly presented in another task. The opportunistic assimilation hypothesis (Seifert, Meyer, Davidson, Patalano, & Yaniv, 1994) supposes that reaching impasse create failure indices in memory and relevant information later introduced in the environment and it may lead to retrieval of these indices, which may result in an insight.

Psychologists was undecided whether insights are initially unconscious or not. Some theorists have claimed that insights are not always conscious from the beginning (Siegler, 2000) or that first, unconscious thought increase the associative search for creative solutions and then solutions could be transferred to consciousness (Zhong, Dijksterhuis, & Galinsky, 2008). Conscious verbal processes can interfere with unconscious processes in insight problem solving (Schooler, Ohlsson, & Brooks, 1993). Moreover, although conscious control alone is known to facilitate creativity (Nickerson, 1999), intentional activities can hamper unconscious processes. Mindful students in a classroom were insensitive to subliminal priming (Radel et al., 2009), and similarly, conscious attention eliminated priming effects on social perception (Dijksterhuis & Van Knippenberg, 2000). How priming effects or unconscious processes interact with more intentional and controlled activities is an important open issue. Unconscious processing in insight problem solving cannot be studied by methods like verbal self-report that require conscious processing.

Thus, it's necessaire to use experimental methods that tap implicit processes, like the subliminal priming technique. Metacognition is known to be effective in enhancing creative thinking. Little is known, however, about how unconscious thought and metacognition interact. It has been shown that subliminal hints facilitate solving insight problems (Hattori & Sloman, 2013). However some evidence (Hattori & Sloman, 2012) have suggested that hints would decrease the rate of solutions in some cases. A higher metacognitive capacity, as the ability to inhibit irrelevant stimuli, would hinder the emergence of insight into the hint condition (Nishida & Castoldi, 2015).

Through our study we wanted to analyze the relationship between conscious and unconscious processes in insight problem solving, using the priming method, and the interaction with two metacognitive factors: the Inhibition and the Mindfulness. In addition, by comparing two samples of different nationalities, we analyzed the influence of the latter on the metacognitive skills and performance through insight problem solving. The aims of our experiment was to show the negative effect of hint on solution rate, associated with high metacognitive function as Inhibition and Mindfulness and we wanted to demonstrate the interaction of culture too.

Results partially confirmed our predictions: we found a significant, although small, difference in *8 Coins problems* solution rate between hint and no-hint condition only in the Japanese sample, with lower solution rate in the hint condition. Moreover, in the Japanese sample, the lower solution rate in hint condition was associated with a high Inhibition. Conversely we didn't find any subliminal effect in the Italian sample. There wasn't a difference in solution rate between hint and no-hint condition. We also didn't find any association between Hints and Mindfulness in the total sample and in the two separated sample. Inhibition is the only factor that seems influenced by the presence of hint, negatively and only in the Japanese sample.

We found a powerful effect of culture: the Italian subjects showed nearly a roof effect in the resolution of the *8 coins Problem*, independent of the hint presentation and the levels of Mindfulness and Inhibitory Capacity. They also have higher level of Mindfulness. The Japanese subjects showed a higher Inhibitory Capacity associated with a low percentage of resolution and a hint's negative effect. The results also indicate that the factor that explains the greatest variance in the insight problem solving is the Nationality, so the subliminal priming is not the main factor of variance:

In the light of the results, we can suppose that the relationship between conscious and unconscious processes could be mediated by cultural factors and consequently subliminal hint might be perceived differently because of cultural and learning predispositions. We can assume that, in some cultures, specific cognitive factors are more implemented than in other cultures. The significant difference in metacognition and in creative thinking could depend on this. The negative hint effect on inhibition and the lower insight problem solving ability in Japanese sample seems present only in the high level of this cognitive ability. Italian people show a lower level of Inhibition than Japanese people, but an higher insight. We can assume that, if in a certain culture, the Inhibition ability is constantly elicited, perhaps creative thinking fails. Future research could clarify this hypothesis

We said that Mindfulness training might be associated with improvements in executive processes, particularly at the level of stimulus selection and that Mindfulness training entails extended practice of these attentional control abilities, and practice generally improves attentional control (Cepeda, Kramer, & Gonzalez de Sather, 2001; Halperin, Sharma, Greenblatt, & Schwartz, 1991; MacLeod, 1991). Despite this evidence, it seems that Inhibition and Mindfulness are composed by different processes: we didn't find any correlation between them (r= -. 157, p=,138). But it could be due to the Task we used to measure Mindfulness, the FFMQ questionnaire. We think that self-report task are less informative than implicit task. Questionnaire usually involves a high degree of voluntary control and awareness, while implicit task, as Flanker Task, implies the involvement of unconscious factors that are difficult for people to control.

Mindfulness may be related to insight and Inhibition but, it is possible that FFMQ reflect self-report method. Just think to self-esteem: participants may think that these questions measure intelligence or cognitive ability. Then, some of them would overestimate their ability because of their high self-esteem, or maybe the opposite. Consciousness could interacts with implicit process, for example, previous research show that verbalized thought hinder insight (Schooler, 1993). So, to investigate the interaction between reasoning processes and cognitive factors, implicit measures could be better.

Moreover it has been difficult to find an association between hints and cognitive factors in Italian sample because of the too many solutions of the insight problem. The *roof* *effect* made ineffective attempts to make meaningful analysis and correct interpretation. It's interesting because at the beginning of the study we decided to use a simplified version of the *8 Coins Problem*, to enable us to obtain a good number of solution and find the association with hints. Since the experimentally conditions were totally similar in Italy and in Japan, we just have to think that Japanese people and Italian people solve problems in a different way. We have to ask how. And we have to ask why. Maybe, as already proposed, cultural education and school course could help us to answer the question.

Anyhow, research about problem solving is very important to understand how people face problematic situations. Particularly insight problem solving represent a good topic regarding to human creativity. Creative problem solving requires an attitude that allows to search for new ideas and use knowledge and experience. Creative problem solving is a framework that encourages whole-brain, iterative thinking in the most effective sequence; it is cooperative in nature and is most productive when done as a team effort (Herrmann, 1995). In everyday life, from childhood to adulthood, people are asked to solve a lot of problem in innovative way. The present research could give a contribution to creative problem solving research, to understand which are the processes involved in this kind of problems and which are the most important features that allow people to solve these problems.

With this study we could better comprehend how human different abilities lead to elaborate internal and external information useful to solve the problematic situation. The results therefore support the possible interaction between the cognitive factors and intercultural differences in the insight problem solving to further investigate with future research.

CHAPTER 5.
THE INTERACTION BETWEEN COGNITIVE ABILITY, RATIONAL THINKING AND LEARNING

5.1 Introduction

Generally, think rationally means being able to use specific mental operations that lead individuals to give logical resolution to a reasoning task.

However people often implement erroneous reasoning that lead to a wrong solution of the task: there are a lot of errors, called biases, which may distort the appropriate reasoning to a right resolution of the problems. Individuals can be considered as information elaboration systems when they are solving a problem (Newell & Simon, 1972). When the task belongs to a field or domain highly structured, we proceed by trial and error, following systematic steps. If the field of the task is weakly structured, we use heuristics, considered a sort of shortcuts that do not guarantee the achievement of the solution, and are likely to lead to serious and systematic biases. "Most of heuristics relies on a strategy that modifies the next search depending on the information obtained in previous research" (Simon & Newell, 1962; Simon 1979).

There are many studies in the literature on *Heuristics and Biases* (Tversky and Kahneman, 1973, 1982) interested in the gap between the rules and effective response actually provided by individuals during the solution of reasoning tasks and the mental processes that people put in place to solve them. The operations may be those used to draw a conclusion, check a hypothesis or to evaluate the probability of an event. They are complex and often consist of several minor operations connected and coordinated.

The reasoning problems in the *Heuristics and Biases* literature allow us to point out the mental processes that subjects put in place to resolve them. In psychological research on reasoning specific tasks are used to highlight certain "acts of thought" (Johnson-Liard, Girotto, Legrenzi,1999).

Stanovich and West (1998, 2008), West and Stanovich (1999) and Toplak, West and Stanovich (2014) in the perspective of *dual-process theory*, wanted to explore how far the measures of cognitive skills and thinking dispositions can predict the gap from legal responses on a variety of tasks of the *Heuristics and Biases* literature. The two authors wanted to investigate the role of individual differences in rational thought: they have examined whether these differences, in the various activities of reasoning, showed patterns of association among themselves, with the measures of cognitive skills and the rules of rational thought. Although more than twenty years of studies have asserted that human responses often deviate from regulatory responses in many processes of reasoning employed to solve cognitive tasks; what has been largely ignored is that in each of these tasks, some people are able to give the normative response.

But why the descriptive results of the actual performance in reasoning tasks, often, does not overlap the normative theory?

Kahneman and Tversky (1982) defined the heuristic thought as the deviations of some true or objective value, most of the violations of the fundamental laws of probability. They assign the divergence from the norm to a reasoning that follows the different principles of normative reasoning, which provides for a systematic deviation from the norm.

On the contrary, we should affirm that the performance errors can be viewed as a failure in the application of a rule, strategy or algorithm that is part of skills of a person, because of a momentary and random lack in the processes required to implement a strategy for example a distraction, a momentary loss of memory, lack of attention, etc.

Moreover, there may be algorithmic/computational limitations that do not allow a regulatory response (Arora & Barak 2009; Goldreich, 2008).

Another perspective provides that, following the conversational rule of communication, you may have interpreted the task in a different way, or, despite having applied the correct one, it might have interpreted alternatively the problem and then giving the appropriate response, but to a different problem, in accordance with pragmatic rules of discourse (Mosconi, 1990, Macchi & Bagassi, 2015, 2012).

Finally there were found large individual variations that represent a possible explanation of the discrepancy between normative and descriptive models.

Stanovich and West referring to Funder (1987) explain how the ability to arrive at a regulatory response, not necessarily results from the level of cognitive ability of individuals: Funder compared the decision errors to optical illusions, asserting that anyone might taste these illusions, does not have to show a deficit in cognitive mechanism or in the judgment. Stanovich and West experiments indicate, at least for certain types of activities, that the inclination toward wrong assumptions, can be domain-specific: it is in some cases connected to computational limits and is provided by thought disposition that can be linked to epistemic and pragmatic objectives of rational thought.

5.2 The relationship between cognitive ability and rational thinking

It has been suggested that the models on individual differences in cognitive ability can be explained by the *dual-process theory* of reasoning (Evans, 2003, 2008; Sloman, 1996) according to which there are two main systems involved in reasoning and decision-making, reflecting respectively the interactional intelligence and the analytical one. *System 1* is old in evolutionary: it comprises a set of autonomous subsystems that include both innate input modules and domain-specific knowledge acquired by a domain-general learning mechanism. *System 2* is evolutionarily recent and distinctively human: it permits abstract reasoning and hypothetical thinking, but is constrained by working memory capacity and correlated with measures of general intelligence (Evans, 2003).

These two systems are usually described as *System Implicit 1* and *System Explicit* 2. Dual-process theorists generally agree that *System 1* processes are rapid, parallel and automatic: only their final product is placed in consciousness. *System 2* is believed to have evolved much more recently and is thought by most theorists to be uniquely human. *System 2* thinking is slow and sequential in nature and makes use of the central working memory system (Baddeley, 2000).

Stanovich and West in their studies (1998, 2008), West and Stanovich (1999) and Toplak, West and Stanovich (2014) have theorized that the great differences in cognitive ability, measured by SAT test -Scholastic Aptitude Test- (see paragraph 5.4), can be investigated only in tasks involving both systems and in which the two systems of reasoning answer to two different signals. In the different reasoning tasks, it is not always just one system to prevail over the other. For instance, the work of the two authors demonstrates how in two different problems such as Linda (Tversky and Kahneman, 1983) and that of the *Asian Disease* (Tversky and Kahneman, 1981) there is the alternating dominance of one of the two reasoning systems: in the *problem of Linda*, in fact, the association system (*System 1*) is dominant, while in the *Asian disease* problem the dominant system is analytical (*System 2*). Despite the different strengths of the two systems, both problems are different in cognitive ability, since the two cognitive systems suggest different answers.

To emphasize that different formulation of a problem could induce the predominance of a certain system of reasoning, rather than another, Stanovich and West (1998) gave subjects other two tasks (in addition to *Linda*) that investigated the conjunction fallacy. In one of the two different versions it was shown that the incidence of the *conjunction fallacy* can be reduced if the extensional reasoning is elicited by the use of problems describing the categories of events in a certain finite population (*problem of Labor* in Reeves and Lockhart, 1993); then if the subjects had to estimate the frequency of the required categories, instead of judging the probability (*the Student problem* in Tversky and Kahneman, 1983, and Fiedler, 1988), the incidence of the conjunction fallacy decreased.

This leads to assert that, according to the cognitive system involved in a certain task, people can arrive to a solution (either with or without errors) rather than another. In the *problem of Linda* (Stanovich and West, 1998) the 80.7% of the sample (i.e. well 121 subjects) have shown the effect of conjunction: those who had committed the fallacy, showed a significantly higher score in the SAT test. Two different *problems of Linda*, even investigating the conjunction fallacy, but with a different structure of the problem (the *problem of Labor* provided information on the categories of events, while the *Student problem* sent an inquiry to investigate the frequency of the required categories) showed that the different structure could decrease the conjunction fallacy.

In the *task of Labor* only 38.3% of those who did not commit the conjunction fallacy showed Significantly higher SAT score than those who had committed; the difference, however, was not as large as that found in the problem of Linda. In the problem of the Student even only 24.6% of the participants had committed the fallacy. Also the 107 subjects who didn't make the mistake had a minimally SAT score higher than those who had committed, but the difference was not statistically significant, nor remotely approaching to *Linda problem*.

Following the *Dual Process theory,* Stanovich and West speculate that in the *problem of Linda*, the association system is the dominant one. The structure of the task maximizes the trend of the two systems to trigger different responses, and in fact, this problem shows the most obvious differences in SAT test . The other two problems remove some of the conflicts between the two systems and, consequently, the differences in cognitive ability decreases.

Kahneman (2003) provides a starting point for explaining why certain tasks of rational reasoning show associations with cognitive ability and others do not. The rational answer requires an ability to reason correctly about the information you have, without a perfect consistency between the beliefs not simultaneously evoked (Kahneman and Frederick, 2005); people with a high IQ level have relatively efficient operations of System 2, which allow them to overcome the erroneous response when they have the proper information.

There are two conditions that must be satisfied for the analytical process, able to filter a heuristics response. These conditions are the two sources of errors in judgment that Kahneman and Tversky (1982) have labeled as "application errors" and "errors of understanding": the first is committed when a person fails to apply a rule that he had learned; the latter refers to mistakes made when people do not recognize the validity of the violated rule (e.g. *Linda Problem*).

The errors of understanding will be referred by Stanovich and West to the "Mindware Gaps" -the individual differences in domain-specific skills that are separate from general factors such as intelligence and working memory capacity- while the errors of application will be attributed to the "Override Detection" (Stanovich & West, 2008; Toplak, Liu, Machpherson, Toneatto, & Stanovich, 2007). Differences in cognitive abilities arise only when the experimental activity allows the variation in the process of both Mindware and Override Detection. However, there is a third source of response that could be one of the most important sources of individual differences in the fluid intelligence: the “Cognitive Decoupling”, which is involved in inhibition of the heuristic response and in elaboration of an alternative answer .

To conceptualize the individual differences in the tasks of *Heuristics and Biases*, Stanovich and West, suggest an interpretative scheme: the first step is to identify whether in an subject, given a task, the process of Mindware is available to carry out the replacement of a heuristic response. If the Mindware is not available, the subject necessarily use heuristic, but if the Mindware is available, the second step will be the need to replace the heuristic answer. If, the participant does not feel the need to replace the heuristics answer, the latter will still be given. The third step is more about the task than the solver; if the Mindware is available and there is the need to replace the heuristic answer, the question becomes whether the task requires sustained inhibition (Cognitive Decoupling) to support the replacement of a heuristic response. If it does not, or the inhibition request is very low, the analytical answer (System 2), will be replaced by a heuristic response. Conversely, if the inhibition request is high, the subjects could holds the "Decoupling Capacity" required to support the replacement and to provide the analytical response.

The association with the cognitive ability in the *Heuristics and Biases* tasks can be the difference in possessing the "Decoupling Capacity" to support the inhibition of heuristic response. Rationality is not uniformly related to intelligence; this ratio will depend on the extent to which the rational response requires the support of the process of Cognitive Decoupling.

An important limitation of this interpretative model is that the thinking tasks that lead to a conflict between the heuristics responses and the analytical ones are not fixed, but depend on the individual history of the acquisition of the Mindware. This acquisition grows with the experiences of statistical and probabilistic reasoning with more conflicts because the Mindware is available to provide an alternative response from the analytical system. The Mindware, used in analytical simulation, may become so highly structured that it can be triggered in the same way as a natural heuristic response.

Moreover, It is also experimentally difficult to understand how the concept of intelligence, identified by Stanovich and West, is related with reasoning skills, in the light of the *dual process-theory*. First of all because the SAT test, used for the intelligence measurement, doesn't seem a pure measure of cognitive ability because it is connected to learning (See paragraph 5.4). It is therefore hard to assume that the solution of this type of cognitive ability tests is linked to the *system 2,* the analytical one. In our opinion, the authors at first postulate the existence of an abstract intelligence that then they fail to grasp experimentally. For this reason the measures used to verify their assumptions are incorrect and so the cognitive processes related to reasoning ability remain obscure. If researchers want to study the abstract intelligence in experimental contexts, it will therefore useful to define better the construct and find an effective measures of this kind of intelligence to correlate with reasoning ability. The new perspectives, offered by the research on the working-memory capacity, might perhaps give a hint (Halford, Andrews & Wilson, 2015; Ma, Husain & Bays, 2014; Redick, Shipstead, Meier, Montroy, Hicks, Unsworth, & Engle, 2016; Unsworth, Fukuda, Awh & Vogel, 2014). When we refer to individual differences in WMC, we are not referring to the working memory concept as a whole, but rather to differences in functioning of what Baddeley and Hitch (1974) called the "central executive", what Norman and Shallice (1986) called the "supervisory attention system" (SAS), and what Posner and Di Girolamo (2000) called "executive control". Miyake et al. (2000) investigated three executive functions "‘task set shifting,’’ ‘‘updating,’’ and ‘‘inhibition’’ and showed that they had some variance in common. Complex measures of WMC exist in the cognitive literature and reflect a variety of influences, but they all measure the ability to control attention, that is, the ability to keep attention focused on one thing and not let it be captured by other events, be they in the external environment or internally generated thoughts and feelings. The ability to engage in controlled processing in attention-demanding circumstances, especially those that require the suppression or inhibition of automatic processing, seems related to individual differences in WMC. Individual differences in WMC may influence research that is guided by dual-process theories. Controlled attention is also referred to goal-directed, top-down, or endogenous attention (Egeth & Yantis, 1997). According to the traditional dual-process viewpoint, controlled attention defines the degree to which automatic processing influences thoughts, feelings, and behaviors. For example, when attention is captured by a stimulus and activates a representation that is inconsistent with processing goals, or when two goals are in conflict with one another, attention must be brought under control to resolve the conflict. The manipulation of representations by the control of attention is typically referred to controlled (sometimes called conscious, explicit, or systematic) processing in dual-process theories. The available evidence from the cognitive literature, however, suggests that despite attention control can sometimes occur with a feeling of conscious deliberation and choice, it need not. Controlled attention can operate at early perceptual stages, influencing how sensory information is selected, taken in, and processed (Barrett, Tugade & Engle, 2004; Luck & Hillyard, 2000; Posner & DiGirolamo, 2000; Shiffrin, 1988).

Otherwise it is necessary to accept the influence of environmental aspects on cognitive ability and to take into account that rational responses are highly learned and situated in the experience, thus increasing individual differences. Only in this case a “situated” cognitive ability can be associated with a reasoning ability equally “situated”. Some authors (Bentall, 1991; Morrison, 2001) have pointed out that beliefs and expectations can produce biases, although at the same time it seems plausible to say that the biases and heuristics can fulfill some specific adaptive function. It is important to consider the use of rationality occurs within situated contexts, since the rationality of course uses abstract processes, but strongly included in practical situations. It is possible that the heuristics and biases facilitate adaptation (Gigerenzer, 2001, 2002, 2011). The not-rational reasoning, not needing to be considered a defect in the design of human cognition, would own instead an daptive characteristics. This aspect would retain its functions of "the economy" in a non-compromised system.

5.3 The effect of learning on the cognitive ability tests

Towards the beginning of the '900, a big amounts of studies were made to the measurement of individual differences in the processes of cognitive ability. Binet and Simon (1905) elaborated a scale of intelligence to differentiate normal individuals from those with mental retardation, in order to direct the latter towards the appropriate specification schools, and create a scale of mental age. For the first time the intelligence matched with the chronological age and with the ability of learning, (Estes; 1982).

Subsequently, thanks to the influence of Spearman (1927), intelligence acquired unitary conception, through the method of factor analysis that identified the “g” factor of intelligence, present in every skill and measured in every task through a test. This factor could be regarded as a kind of "energy" transferable from a mental operation to another.

The vision of an unitary intelligence proposed by Spearman, however, was soon challenged by the supporters of the psychometrist Thurstone (1938), who argued that intelligence was an articulated set of primary cognitive abilities, relatively independent of each other and not attributable to a unitary factor. Thurstone spotted seven faculties which considered primary: verbal comprehension, fluency, calculation, spatial visualization, associative memory, speed of perception and reasoning. Also Gardner (2000) supposed a much larger number of independent factors, leading to an extreme crushing of the concept of intelligence. Cattell (1963) resumes factor model taking into account the research on the importance of cultural and educational conditions factors, which had been a little neglected by pure psychometrists. The author draws up what is called the theory of fluid intelligence (non-verbal) and crystallized. This model, still considered relevant in cognitive aging research, explains individual differences in the development and decline of ability in old age.

Fluid intelligence with basic functions of information processing and problem solving, and is expressed in trials that require organizational speed, mental agility, inductive reasoning, etc. The fluid component is linked to the physiological decline and a reduction thereafter as of the third age.

The crystallized intelligence, however, is related to the socio-cultural and environmental aspects, and is influenced by educational factors; It is stable over time, and concerns the general culture, language comprehension, vocabulary, etc. The deficit in the crystallized component are to be found in the regression phenomena due to the absence of cognitive stimulation (Social deprivation)

In the early 70s, the theorists of cognitivism criticized the test and techniques to measure general intelligence. Sternberg (1984) which is currently the most important expert on intelligence, proposes an intelligence *triarchic model*, which explains the intelligence according to three subcategories: Context that see the intelligence in relation to its surroundings; the contextual intelligence is the ability to adapt to their environment. Experiential that see the intelligence in relation to the internal environment; experiential intelligence is the ability to cope with new tasks and automate the execution. Componential that see the intelligence in relation to the internal environment; the componential intelligence corresponds to the traditional concept of intelligence.

A behavior is intelligent when allows a better adaptation to the environment through a process of selection and modeling of the context.

The Sternberg theory, even if it is not able to represent the structure of the mind is like a map that allows to understand and evaluate the most important dimensions of intelligence, trying to explain with a single model that in the past has been explained by partial models.

From a methodological point of view, he takes evidence from psychometrics tradition (reasoning tasks) and Piaget (storage and classification); the necessary steps in a task, in fact, are selected and measured according to various criteria (possibility of quantification, reliability, construct validity and empirical validity).

Sternberg also introduces the method of partial evidence that allows to separate the components and specify the order of the processing steps; Finally it provides insight into difficulties and is therefore useful both for diagnostic purposes and for training purposes.

In the light of the above considerations, it is well-recognized that the application of tests of cognitive ability from one ethnic group to another without appropriate standardization is highly problematic for both diagnostic and placement purposes (Ardila and Moreno, 2001;

Fletcher, Todd, & Satz, 1975; Hanna, House & Salisbury, 1968; Loewenstein, Arguelles, Arguelles & Linn-Fuentes, 1994; Manly, Jacobs et al., 1998; Ogden & McFarlane-Nathan, 1997; Okazaki & Sue, 2000; Stricks, Pittman, Jacobs, Sano & Stern, 1998; Viljoen, Levett, Tredoux & Anderson, 1994). Many of the differences found on comparisons by these researchers have been attributed to a homogenous set of socio-cultural factors that happen to characterize a particular ethnic group, rather than ethnic attributes themselves. Moreover, an ethnic group may not be homogenous in terms of socio-cultural characteristics (Gasquoine, 2001; Manly et al., 2000; Shuttleworth-Jordan, 1996). This will be matched by variable effects on cognitive test performance. Socio-cultural influences involve a number of inter-related variables that are difficult to separate, including language and reading ability, level and quality of educational attainment, socio-economic status, home and schooling socialization (Ardila, 1995; Manly et al., 2000; Olazaran, Jacobs & Stern, 1996; Shuttleworth-Jordan, 1996). Ardila argues that culture indicates the relevance of elements, and gives models for ways of thinking, acting and feeling, with resultant variations in cognitive test results. Therefore , Rosselli and Ardila (2003) face the common view that visuospatial and nonverbal tests are culturally and educationally free than verbal tests.

A universalist conception of intelligence would argue that the measurement of intelligence can be achieved with the same instruments in different cultures. In support of this assumption is the common finding of cross-cultural congruence with Wechsler IQ scales. This has been demonstrated for American blacks versus whites (Faulstich, McAnulty, Carey & Gresham, 1987; Kaufman, McLean & Reynolds, 1991); for a Spanish speaking versus English speaking US sample (Demsky, Gass & Golden, 1998); for Argentinians versus the US sample (Insua, 1983), for Italians versus the US sample (Orsini & Laicardi, 2000), and for Chinese versus the US sample (Lynn & Dai, 1993). However, the universalist notion is problematic in light of the need for significant item adjustment, and differences in subtest data that are reported across a broad spectrum of studies on the cross-cultural application of

Wechsler IQ test. In addition to Shuttleworth-Jordan (1996) and Manly et al. (2000), a good number of other cross-cultural researchers in recent years have underlined the importance of quality of education as a possible moderating variable in psychometric test performance (Fillenbaum, Heyman, Huber, Ganguli, & Unverzagt, 2001; Grieve & Viljoen, 2000; Insua, 1983; Nell, 1999; Okazaki & Sue, 2000; Stricks et al., 1998).

5.4 The effect of learning on the SAT Test

Despite Stanovich and West (1998, 2008) doubted on the ability of cognitive tests to consider essential skills of psychological functioning and they criticized the completeness of cognitive measurement (they noted that many non-cognitive domains such as social-skills, creativity, empathy, interpersonal skills and individual differences were almost entirely ignored by the tests of cognitive ability), they used SAT test in their studies.

The Scholastic Aptitude Test (SAT) occupies an important place in USA and it is probably the most widely taken test in the Nation. It has been taken over the past 40 years by most students interested in applying for college admission—over one third of high school graduates. The score has partially determined whether college admission is granted and which college one attends. This test is composed by three major sections, Critical Reading, Mathematics and Writing to complete within 3 hours and 20 minutes.

Regardless of their considerations on not-cognitive domains, the two Authors, should keep in mind the effect that learning could have had on the SAT.

Early, in SAT Test, cognitive ability was operationalized by an academic aptitude measure that loads highly on psychometric "g" – the general intelligence. Matarazzo (1972) views the SAT primarily as a measure of general intelligence. Carroll (1993) agrees but suggests that the test is weighted toward crystallized intelligence in the context of the psychometric theory of fluid–crystallized intelligence (Horn & Cattell, 1967; Horn & Hofer, 1992). Fluid abilities are processes such as memory and reasoning which operate across a range of domains, whereas crystallized abilities are thought to reflect one's experiential history, and are assessed by tests of vocabulary, general information, and nearly all types of acquired knowledge (Salthouse, 1988). SAT type measures of cognitive ability have been shown to be related to measures of intellectual engagement, reflective thought, and thorough information processing (Ackerman, 1996; Ackerman & Heggestad, 1997; Baron, 1985; Carroll, 1993; Goff & Ackerman, 1992).

However, like many other tests, the SAT has attracted criticism from many experts. These criticisms focus on whether the test is equitable to all those taking it, whether it can validly predict success in college, and whether its use improves the college admission process. All of these concerns focus on the appropriate interpretation and use of individual-level scores in the college admission process.

Annual SAT average scores have been continuously published since Sixties. These scores get big media coverage at every level because they give easy and, often, the only available comparative score data along local schools and school districts and states. SAT scores are often seen as reliable indicators of the quality of the education system, because they are produced at the end of education before college, so that SAT scores frequently animate the public debate on education. Is important that they can modulate the attitude of people that pay taxes toward schools: Whether schools are improving or deteriorating, whether money is spent efficiently or inefficiently, whether educational cost should increase or decrease, and how much support to give for alternative educational policies.

Differences in SAT scores primarily reflect the different characteristics of self-selected population taking the test and little about the quality of the schools attended. The changes in average scores over time also primarily reflect the characteristics of test takers. Now the USA trends actually move in the opposite direction to school quality. The better job is that the education system does in preparing more students to meet college standards, the lower is the average SAT score. These tests reflect the most accurate assessment of how student achievement is changing in the USA. The data also show that all racial-ethnic groups score higher at each age group in both reading and math but that the largest improvement have been made respectively by Black students, Hispanic students, and lower by White students (Hedges & Nowell, 1998).

Therefore, the primary problem with SAT scores is that commentators of such scores often assume that comparisons have validity as an indicator of the quality of education, the second problem is the characteristics of the sample. The possible way to solve these problems is to collect extensive family and schooling-related data, and try to collect these data as well as possible so that there are no omissions that would make difficult the preparation of reliable statistics. We must also ask whether it is still so necessary to use this type of test to assess students' skills that need to attend college, but especially if it makes sense to use the SAT to evaluate cognitive ability in experimental psychology.

5.5 THE EXPERIMENT

Stanovich and West (1998, 2008), West and Stanovich (1999) have hypothesized that individual differences in the ability to solve reasoning problems may be influenced by cognitive ability owned by subjects. As mentioned above, they have used the SAT test to operationalize cognitive ability. The Authors didn't consider the possibility that SAT is dependent on learning. This is an important lack, since numerous studies have suggested the profound influence of culture and learning on the SAT test. Furthermore, despite this test is divided into three subtests (Math, Critical Reading, Writing) Stanovich and West considered the different SAT subtests as a unit and analyzed the correlation only between it and the solution rate in reasoning tasks. However, in our opinion, this choice says little about the specific skills of subjects and the possible interaction between them and the resolution of the reasoning problems. From our point of view, the authors have overlooked the difference between the various subtests of the SAT, achieving incomplete results. This omission allows us to recheck the results obtained by the two Authors. If literature already tells us that the SAT is influenced by education, consequently it was our interest to understand if specific learning can lead to different results on SAT test. In fact, if in the United States any person receive a undifferentiated instruction before the College, in Italy, on the contrary, this differentiation exists during high school, in which the course of study is ordered on different curricula. According to our hypothesis, the opportunity to choose their own path in high school, provides students type of diversified training and this could lead to more or less facilitation in the resolution of cognitive tests like the SAT. We assumed that three common course of study (e.g. Classics, Science, and Foreign Language) in the current Italian high school system, might influence SAT subtests scores. In particular, our study aims to demonstrate that a specific kind of course of study, with a specific training, would influence the successful in the single subtests of SAT. Science class might lead to better performance in Math section, while Classic might do the same in Critical Reading and Writing. Regarding Foreign Language we assume low scores in any subtests because in this course of study there isn't a specific training for Math, Reading or Writing.

We also assumed not to find a significant interactions among reasoning skills with the total SAT, as we don't consider it a good measure of cognitive ability, since, as already said, too conditioned by school education. Moreover we were interested in controlling the association between Reasoning Ability and Course of Study to check whether particular educational pathways might influence the resolution of reasoning tasks.

We thought to repeat the Author's studies, adding Course of Study as independent variable and checking the correlations between Total SAT, each subtests of the SAT and the reasoning problems with the Course of Study.

Therefore we administered three reasoning problems, the *Linda Problem*, The *Wason Selection Task* and one *Syllogism* to 220 students attending the fourth class of an High School. Then they were asked to complete the SAT test within 3 hours and 20 minutes.

5.5.1 Method

Participants

220 (M=99, F=121; Mean age=18,10; DS=.441) students attending the fourth class of an High School at Cinisello Balsamo-Milan, took part to our study. Signed parental consent was obtained for all underage participants; older students gave their consent.

Information about parental education was not required for this study. Eleven teachers and eleven classrooms volunteered to participate; in particular, there were 8 (M=85, F= 64; Mean age=18.08; DS=.034) Science sections, 2 (M=13, F=32; Mean age=18.16; DS=.063) Classic sections and 1 (M=1, F=25; Mean age=18.08; DS=.077) Foreign Language section. The three schools were similar in terms of demographics. All the students, tested in Italian, were Italian speakers. None of our participants had a learning disability certificate. Subjects with more than 3 SD in SAT score were excluded from analysis.

Measures

Test SAT

The Scholastic Aptitude Test is a three-hour paper-and-pencil exam used for university admissions testing. The verbal section of the SAT test contains four types of items: antonyms, reading comprehension, verbal analogies, and sentence completion items in which the examinee chooses words or phrases to fill in a blank or blanks in a sentence. According to Carroll (1993), the mathematical section contains “varied items chiefly requiring quantitative reasoning and inductive ability." The standardized scores on the verbal and mathematical sections are added together to form the total score. In the entire population of test takers throughout the previous two decades, total scores have averaged approximately 950 with a standard deviation of approximately 150 (Willingham, Lewis, Morgan, & Ramist, 1990).

The SAT test required 3 hours and 20 minutes of time and was divided into 10 sections (a short essay, 3 sections of writing, 3 math and 3 of comprehension):

Section 1

Essay

Time: 25 minutes

Section 2

Math questions

Time: 25 minutes

Section 3

Time: 25 minutes

1. Completion of sentences

2. Reading comprehension

Section 4

There wasn't a fourth section in this protocol

Section 5

Time: 25 minutes

1. Correctness and effectiveness of expression

2. Ability to recognize grammar and usage errors

3. Improve sentence structure or word choice in a text

Section 6

Math questions

Time: 25 minutes

Section 7

Time: 25 minutes

1. Completion of sentences

2. Reading comprehension

Section 8

Math questions

Time: 20 minutes

Section 9

Time: 20 minutes

1. Completion of sentences

2. Reading comprehension

Section 10

1. Correctness and effectiveness of expression

Time: 10 minutes.

Along with the protocol was handed an answer sheet on which the students were required to write in their own pen register number, the class (specifying the address) and the answer to every question.

Regarding to the correction of the SAT it has been used a predefined grids that assign group to the scores obtained in the different sections so as to have both, the partial scores diversified in the fields of writing, mathematics and understanding, and the total SAT scores. The mean total SAT score was 1430 (SD = 160,2). These reported scores match the averages of this institution (520, 587, and 1107) quite closely. The mean reported Reading SAT score of the students was 480 (SD = 64) while the Writing mean score was 471 (SD = 66); Reading and Writing together score SAT-V (verbal) of which the mean is 479 (SD = 57) and the mean reported mathematical SAT score was 470 (SD = 76).

The tasks

In addition, the same subjects were given 3 reasoning tasks coming from the literature of *Heuristics and Biases*: the *Wason Selection task* (1966), the *Linda Problem* (Kahneman and Tversky, 1982) and one *Syllogism*.

Linda Problem

Among the errors made in reasoning problems, there is one on the evaluation of the probability of the intersection of two events (Tversky and Kahneman. 1982, 1983).

The probability that two events occur simultaneously (A and B) is necessarily lower than individual events (A) and (B). The principle is one of the basic axioms of probability theory, and before the law of inclusion of the logic.

[2] Reading + Mathematic + Writing

Kahneman and Tversky (1983) showed the conjunction fallacy through one of the most well-known literature of heuristics and biases. The problem was as follows:

“Linda is 31 years old, single, outspoken, and very bright. She majored in philosophy. As a student, she was deeply concerned with issues of discrimination and social justice, and also participated in anti-nuclear demonstrations.”

Please rank the following statements by their probability, using 1 for the most probable and 8 for the least probable.

a. Linda is a teacher in an elementary school

b. Linda works in a bookstore and takes Yoga classes

c. Linda is active in the feminist movement

d. Linda is a psychiatric social worker

e. Linda is a member of the League of Women Voters

f. Linda is a bank teller

g. Linda is an insurance salesperson

h. Linda is a bank teller and is active in the feminist movement

The last item is the union of a typical "representative" woman feature “feminist" with another not representative feature “bank teller”. In most cases the utterance A was considered less likely utterance A and B.

In Tversky and Kahneman view this error is due to heuristics of "representativeness", according to which the probability of an event is determined by its source or process that produces it. In Linda Problem, the category "feminist movement" is considered more representative (thanks to the presence of the word "feminist") in the description of Linda, compared to the category "bank teller".

In the present study, we examined the performance of 220 subjects on the Linda Problem as given earlier. A within-subject version of the conjunction judgement task, it represents what Tversky and Kahneman (1983) call a “direct subtle” test of susceptibility to the conjunction fallacy, where the conjunction and its constituents are directly compared by the same subjects, but the inclusion relation is not emphasized.

Wason Selection Task

Originally used by Wason (1966), the abstract version of the selection task has been studied extensively in the deductive reasoning literature (for detailed discussions of the enormous literature on the task, see Evans, Newstead, & Byrne, 1993; Evans & Over, 1996, 2004; Sperber, Cara, & Girotto, 1995; Stanovich & West, 1998). The problem involves reasoning about the falsifiability of an "if P then Q" type of rule.

The participant is shown four cards lying on a table showing two letters and two numbers (A, D, 2, 7). They are told that each card has a number on one side and a letter on the other and that the experimenter knows the following rule "if P, then Q" with respect to the four cards: "If there is an A on one side then there is a 2 on the other". The participant is then told that he must turn over whichever cards are necessary to determine whether the experimenter's rule is true or false. The four cards represent p, not-p, q and not-q. Specifically p is represented by the vowel A, not-p by consonant D, q the number 2, not-q number 7. The rule is false when p is true and q false, that is if participant give p and not q. In the case presented to the subjects, the rule is false only if there is a vowel on one side of the paper and there is an even number on the opposite side. In all other cases the rule is false. Performance on such abstract versions of the selection task is extremely low (Beattie & Baron, 1988; Evans, 1989; Griggs & Cox, 1982; Jackson & Griggs, 1990; Wason & Evans, 1975). Typically, less than 10% of individuals make the correct selections of the A card (P) and 7 card (not-Q). The most common incorrect choices are the A card and the 2 card (P and Q) or the selection of the A card only (P).

Syllogism

The linear syllogisms, are composed of two premises, that indicate the position of the terms in a series or on a line and a conclusion, which is precisely the required solution.

A *belief bias* effect was demonstrated on the syllogistic reasoning task. The *Belief bias* occurs when people have difficulty evaluating conclusions that conflict with what they think they know about the world (Evans, 2002; Evans, Barston, & Pollard, 1983; Evans, Newstead, Allen, & Pollard, 1994; Klauer, Musch, & Naumer, 2000). It is most often assessed with syllogistic reasoning tasks in which the believability of the conclusion conflicts with logical validity. One reasoning problem, drawn from Markovits and Nantel (1989), were completed by the participants. We gave consistent syllogisms were the validity judgment was congruent with the believability of the conclusion (e.g., All fish can swim; tuna are fish; therefore, tuna can swim — which is valid).

Procedure

Participants completed the protocol made by the 3 tasks and SAT. They were tested in their respective classes. For the purposes of some of the analyses described below, the 110 students with SAT scores below the median (952,50) were assigned to the low-SAT group, and the 110 remaining students were assigned to the high-SAT group. The Kolmogorov-Smirnov test returned a standard normal distribution of the sample for the SAT (p= .200).

5.6 Results

Regarding SAT correction, we used predefined grids to obtain both the partial scores diversified in various fields of Reading, Mathematic and Writing, and the total scores of the general SAT test. The mean total SAT (SAT-M + SAT-V) score for 220 students was 950,66

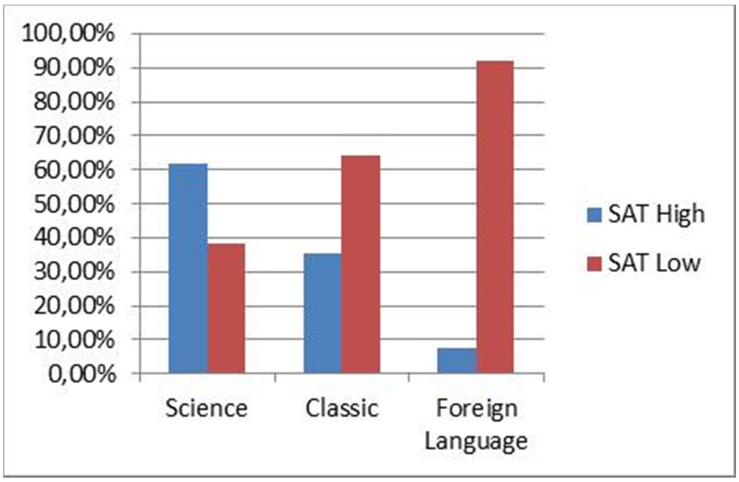
(SD = 111; Min=650; Max=1280). The mean reported Reading SAT score of the students was 480 (SD = 64) while the Writing mean score was 471 (SD = 66); the mean of Reading and Writing together score SAT-V (verbal) is 479 (SD = 57); the mean reported in mathematical SAT score was 470 (SD = 76).

Table 1 and Graph 1 display, for each of the experimental tasks, the mean response as a function and cognitive ability group (low vs. high SAT). The *Chi square* analysis shown a significant difference in SAT scores in each course of study: (X^2 (2) 30,592 $p < .01$). Students from Science and Classic had higher SAT scores than the others.

Tab. 1

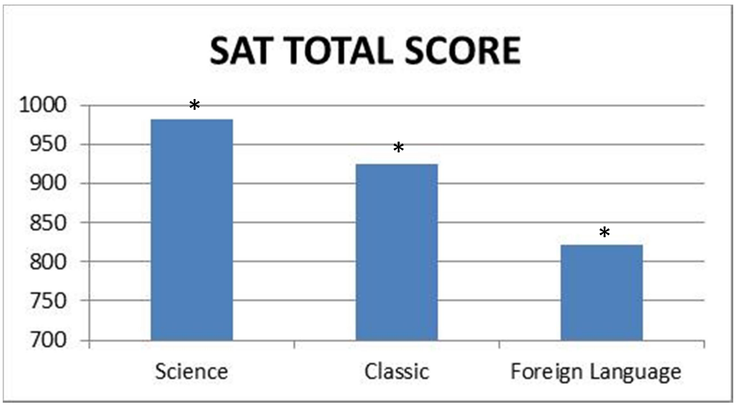
SAT scores of participants who belong to different course of study		
	SAT low (110)	SAT High (110)
Science	38%	62%
Classic	64%	36%
Foreign language	92%	8%

Graph 1. SAT scores of participants who belong to different course of study



Then we conducted an *ANOVA* Between to control the difference in SAT test scores for the 3 courses of study. We found a significant difference between all courses (F (2,217)= 30,437 p<0.01). Subjects from Science course of study have higher scores, followed respectively by students of Classic and Foreign Language (Graph. 2).

Graph 2. SAT Total score means for each course of study



LSD and Bonferroni Post Hoc test and multiple pairs comparisons were conducted to define which means differ. Each of the three courses of studies presents significantly different scores in Total SAT from each of the other (Tab.2).

Tab. 2 Multiple comparison of Total SAT score means between Courses of study

	(I) Course of study	(J) Corso_di_studi	Mean difference (I-J)	*p*
LSD	Science	Classic	83,53*	0***
		Foreign Language	127,70*	0***
	Classic	Science	-83,53*	0***
		Foreign Language	44,17*	0,003***
	Foreign Language	Science	-127,70*	0***
		Classic	-44,17*	0,003***
Bonferroni	Science	Classic	83,53*	0***
		Foreign Language	127,70*	0***
	Classic	Science	-83,53*	0***
		Foreign Language	44,17*	0,008***
	Foreign Language	Science	-127,70*	0***
		Classic	-44,17*	0,008***

**p <0.05 ***p <0.01

SAT subtests scores

First of all, Pearson product-moment correlations were estimated between each factor. Math, Reading and Writing are all significantly correlated (Tab.3):

Tab. 3 Correlation between SAT Subtest

	Mathematic	Reading	Writing
Reading			0,553***
Mathematic		0,362***	0,312***

**p<0,05 ***p<0,01

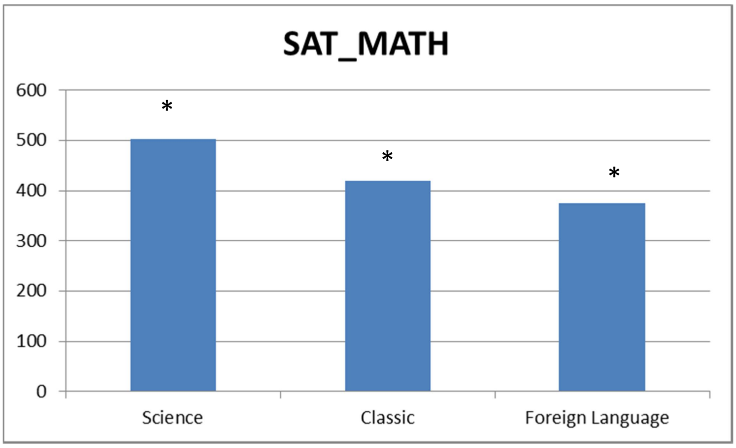
Parallel analyses to investigate the subtest scores in each course of study are also reported (Table 4). Separate analyses with the verbal SAT–V, Reading and Writing, and the mathematical SAT score were conducted. We found significant differences in each subtest scores. SAT-Reading (X^2 (2) 17,525 $p < .01$) SAT-Writing (X^2 (2) 9,672 $p < .05$) SAT-M (X^2 (2) 43,511). (See also Graph. 3).

Tab. 4 Distribution of each sample in High/Low SAT subtests

	Math-High	Math-Low	Reading-High	Reading-Low	Writing High	Writing-Low
Science	56,40%	43,60%	45,60%	54,40%	46,30%	53,70%
Classic	13,30%	86,70%	66,70%	33,30%	64,40%	35,60%
Foreign Language	3,80%	96,20%	15,40%	84,60%	26,90%	73,10%

ANOVA between was run for the SAT subtest scores. Regarding Math scores, we found a significant difference between all ($F(2,217)=72{,}455$ $p<0{,}01$). Subjects from Science course of study have higher scores, followed respectively by students of Classic and Foreign Language (Graph. 3):

Graph. 3 Math Total score for each course of study



With LSD and Bonferroni Post Hoc test we found similar result to the Total score (Tab.5) . Each of the three Courses of Studies presents significantly different scores in Math SAT:

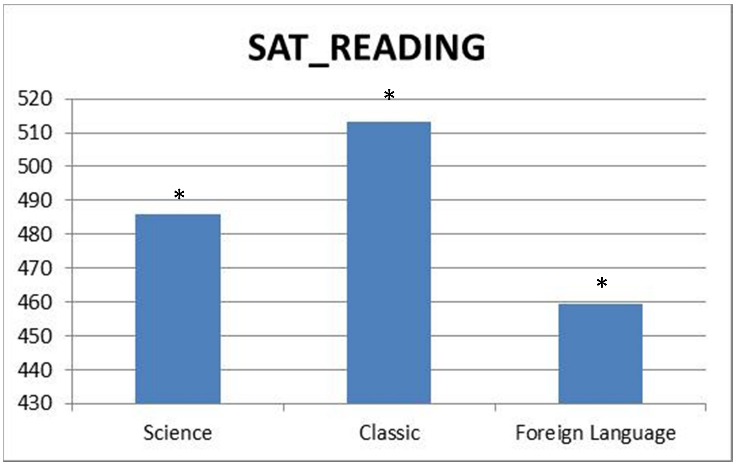
Tab. 5 Multiple comparison between Math SAT score

	(I) Course of study	(J) Corso_di_studi	Mean difference (I-J)	*p*
LSD	Science	Classic	83,53	0***
		Foreign Language	127,7	0***
	Classic	Science	-83,53	0***
		Foreign Language	44,17	0,003***
	Foreign Language	Science	-127,7	0***
		Classic	-44,17	0,003***
Bonferroni	Science	Classic	83,53	0***
		Foreign Language	127,7	0***
	Classic	Science	-83,53	0***
		Foreign Language	44,17	0,008***
	Foreign Language	Science	-127,7	0***
		Classic	-44,17	0,008***

**$p<0.05$ ***$p<0.01$

For Reading SAT scores, we did the same analysis (Graph. 4 and Tab. 6). Classic sample shows significantly higher scores, followed by Science and Foreign language sample ($F(2,217)= 6,329$ $p<0,01$):

Graph. 4 SAT Reading score means for each course of study



LSD and Bonferroni Post Hoc test suggest that there is a significant difference between Classic with Science sample and Classic with Foreign Language sample, but not between Science sample and Foreign Language sample (Tab. 6):

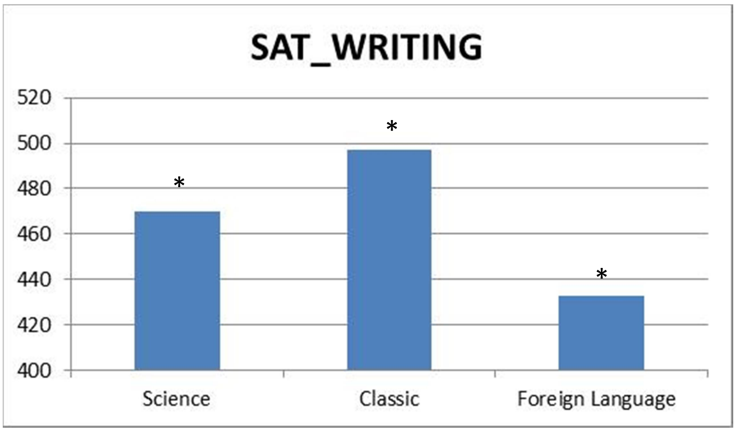
Table. 6 Multiple comparison of Reading SAT score for each Course of Study

	(I) Course of study	(J) Corso_di_studi	Mean difference (I-J)	*p*
LSD	Science	Classic	-27,29	0,012**
		Foreign Language	26,42	0,05**
	Classic	Science	27,29	0,012**
		Foreign Language	53,72	0,001**
	Foreign Language	Science	-26,42	0,05**
		Classic	-53,72	0,001**
Bonferroni	Science	Classic	-27,29	0,035**
		Foreign Language	26,42	0,15
	Classic	Science	27,29	0,035**
		Foreign Language	53,72	0,002**
	Foreign Language	Science	-26,42	0,15
		Classic	-53,72	0,002**

**p <0.05 ***p <0.01

Regarding Writing scores we find a significant difference between the 3 courses of study, with significantly higher scores in the Classic sample (Graph. 5), followed by Science and Foreign Language ($F(2,217) = 8,314$ $p<0,01$):

Graph. 5 Writing Total score for each course of study



With LSD and Bonferroni Post Hoc test we found similar results.Each of the three courses of studies presents significantly different scores in Writing Score from each of the other (Tab. 7):

Tab.7 Multiple comparison between Writing SAT scores

	(I) Course of study	(J) Corso_di_studi	Mean difference (I-J)	*p*
LSD	Science	Classic	-27,31	0,013**
		Foreign Language	37,11	0,007***
	Classic	Science	27,31	0,013**
		Foreign Language	64,42	0***
	Foreign Language	Science	-37,11	0,007***
		Classic	-64,42	0***
Bonferroni	Science	Classic	-27,31	0,04**
		Foreign Language	37,11	0,022**
	Classic	Science	27,31	0,04**
		Foreign Language	64,42	0***
	Foreign Language	Science	-37,11	0,022**
		Classic	-64,42	0***

**$p<0.05$ ***$p<0.01$

SAT Total scores and reasoning task

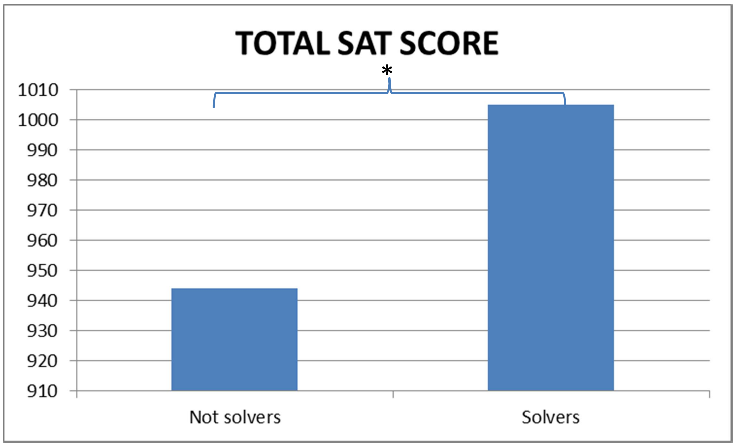
We run a *Chi Square* analysis, dividing the sample into Low-SAT group and High-SAT group.

Wason Selection task

Participants who completed this task were 26 (11,09%). The correct response was to choose the P and not-Q cards. All remaining response patterns were classified as Other. The major response patterns on the *Wason selection* task and the mean SAT score associated with that pattern, are displayed in Table 9. Cognitive ability was associated with the response given to the *Selection task*. In *Chi square* analysis, there was a significant effect of group ($X^2(1)$ 6.161 p <05).

We also run a *ANOVA* Between to find differences between solver and not solver in Total SAT score (Graph.6). We have a significant difference in Higher SAT Total score in the solvers group ($F(1,217)=7,040$ $p<0.01$).

Graph. 6. Total SAT scores means of solvers and not solvers in *Wason Selection task*

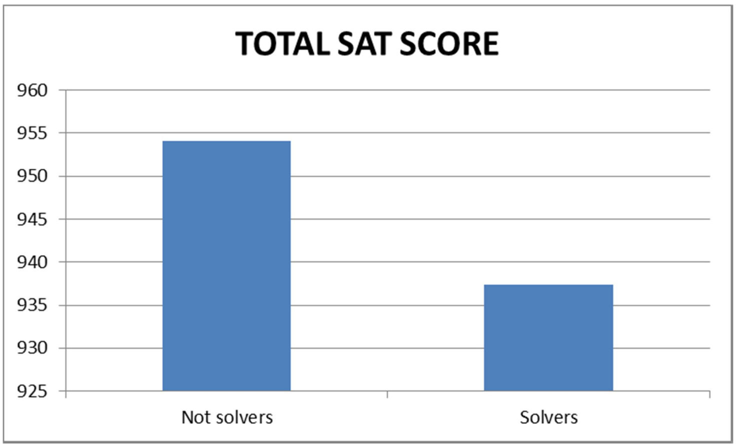


Linda problem

The means of both groups displayed the expected conjunction fallacy —*Linda* was judged more probably a feminist bank teller than a bank teller. Surprisingly the solution rate was 16% with 35 participants who completed the task. The interaction was in the opposite direction from the expected finding—the high-SAT group was more susceptible to the conjunction fallacy. The *problem of Linda* showed no significant difference ($x^2(1)\ .84\ p = .771$) between the high/low group (table 3), indeed apparently minor solutions correspond to the higher SAT scores (Stanovich and West, 2008).

We conducted *ANOVA* between also for this problem. Contrary to *Wason selection task*, we didn't find any difference between solvers and not-solvers (Graph. 7), despite the higher Total SAT score in the Not-solvers sample (F(1,217)=0,653 p =.420).

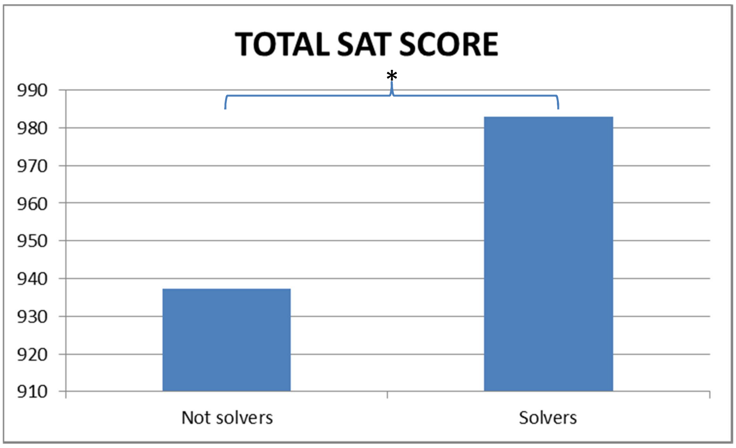
Graph. 7 Total SAT scores between solvers and not solvers of *Linda Problem*



Syllogism

Participants who completed this task were 68 with 31,1% of the solution rate. To give the correct solution, they had to sign as valid the conclusion of the argument. The *Syllogism* has reported a significant difference ($X^2(1)\ 6.491\ p < .05$); higher SAT scores were related to a greater number of correct solutions to the task (table 3). When we conducted *ANOVA* between for *Syllogism*, we found a significant difference between Solvers and Not-solvers in SAT Total score (Graph. 8), with higher score in the first group (F(1,217) =8,127 p<0,01):

Graph. 8 Total SAT scores between Solvers and Not Solvers of *Syllogism*



As already said, for each of the experimental tasks, we conducted an analysis that examines whether the magnitude of the effect or bias demonstrated by the task was moderated by cognitive ability, whether the solution rate interacted with SAT group. Table 8 summarize the results:

Tab. 8

Table 1.
Mean SAT Total Scores of Participants Who Gave the Correct and Incorrect Responses to the 3 Problems

	Incorrect	Correct	*F*
Wason Selection Task	944,71	1005,19	7,04**
Linda Problem	954,076	937,429	0,653
Syllogism	937,219	982,941	8,127**

Figures in parentheses are the number of participants giving the correct and incorrect responses.
* = P < .05, ** = P < .01, all two-tailed

The *ANOVAI* shows that in the case of the *Wason Selection Task* and in *the Syllogism* the SAT mean of those who solved the problem is significantly different from the mean of those who did not solve the task, with a higher mean in the first group.

After, we run a multifactorial ANOVA, with SAT Total score as dependent factor and Reasoning tasks as Independent to assess whether an interaction between factors were present (Tab.9):

Tab. 9 Test of Between-subject effects of each reasoning task

Source	*df*	*F*	*p*
Wason	1	6,709	0,10*
Linda	1	0,295	0,588
Syllogism	1	2,39	0,124
Wason * Linda	1	1,355	0,246
Wason * Syllogism	1	0,066	0,797
Linda * Syllogism	1	0,072	0,789
Wason * Linda * Syllogism	1	0,494	0,483
Error	211		

* = P < .05, ** = P < .01

As the table 9 shows, there isn't any interaction effect of the tasks, but until now, the only main predictor of the SAT scores is the *Wason Selection task.*

Then we calculated the Reasoning Ability factor as the sum of solution rate in the 3 different task. So we conducted LSD and Bonferroni Post Hoc test and multiple pairs to find the differences of Total SAT means for each level of Reasoning ability. SAT Total scores are significantly different only between 0 problem solvers and 3 problem solvers (Tab. 10), suggesting that who has an higher total SAT scores also has higher Reasoning ability and this difference is more clear between the two extremes of the reasoning skills: very high (3 problems solved) and very low (0 problem solved).

Tab. 10 Multiple comparison of SAT Total Means in reasoning ability

	(I) Reasoning_ability	(J) Reasoning_ability	Differenza media (I-J)	*p*
LSD	0 problem solved	1 problem solved	-15,35	0,316
		2 problems solved	-41,17	0,075
		3 problems solved	-81,23	0,037
	1 problem solved	0 problem solved	15,35	0,316
		2 problems solved	-25,82	0,295
		3 problems solved	-65,88	0,098
	2 problems solved	0 problem solved	41,17	0,075
		1 problem solved	25,82	0,295
		3 problems solved	-40,06	0,354
	3 problems solved	0 problem solved	81,23	0,037**
		1 problem solved	65,88	0,098
		2 problems solved	40,06	0,354
Bonferroni	0 problem solved	1 problem solved	-15,35	1
		2 problems solved	-41,17	0,448
		3 problems solved	-81,23	0,22
	1 problem solved	0 problem solved	15,35	1
		2 problems solved	-25,82	1
		3 problems solved	-65,88	0,585
	2 problems solved	0 problem solved	41,17	0,448
		1 problem solved	25,82	1
		3 problems solved	-40,06	1
	3 problems solved	0 problem solved	81,23	0,22
		1 problem solved	65,88	0,585
		2 problems solved	40,06	1

**p <0.05 ***p <0.01

SAT subtest and Reasoning tasks

After the previous analysis we checked the relation between each SAT subtest and correct responses to reasoning tasks with *Chi square* statistical analysis. We wanted to verify the hypothesis that specific abilities, such as reading comprehension, math or writing skills could be associated to specific reasoning problem. The interaction in the conditional reasoning occurred for SAT–V ($X^2(1)\ 4.469\ p < .05$) and SAT–M ($X^2(1)$ 6.900 $p< .05$). The interaction in the conjunction fallacy didn't occurred either for SAT–M ($X^2(1)$ 0.41 $p= .839$) and for SAT–V ($X^2(1)$ 0.24 $p=.877$). the Belief bias was less frequent in SAT-M ($X^2(1)$ 5.267 $p <.05$) than in SAT-V ($X^2(1)$ 3.232 $p < .05$).

Reading

Those who had higher SAT Reading subtest doesn't present difference in solution rate in the *Wason Selection Task* ($X^2(1)\ 4{,}195\ p = .06$). The *problem of Linda* did not lead to the same evidence: indeed they seems to repeat the same pattern emerged with the total score: those with high reading scores have solved less than their colleagues with lower scores ($X^2(1).231\ p = .630$). With the *Syllogism* it seems there is no correlation between the correct resolution of the *Syllogism* and a high/low score in SAT Reading subtest test ($X^2(1)\ .950$
$p = .330$).

Mathematic

In the *Wason Selection Task*, higher math scores match with more solution rate (X^2 (1) 6,900 $p <.05$). In the *Linda problem*, the high scores in mathematics do not seem be associated with the proper resolution of the *problem of Linda* ($X^2(1)$ .041 $p = .839$), but on the contrary, as for the SAT total score and the reading subtest scores, it seems that low scores, obtained in the mathematics section, are associated with a greater number of correct solutions of the problem. In *Syllogism* high scores in the math section seem associated with a higher resolution of the problem ($X^2(1)\ 5{,}267\ p < .05$).

Writing

The writing section seems not related to the resolution of *the Wason Selection Task* ($X^2(1)\ 2{,}184\ p = 139$). The proper resolution of the *Linda Problem* was not associated with a higher score in writing ($X^2(1)\ .083\ p = 0.773$). Even the *Syllogism* didn't revealed a significant difference between the high score in writing and the resolution of this task ($X^2(1)\ 0.491\ p = .483$). (Tab.11 and 12).

Tab.11 Solution rate in each Reasoning task for each SAT subtests

		Reading high	Reading Low	Math High	Math low	Writing high	Writing low
Wason	Not solved	44,00%	56,00%	38,30%	61,70%	46,10%	53,90%
	Solved	65,40%	34,60%	65,40%	34,60%	61,50%	38,50%
Linda	Not solved	47,30%	52,70%	41,80%	58,20%	48,40%	51,60%
	Solved	42,90%	57,10%	40,00%	60,00%	45,70%	54,30%
Syllogism	Not solved	44,40%	55,60%	36,40%	63,60%	46,40%	53,60%
	Solved	51,50%	48,50%	52,90%	47,10%	51,50%	48,50%

Tab. 12 Difference in SAT subtest (*Chi square*) of participants who gave the correct and incorrect Responses to the 3 Problems

	x2 (Mathematic)	x2 (Reading)	X2 (Writing)
Wason Selection Task	6,900 *	4,195	2,184
Linda Problem	0,41	0,231	0,83
Syllogism	5,267*	0,95	0

Figures in parentheses are the number of participants giving the correct and incorrect responses.
* = P < .05, ** P < .01; all two-tailed.

As suggested by the analysis, only to high math scores are associated more solution rate in the *Wason Selection Task* and in the *Syllogism.*

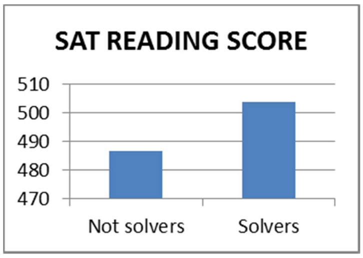
We conducted a similar analysis With *ANOVA*, to check the difference in SAT subtests means between solvers and not-solvers of reasoning tasks, to confirm if specific SAT subtests could be correlated to the solution rate in specific reasoning task:

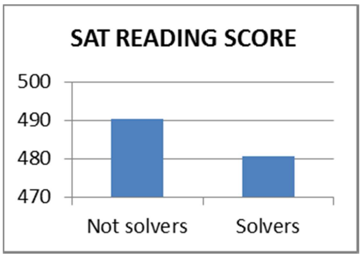
Reading

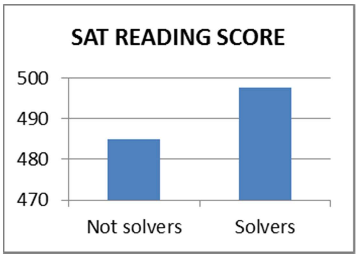
There isn't significant difference in SAT Reading scores between Solvers and Not-solvers in the *Wason Selection Task* ($F(1,217)=1,597$ p=.208) but solvers shows higher scores. The *problem of Linda* lead almost to the opposite pattern: Not-solvers have an higher score in SAT Reading, but not significant ($F(1,217)=0,686$ p=.408). With the *Syllogism* it seems there is no correlation between the correct resolution of the syllogism and a score in SAT Reading subtest test ($F(1,217)=1838$ p=.177) (Graph. 9).

Graph. 9 Means of SAT Reading Scores in solvers and Not-solvers

Wason Linda Syllogism







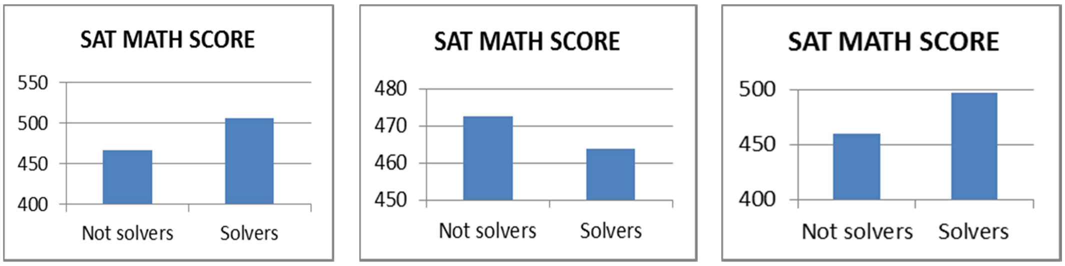
**p<0.05 ***p<0.01

Mathematic

In the *Wason Selection Task*, solvers shows a significant higher score in SAT Math ($F(1,217)=1,597$ $p<0.05$). In the *Linda problem*, we find the same pattern of SAT Reading: not solvers seems have higher scores, but not significantly higher ($F(1,217)=0,393$ $p=.531$). In the *Syllogism* solvers have significantly higher SAT Math scores than Not-solvers ($F(1,217)=11,784$ $p<0.01$) (Graph. 10).

Graph. 10 Means of SAT Math scores in solvers and not solvers

Wason** Linda Syllogism***



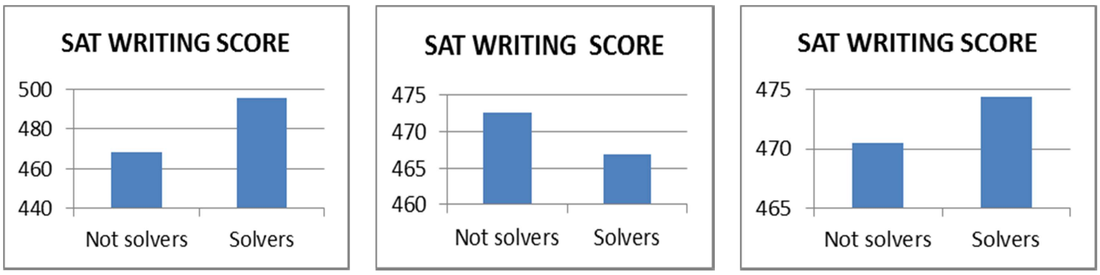
**p<0.05 ***p<0.01

Writing

A higher score in the Writing section is only weakly related to the resolution of the *Wason Selection task* ($F(1,217)=3,991$ $p=.057$). There is no difference between Solvers and Not-solvers of the *Linda Problem* in SAT Writing scores, but even in this task, Not-solvers present higher SAT Writing scores ($F(1,217)=0,223$ $p=.637$). The *Syllogism* solvers have similar SAT Writing scores of Not- solvers ($F(1,217)=0,168$ $p=.683$) (Graph. 11).

Graph. 11 Means of SAT Writing scores in solvers and not solvers

Wason Linda Syllogism



**p<0.05 ***p<0.01

The *ANOVA* indicates that solution rate in reasoning tasks is only linked to Math SAT scores. In fact, participants who show an higher scores on the math section of SAT also solve more the *Wason Selection task* and the *Syllogism*. This result is interesting because it could mean that the relationship between total SAT and reasoning skills could only be explained by the math section (Tab. 13). We can suppose this hypothesis since both the total SAT and the math subtests correlate with the same two tasks:

Tab.13 MANOVA: Test of Between-subject effect of Reasoning tasks on SAT subtests and SAT total scores

		F	*p*
Syllogism	Reading	1,838	0,177
	Writing	0,168	0,683
	Math	11,784	0,001***
	Total SAT	8,127	0,005***
Wason Selection Task	Reading	1,597	0,208
	Writing	3,991	0,057
	Math	6,069	0,015**
	Total SAT	7,04	0,009***

**p<0.05 ***p<0.01

Course of Study and Reasoning tasks

Subsequently we were interested in checking the relation between the Course of Study and solution rate in each reasoning task, to control, with *Chi square* analysis, whether the specific pathway of learning could influence the ability to reach the solution in different reasoning problem. (Table 14 and Graph. 12)

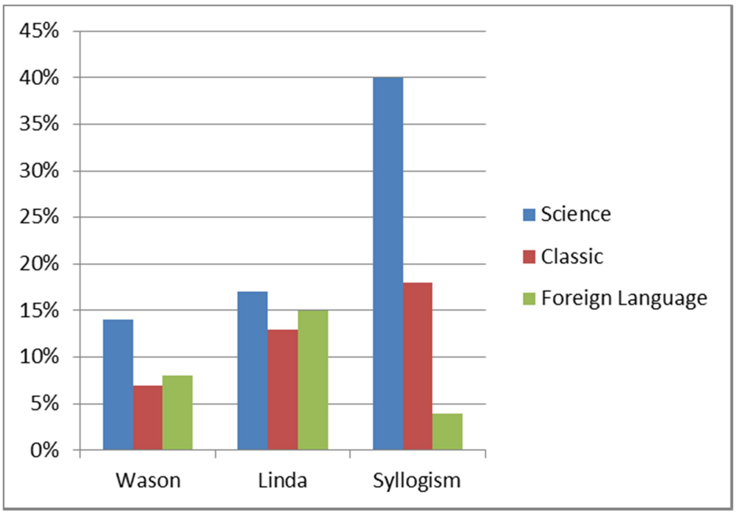
In the *Wason Selection task* we didn't find any difference between Science, Classic and Foreign Language courses of study (X^2 $(2)\ 2.359\ \ p = .307$) in solution rate.

Regarding the *Linda Problem* the same result was found: no significant difference between Science, Classic and Foreign Language course of study ($x^2(2)\ 0.333\ \ p = .847$) in solution rate. The only significant difference is shown by the *Syllogism* in which more solution rate was associated to Science (X^2 (2) 18.062 $p < .01$).

Tab. 14 Reasoning Tasks solution rate for each course of study

	Wason (220)	Linda (220)	Syllogism (220)***
Science	14,20%	16,90%	39,90%
Classic	6,70%	13,30%	17,80%
Foreign Language	7,70%	15,40%	3,80%

Graph. 12 Reasoning Tasks solution rate for each course of study



Results, therefore show that Reasoning Ability in each reasoning task might not be affected by Course of study, except for the *Syllogism* in Science course.

The relationship between SAT, learning and reasoning ability

Then we analyzed the relationship between SAT subtests scores, Course of Study and Reasoning Ability. We wanted to verify if the high or low SAT subtests scores of participants belonging respectively to Science, Classic and Foreign Language was associated to more solutions in each reasoning task. We indeed conducted a *Chi square* analysis (Tab. 15).

Tab. 15 Reasoning ability linked to Course of Study and SAT subtests scores

		Reading high	Reading Low	Math High	Math low	Writing high	Writing low
Science	Wason not solved	42,50%	57,50%	53,50%	46,50%	43,30%	56,70%
	Wason solved	66,70%	33,30%	76,20%	23,80%	66,70%	33,30%
Classic	Wason not solved	66,70%	33,30%	11,90%	88,10%	66,70%	33,30%
	Wason solved	66,70%	33,30%	33,30%	66,70%	33,30%	66,70%
Foreign Language	Wason not solved	12,50%	87,50%	4,20%	95,80%	25,00%	75,00%
	Wason solved	50,00%	50,00%	0,00%	100,00%	50,00%	50,00%
Science	Linda not solved	47,20%	52,80%	57,70%	42,30%	47,20%	52,80%
	Linda solved	40,00%	60,00%	52,00%	48,00%	44,00%	56,00%
Classic	Linda not solved	64,10%	35,90%	12,80%	87,20%	66,70%	33,30%
	Linda solved	66,70%	33,30%	16,70%	83,30%	50,00%	50,00%
Foreign Language	Linda not solved	18,20%	81,80%	4,50%	95,50%	22,70%	77,30%
	Linda solved	18,20%	81,80%	0,00%	100,00%	50,00%	50,00%
Science	Syllogism not solved	42,70%	57,30%	55,10%	44,90%	43,80%	56,20%
	Syllogism solved	50,80%	49,20%	59,30%	40,70%	50,80%	49,20%
Classic	Syllogism not solved	67,60%	32,40%	13,50%	86,50%	64,90%	35,10%
	Syllogism solved	62,50%	37,50%	12,50%	87,50%	62,50%	37,50%
Foreign Language	Syllogism not solved	16,00%	84,00%	4,00%	96,00%	28,00%	72,00%
	Syllogism solved	0,00%	100,00%	3,80%	96,20%	0,00%	100,00%

*p<0,05

Only in the *Wason problem* we found significant differences between high SAT participants and low SAT participants belonging to Science Course of Study (Tab. 16). More Precisely an higher percentage of solution rate in the *Wason Selection task* occurred only in subjects with high Reading SAT scores belonging to Science (X^2 (2) 4,231 p< 0,05). The same pattern, only in Science participants, occurs for Math (X^2 (2) 3.766 p< 0,05) and for Writing (X^2 (2) 3.951 p< 0,05). This result suggests that perhaps these three cognitive abilities, only supported by the scientific learning, could be involved in deductive reasoning.

Tab. 16 Difference in reasoning tasks solution rate (*Chi square*) of participants of different course of study with high/low SAT subtests scores

	(x2)Wason Selection Task	(x2)Linda Problem	(x2)Syllogism
Reading*Science	4,231*	0,428	0,949
Reading*Classic	0	0,865	0,076
Reading*FL	1,994	0,354	0,189
Math*Science	3,766*	2,77	0,263
Math*Classic	1,113	0,67	0,006
Math*FL	0,87	0,189	0,042
Writing*Science	3,951*	0,83	0,704
Writing*Classic	1,358	0,63	0,016
Writing*FL	0,586	1,28	0,383

*p<0.05 **p<0.01

Finally, in the light of previous research on the relationship between learning and Intelligence, we tried to understand what variable better predicts Cognitive ability measured by SAT. We wanted to assess whether it is explained by the interaction of Reasoning Ability and Course of Study or there was a single predictor. We conducted a multifactorial *ANOVA*, with SAT Total score as dependent factor; we considered Reasoning Ability and Course of Study as independent variables. Tab. 17 and 18 link the means in Sat Total score for Course of Study and Reasoning Ability.

Tab. 17 Test of Between-subject effects of Reasoning ability*Course of Study

Source	*df*	*F*	*P*
Reasoning ability	3	0,829	0,479
Course of study	2	16,361	0,000***
Reasoning ability * Course of Study	3	0,42	0,739
Errore	210		

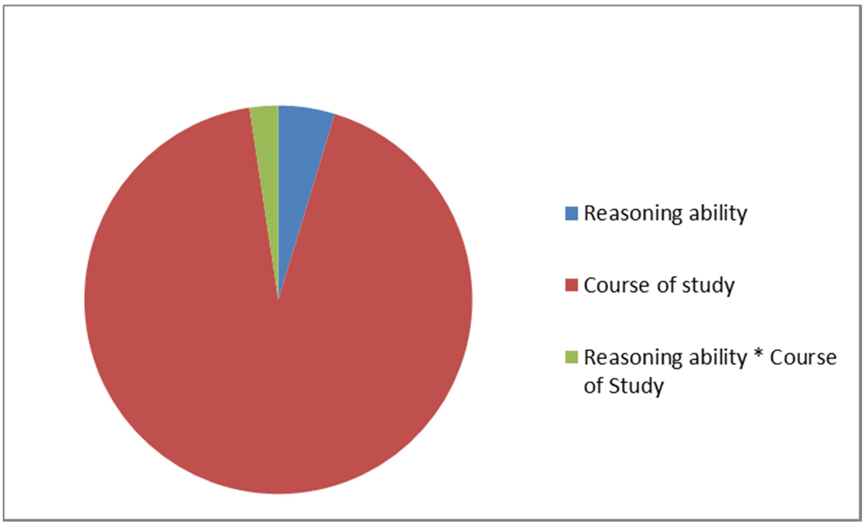
**p<0.05 ***p<0.01

Tab. 18 Descriptive statistics of SAT Total score means for Course of study*Reasoning Ability

Reasoning_ability	Course of study	Means	SD	N
0 problem solved	Science	978,75	87,754	76
	Classic	919,52	83,17	31
	Foreign Language	819,74	88,435	19
1 problem solved	Science	983,37	122,379	46
	Classic	921,36	130,328	11
	Foreign Language	826,43	90,908	7
2 problem solved	Science	979,74	108,902	19
	Classic	991,67	45,092	3
3 problem solved	Science	1021,43	81,533	7

We didn't find any interaction between factors (Graph 13). The only main predictor of SAT total score is the course of study ($F(1,210)=16,361$ $p<0.01$). Moreover, as mentioned above, Science course appears better associated with the highest average in the SAT test. Results show that the influence of learning on SAT test is confirmed.

Graph. 13 SAT score predictors



5.7 DISCUSSION

The results confirm our first predictions. As assumed, the SAT scores are deeply related to specific Course of Study: subjects from Science, followed by those of Grammar course, shows higher performance in Total SAT. Moreover Science sample has higher scores in the math section and Grammar sample do the best in the Reading and Writing part. Subjects from Foreign Language show always the lowest scores in both the total section and in the subtests. This lead us to think that the specific training learning could influence the performance in this kind of test. SAT is considered an index of intelligence, but in our opinion it couldn't be a good measurment, since it's too much linked with expertise.

Moreover, at first, an analysis of interaction between each task shows that the only predictor of the SAT test would be the *Wason Selection Task*. But if we add to the analysis the Course of Study, the latter becomes the only effective predictor of the total SAT. Rationality seems not clearly and uniformly related to intelligence, measured by SAT. Maybe people of higher cognitive ability are no more likely to recognize the need for a normative principle than are individuals of lower cognitive ability

The evaluation of the subtests has allowed us to better understand this aspect. In fact in Stanovich and West studies (1998, 2008) subtest scores were not taken into account, thus losing the possibility to reach more comprehensive conclusions. In our research, those who solved the problem of *Wason* and the *Syllogism* show the total SAT scores significantly higher, but most of those who solved the *Linda problem* have obtained lower scores in the SAT. Furthermore, the analysis of the subtests makes such pattern even more indefinite. In fact, despite the subtests are highly correlated with each other, the results show that only the Math section is associated with a higher resolution of the *Wason* problem and the *Syllogism*. At least, the scores in Reading and Writing don't appear to be related to the ability of reasoning, measured by the three problems of our study. The *Wason* and the *Syllogism* may share the same thought processes, since they are both examples of deductive reasoning which may be associated with analytical cognitive systems (System 2). It is also interesting to note that *Linda* did not present any association. And even those that solve the *Linda problem* show lower scores - although not significantly - in all sections of the SAT, as already noted by Stanovich and West (2008). This indicates that the functions involved in this special kind of task are very different from the others. We may perhaps assume that subjects who get low scores in the SAT may have less comprehension skills and this could lead paradoxically the same subjects not to commit the conjunction fallacy. However, people with high scores on the SAT may implement more sophisticated reasoning, involving also the pragmatic thinking, that lead to the error in the *Linda* task. More investigation is needed about this issue.

One of our aims was to analyze the correlation between the curriculum and the solution rate in reasoning problems. We found no association between these two variables, except for the Science curriculum. In fact it seems that subjects from the Science show higher rates of solution of the *Syllogism*. This could be explained by the fact that during the second year in the Science course ,the math program specifically includes the study of syllogisms. Therefore, the syllogistic reasoning could be intensively trained and we might understand the reason of the better performance.

One interesting result regards the interaction between Course of Study, Reasoning ability and Cognitive ability measured by SAT. We found an association only for the *Wason Selection task*. Subjects with high performance in Reading, Math and Writing belonging to Science better solve this task. The same doesn't happen for *Linda* and the *Syllogism.* Future research could clarify if the Science studies allows to obtain a greater global cognitive ability, in which knowledges are highly interrelated and lead to a greater abstraction ability and logical application

Certainly other considerations are necessary. First of all it is possible that the choice of the course of study is related to genetic and specific individual differences predispositions.

The Course of Study, therefore, would be presented as a mediator of these in the performance at the SAT test. It would be interesting to identify certain predisposing factors, such as the feedback obtained in the different cycles of study in different subjects (e.g. math, reading, writing), to assess their degree of correlation with the SAT and the own course of study.

If the reasoning skills appear not so specifically related to either course of studies and the SAT, it would be necessary to find other factors that explain the performance in reasoning task.

Future studies should therefore consider the differences between the several reasoning problems and try to find some more effective instruments that make it clear the specific associations between different cognitive activities. As already said, the SAT does not seem to fulfill this aim.

We also met another great problem with the use of this test: the length. One of the most contentious debates in the field of testing currently is the potential impact of extended time and speediness on performance on standardized tests. The debate has taken place in the literature (Camara, Copeland, and Rothschild, 1998; Huesman and Frisbie, 2000; Munger and Loyd, 1991; Zuriff, 2000) and in the public media (Heyboer and McCarron, 1999), and is closely linked to issues concerning the rights of test-takers with disabilities to reasonable and appropriate test accommodations (Mandinach, Cahalan, and Camara, 2002; Pitoniak and Royer, 2001).

In our opinion the SAT test requires an excessive amount of time. The estimated timing of the solution of the questions are fair, but three hours of testing certainly causes a deep effort and a major deterioration of attentional capacity. The proof is the fact that, in our experiment, the last two sections of the test were less precise than earlier, decreasing in performance levels.

As already noted, our study starts by Stanovich and West experiments, which explain individual differences in the ability of reasoning in the light of the *dual-process theory*. Dual-process theories of the mind are ubiquitous in psychology. There are dual-process theories of attribution (Trope, 1986; Uleman, Newman, & Moskowitz, 1996), person perception (Brewer, 1988; Fiske & Neuberg, 1988; Gilbert, 1989; Zárate, Sanders, & Garza, 2000), stereotyping and prejudice (Devine, 1989), persuasion (Chaiken, 1980; Petty & Cacioppo, 1986), mental control (Wegner, 1994;Wenzlaff & Wegner, 2000), self-regulation (Baumeister & Heatherton, 1996; Metcalfe & Mischel, 1999), emotion (Teasdale, 1999; van Reekum & Scherer, 1997), and personality (Pacini & Epstein 1999). A central principle of these theories is that behavior is determined by the interplay of automatic and controlled processing. It is not yet clear how these thought processes can be measured or evaluated since there are not yet available instruments that measure implicit and explicit processes as well as postulated by Stanovich and West. It is still difficult to understand how *System* 1 and the *System* 2 are integrated in the resolution of a reasoning problem, in order to reach the correct solution or to develop the biases that lead on the contrary to the ineffective heuristics. The previously mentioned concepts of "Mindware gap", "Override Detection" and "Cognitive Decoupling", although very interesting and useful, are difficult to demonstrate in the empirical point of view. It is also for this reason that the results of the previous studies are partial and not so explanatory of the reasoning operations. The point of convergence is the question: ‘‘Which factors limit/increase human reasoning abilities?’’ In our opinion, the most promising candidate at present could be working-memory capacity (Halford, Andrews & Wilson, 2015; Kyllonen & Christal, 1990; Ma, Husain & Bays, 2014; Redick, Shipstead, Meier, Montroy, Hicks, Unsworth, & Engle, 2016; Unsworth, Fukuda, Awh & Vogel, 2014). Perhaps the reasoning skills could be seen in the light of the working memory functioning that could better reflect individual differences. Individual differences in the ability to control attention are a major contributor to individual differences in working memory capacity (WMC). A strong relationship between working-memory capacity and reasoning has been found in several studies (Engle, Tuholski, Laughlin, & Conway, 1999; Fry & Hale, 1996; Halford, Andrews &

Wilson, 2015; Kyllonen, 1996; Kyllonen & Christal, 1990; Salthouse, 1992; Salthouse, Babcock, Mitchell, Palmon, & Skovronek, 1990, Stanovich and West, 2011). Similar to intelligence, working-memory capacity can be structured along two facets the content facet and the function facet (Oberauer, Su¨ß, Schulze, Wilhelm, & Wittmann, 2000).

According to the traditional dual process assumptions, controlled attention set the degree to which automatic processing influences thoughts. Despite their differences, dual-process theories share the common idea that thoughts, behaviors, and feelings come from the interaction between conscious and unconscious attention. Both types of attention can be put on to representations to increase or decrease their level of activation. Controlled processing might arises from the central executive aspect of working memory (such as the SAS) and come when attention is applied in a goal-directed or top-down trend. Complex mental processes and social behavior may operate without conscious awareness (Bargh & Ferguson, 2000), but they rarely happen without the control of attention, at least if there is some level of interference. About this, another great advantage of the convergence of the *dual-process theory* and WM is the fact that there are many tasks, both implicit and explicit, used in experimental psychology to measure the Working memory functions. As already mentioned, it would be useful to define the associations between specific reasoning problems and specific cognitive functions. Moreover the general limited length of WM tasks would prevent the problem of cognitive tests such as the SAT, which take too long time.

Therefore, further research might also indicate whether the identification of analytic and associative intelligence with the different sets of processes in the two-process theories of Sloman (1996) and Evans and Over (1996) is a useful theoretical step. Regardless of the outcome of that theoretical program, the present studies provide a demonstration of how analyses of individual differences can be used to help explain instances where descriptive and normative models of human reasoning do not coincide.

Another important issue of further consideration is the “educability” of the abstraction and the reasoning ability in the real contexts. It would be interesting to run new studies that provide specific training to apply reasoning skills; it’s useful to know how the exercise could have an effect on reasoning skills and whether this might spread to other cognitive abilities and behavior. I also wonder if, even at school, it might have sense the training of reasoning skills, to find an effect on learning. Often the reasoning in the school is implicitly exercised, especially by math, but maybe it would be more helpful to teach the students some explicit strategies, especially when abstract reasoning arise, and put them into practice. Maybe, in an ecological point of, awareness of the main reasoning processes would allow a better application in all contexts in which people live, so that knowledge could really become “situated”.

GENERAL CONCLUSION

The present work has set the goal to reconsider the functioning of Cognitive Ability within a different and complex context of interaction between individual and environmental factors.

The need arose from the difficulty of finding a single definition of Intelligence and a current lack of correlation, shown by contemporary research, between the concept of Cognitive Ability with specific cognitive skills. The multiplicity of theories and methods of evaluation, certainly enriches the knowledge of the phenomenon, but at the same time it prevents to find a common methodological language to study it.

Our attention has focused mainly on the definition of Cognitive Ability and its interaction with reasoning ability, insight problem solving and cultural/learning aspects. Too often, research has moved away from the consideration of exogenous factors, for the comprehension of human cognition, assuming it is only an "autopoiesis" of the brain, separated from the surrounding environment. For these reasons, the researches included in my thesis try to show how some high cognitive abilities, such as insight problem solving and reasoning skills, could be influenced by cultural and contextual factors.

In the first study the results show how the insight problem solving in children could be determined by pragmatic-interpretive skills of language that the normative child owns and which may be further increased by exercise, especially at school. It is known that school education privileges mathematical and analytical learning to solve problems at the expense of the comprehension ability, that necessarily comes into play in order to understand the meaning of the problem.

The second study supports the hypothesis that some cognitive factors -such as the Inhibitory Capacity and Mindfulness- and insight problem solving could be influenced by environmental factors. The comparison of two different nationalities shows how the solving procedures of the same problems can be very different, with significantly dissimilar performance in cognitive abilities.

The third study focuses on the reasoning skills and Cognitive Ability in a sample of adolescents and shows how the SAT test fails to grasp the reciprocal interactions. In fact, our research shows that the cognitive skills, traditionally measured with this psychometric test, cannot give an account of pure Cognitive Ability, because too influenced by schooling, and also do not show a clear relationship with reasoning skills. The results confirms that neither good definition of Cognitive Ability nor an adequate assessment to measure it have been found yet.

In general we can conclude that research on Cognitive Ability should introduce a common concept to describe it and find a shared measurement for its assessment. This way, Cognitive Ability could more easily be analyzed in interaction with some other cognitive factors, such as reasoning and problem solving, in order to understand any overlap or inconsistencies. Finally, the research in this area should always take into account culture and quality of learning. This would allow us to understand how they modulate the interaction between factors, even in an developmental perspective.

In the light of these considerations, the task of future research will be, on the one hand, to standardize the procedures for assessing and conceptualizing Cognitive Ability, the other to consider any effect of cultural and contextual differences. The continued cross-cultural and contextual examination of cognition will also help us discover true cognitive invariances across different people. As cultural/learning diversity and intercultural contact have become increasingly commonplace in societies around the world, psychologists play an important part in learning about the cognitive implications of human cultural diversity, as well as investigating about the cognitive foundations of culture

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Ringraziamenti

Desidero prima di tutto ringraziare la mia tutor, la Prof.ssa Macchi che mi ha guidato e consigliato lungo questi anni di dottorato con grandissima professionalità e disponibilità. Sono certa che senza il suo aiuto la mia esperienza non avrebbe avuto lo stesso valore.

In secondo luogo vorrei rivolgere un sentito ringraziamento a Masasi Hattori, Professore di Psicologia Generale presso la Ritsumeikan University di Kyoto grazie al quale ho svolto uno stimolante periodo di ricerca. La stessa gratitudine si rivolge ai colleghi giapponesi, Yuki Nishida e Ryo Orita, che mi hanno supportato nella conduzione della nostra ricerca inter-culturale.

Vorrei ringraziare anche le scuole che mi hanno permesso di condurre gli esperimenti esposti in questa tesi: in particolare ricordo le scuole primarie “Martiri della Libertà di Sesto San Giovanni, “Santa Caterina” di Sesto San Giovanni, “Cuoco Sassi” di Milano, e la scuola secondaria superiore “L. Casiraghi” di Cinisello Balsamo.

Ringrazio inoltre i reviewers, il Prof. Antonietti ed il Prof. Marucci, i quali hanno mostrato un vivo interesse ed un sincero apprezzamento per il lavoro che ho svolto, contribuendo, attraverso utili commenti, al miglioramento della mia tesi.

Infine ringrazio tutti coloro che non hanno mai smesso di credere in me, specialmente mio marito Andrea, i miei genitori Alberto e Tiziana, mio fratello Giovanni, mia cognata Daniela, i miei suoceri Paola e Piero, i miei zii Cristina e Simone, i colleghi di dottorato, in particolare Maruska e Roberta e la mia cara amica Chiara.