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A Cognitive Architecture founded on Dual-Process Theory predicts individuals' potential for Rational or Experiential Style of Thinking

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Abstract

Dual-Process theories have been suggested by psychologists, covering multiple aspects of human information processing such as deductive reasoning, problem-solving and decision making. Cognitive-Experiential Self Theory is a Dual-Process Model of cognition, advocating that individuals' behaviour is determined by two distinct information processing systems (the Rational and Experiential one), which operate different functions. The aim of this research was to examine the predictive functional relationship between Analytic Cognitive Ability, Working Memory Capacity, Logical Deduction Problem-Solving Ability, Counterfactual Thinking Ability, Emotional Expressiveness and Actively Open-Minded Thinking Disposition on individuals' potential for Rational or Experiential Style of Thinking. A wide range of assessment strategy tasks was employed to explore multiple aspects of human information processing through a correlational design on a recruited sample of 258 participants. A binominal logistic regression statistical analysis was used, and the results revealed that all the predictor variables explained a small yet statistically significant amount of the variance of Style of Thinking. In particular, the Model accounted for between 10% and 13% of the variance in Style of Thinking, with 68.3% of those having Rational Style of Thinking being correctly predicted while 58.6% of those having Experiential Style of Thinking being also correctly predicted, and 63.9% overall. Despite the minimal practicality of the proposed Model, which was due to the small variance indicated by the predictor variables, it follows a methodological design originating from the Dual-Process Theory, that could be further exploited in future studies. With regards to the transitivity of preference, it is crucial to devise models to demonstrate how these two systems may interact in the human brain and how their competition and conflict could be resolved for the sake of self-control behaviour.

Key words: Dual-Process Theories, Cognitive-Experiential Self Theory, Rational Style of Thinking, Experiential Style of Thinking.

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Introduction

Cognitive-Experiential Self Theory (CEST) and Types of Rationality

Dual-Process theories have been suggested by psychologists, covering multiple aspects of human information processing such as deductive reasoning, problem-solving and decision making [1, 2]. Cognitive-Experiential Self Theory (CEST) is a Dual-Process Model of cognition developed by Epstein [3], advocating that individuals' behaviour is determined by two distinct information processing systems, which operate different functions [4-6]. The first one is the experiential system, which is predominantly preconscious, intuitive, automatic, rapid, holistic [7] and emotionally driven [3]. Contrastingly, the second system is the rational processing one, which originates from our ability to decontextualise [8]. This requires computational resources while being identified as deliberate, conscious, reason-based, slow and relatively emotion-free [9, 10]. Simultaneously, this is an exclusively human system, which is guided by relevant standards and culturally transmitted rules [8, 11-16]. Epstein [3], however, stipulates that these qualitatively discrete cognitive systems may operate parallelly and be bidirectionally interactive while influencing an individual's information process.

Additionally, the CEST links these systems with separate types of rationality such as the normative and instrumental ones [17]. Normative rationality entails explicitly abiding by the normative theory while depending on the rational system, which solely serves to rationalise intuitive choices. This system though, is required for hypothetical thinking, thus making it an essential means of foresight and flexibility [1]. Instrumental rationality, however, is characterised by deviations from logic and decision theory, mainly deriving from the experiential system [18]. In this respect, a large body of evidence has been accumulated, supporting that an individual's preferred system of cognition is correlated with a tendency to judgment biases in laboratory experiments [4, 5, 12, 14, 19-22] and in simulated everyday decision-making processes [23, 24]. More specifically, individuals who prefer rational thinking may usually be less prone to cognitive judgment biases while those who are in favour of experiential thinking may be more susceptible to these biases [4, 5, 12, 15, 19, 25, 26]. Therefore, preferring one system over the other might be influenced by an individual's enthusiasm for intellectual challenges or trusting their instincts [21, 27, 28].

A great deal of research indicates that the chosen benchmark of rationality connects with individual differences [23, 29, 30]. Sleboda & Sokolowska [27] have examined the relation between decision strategies and cognitive style by capturing two distinguished dimensions of personal information processing. They have effectively utilised the Rational Experiential Inventory (REI) through which researchers can pinpoint which cognitive system (the Rational or the Experiential one) an individual may be using to a greater extent. They identified that higher scores on rational and engagement ability scale are a relatively strong predictor for rational cognition. Accordingly, the present study utilises the half version of REI [31], which is a self-declarative questionnaire grounded in the tenets of Dual-Process CEST [32] with excellent psychometric properties [33, 34] and good cross-cultural stability [35], in order to gauge individuals' ability for Rational or Experiential Style of Thinking for general decision-making processes.

Analytical Thinking Ability

In the same vein, Frederick [36] introduced the Cognitive Reflection Test (CRT), which is a multifaceted construct measuring an individual's inclination to override a spontaneous response and further reflect to find an accurate answer. This has been also associated with the Dual-System Theory [37] to explore individual differences in the preponderant information processing system through mathematical logic problems [36], thus reflecting the concept of attribute substitution [38, 39]. Based on the heuristics-and-biases literature, Toplak, West & Stanovich [40] concluded that despite the CRT being substantially correlated with cognitive ability, it is a more reliable predictor of performance on a wide range of tasks than the measurement tools of intelligence, cognitive ability, executive functioning and thinking dispositions. High scoring in the CRT indicates that the rational

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system overrides the experiential system functioning, hence reflecting analytical thinking ability [40, 41]. Brañas-Garza et al. [42] reported that participants with an advanced analytic cognitive ability can better perform when facing such problems and are capable of resisting the contextualisation of problems related to prior knowledge. This study takes the aforementioned notion into consideration, as it is intended to examine individuals' analytic cognitive ability and its possible association with the transition between the rational and experiential systems. In this case, however, a reworded CRT combination proposed by Bronstein [4, 5] is employed rather than merely self-report, cognitive ability-oriented measurements in this case.

Working Memory Capacity

Importantly, numerous studies maintain that analytic reasoning processing, which is anchored in the rational processing system [8, 43, 44] is ordinarily more arduous while requiring working memory resources [45-47]. This is because analytic processing is a consecutive process that dictates the operation of central working memory limited by its capacity [15, 16]. Working memory (WM) is a core element of the active information processing [48] and it makes for "the aspect of cognition where this information is actively maintained, manipulated, elaborated and temporarily retained" [49, 50]. WM is typically evaluated in respect of its capacity or span [49, 51]. However, there are several views of what span or capacity may measure [52, 53]. Namely, they may test the resource allocation [51], the capability to control attention [54, 55] or the interference handling ability [56]. Overall, all three views, which are crucial to the understanding of rational processing, conclude that individuals with a large span are much more capable of processing information in WM compared to those with a smaller one [45, 54, 55].

The Mental Model Theory further supports that the more representations are demanded to draw an accurate inference, the more WM resources should be retained and manipulated [57, 58]. Similarly, De Neys et al. [43, 44] pointed out that individuals with higher WM capacity could perform better in cognitive processing tasks demanding multiple representations. Likewise, according to a path analysis conducted by Fletcher, Marks & Hine [45] for individuals, who have a higher WM capacity, more tasks of this kind may probably lead to successful results. This makes the analytic processing rewarding while raising the possibility of adopting a preference for rational thinking. Contrastingly, participants with a lower WM capacity may find tasks, that require proficiency in attention control, more onerous thus making more mistakes. This, however, can lead to an aversion of the rational thinking style [59].

Taking into consideration all the aforementioned information, the present study intends to examine how WM may contribute to understanding the conditions under which both of the rational and experiential systems are operated and optimised. Specifically, this study inquires whether WM capacity can predict individuals' potential for rational or experiential style of thinking. In contrast with previous studies, the proposed research intends to test this assumption by deploying a more acceptable measurement of WM in the field of reasoning, that is the Operation Span Test (OSPAN) [60]. OSPAN considers the aggregate resource allocation, the capability to control attention as well as the ability of interference handling [53]. This incorporates the temporary storage of a set of information and concurrently the information processing while focusing on the interrelation of WM and problem-solving [61, 62].

Deduction Problem-Solving and Counterfactual Thinking Ability

Additionally, an interesting point to be considered is the evident conflict between logical processes and non-logical biases on syllogistic reasoning through categorical logic tasks- simple types of deductive reasoning [63]. Deductive reasoning is the ability to evaluate the logical validity of a deduction founded on its premises [19]. In these tasks, participants are asked to draw inferences based on both consistent and inconsistent premises, with real word validity. Analysing participants' answers indicates that two conflicting processes are employed [5], thus leading to the approval of arguments with believable inferences [64]. Verschueren

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et al. [65] introduced the Dual-Strategy Model, which indicates that reasoners engage in two qualitatively different strategies for deductive reasoning [11]; namely, the statistical and counterexample strategy. The former is intuitive, faster and demands fewer cognitive resources while the latter is affiliated with a dichotomous evaluation of validity, demanding higher cognitive ability [65].

This study is designed to gain more insight into these deductive strategies and explores whether deductive ability might predict individuals' potential for rational or experiential style of thinking. This can be realised by using syllogistic reasoning problems so that the content effect is diminished through abstract problem-solving with no previous familiarity, experience or emotion interference [23]. Nevertheless, studies using deductive reasoning tasks are limited, since they typically investigate reasoning merely with abstract components [43, 44]. Consequently, the background knowledge retrieval problem is sidestepped [64]. The contribution of the proposed study is also to examine everyday reasoning, especially counterfactual thinking ability. Counterfactual thinking ability is the ability of thinking in a manner that is contrary to current facts [66]. This demands the retrieval of stored background experience and knowledge [67], which is instantiated by the function of the experiential system [5]. Counterfactual thoughts mentally represent alternative versions of an actual event, state or action and are intertwined with an individual's consciousness, thus comprising a pervasive human attribute [68]. Notably, counterfactual thoughts are generally conceived as conditional propositions involving both an antecedent and a consequent [67].

In this respect, studies so far have been emphasising the underlying cognitive mechanisms causing the generation of counterfactual thoughts [69, 70]. Kahneman and Miller [38] defined such counterfactual thoughts as a standardised average of knowledge and anticipations stemming from previous experiences. This is a concept mainly based on past formulations as "adaptation level" and "comparison level". Therefore, an outcome diverging from its norm to a great extent will typically evoke a counterfactual alternative to that outcome [66], entailing the transition from the experiential information processing to rational one [67]. Hence, counterfactuals are customarily generated through the restoration of remarkable antecedents back to their original state [66]. Correspondingly, the present study deploys an alternative conditional task in order to examine individuals' counterfactual thinking ability in everyday conditions while predicting their potential for rational or experiential style of thinking. This, however, is significantly demanding because, in this case, analytic and decontextual reasoning is required, as only the rational system can provide it [8, 44].

Actively Open-Minded Thinking Disposition

Indulgingly, Lin et al. [71] suggested that some individual differences, such as cognitive style might determine the decision of the information processing system. Cognitive style is an amalgam of personality traits and mental abilities [21, 72]. Bronstein et al. [4, 5] also advocated that there are personality traits differences in cognitive style, influencing the preference over the rational or experiential information processing. By the same token, Cook & Gonzales [32] identified that the Openness to Experience and Extraversion personality traits strongly and positively associate with rational information processing, hence indicating thoughtful engagement. However, the above study employed the Ten-Item Personality Inventory (TIPI); an extremely brief measurement of the Big Five personality dimensions [73]. Ypofanti et al. [74] administered the TIPI to a Greek population, and the results indicated an unacceptable Cronbach's alpha in most subscales (Cronbach's α: 0.52 for openness to experience, 0.52 for conscientiousness, 0.55 for extraversion, 0.46 for emotional stability and 0.39 for agreeableness). Consequently, the TIPI may be considered an inappropriate questionnaire with diminished psychometric properties, as it encompasses merely ten questions to examine five personality traits.

On the contrary, a considerable amount of research on reasoning proposes that Actively Open-minded Thinking (AOT) is a personality trait and a highly intellectual type of thinking at the same time, which defines individuals' dispositions irrespective of their cognitive ability [21, 73]. This is further reflected by Svedholm-Häkkinen & Lindeman [75],

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who suggested that AOT can better predict high intellectual reasoning skills than cognitive ability. Stanovich and Toplak [21] have advocated that AOT can effectively predict the performance on heuristics and biases tasks while avoiding reasoning traps and cognitive judgment biases, thus displaying ability for higher levels of reflective thinking but still being less influenced by immediate experience. More precisely, AOT indicates the intention to consider alternative opinions [76], the openness to evidence contradictory to existing beliefs [77], the ability for reflective thinking, and the willingness to postpone closure [30]. The present study examines whether individuals' tendency to engage in flexible thinking may predict their potential for rational or experiential style of thinking. To operationalise this tendency, a reliable and recent measurement [75, 77] evolved from previous scales such as the openness-values facet of the Revised NEO Personality Inventory by Costa & McCrae is used [76, 78].

Emotion Regulation Ability

Last but not least, there have been numerous ongoing debates over rationality concerning both emotion and reasoning literature [79]. Importantly though, little empirical research has paid direct attention to the investigation of the correlation between emotion and reasoning [80, 81]. In terms of thinking, individuals adopt strategies derived from their emotional recognition and generation [82]. Success in emotion regulation could be predicted by individuals' differences in their cognitive ability [83]. Schmeichel et al. [84] investigated the correlation between individual differences in WM capacity and the self-regulation of emotional expression. Their research indicated that individuals with higher WM capacity could effectively inhibit the expression of positive and negative emotions than those with lower WM capacity. These findings suggested that cognitive ability contributes to emotion regulation while controlling emotional expressiveness [84].

In this regard, Gyurak et al. [85] combined a Dual-Process Framework with emotion regulation. In their study, they proposed that people regulate their emotions by capturing two distinguished dimensions of personal information processing which are bidirectionally interactive, that is, the rational and experiential process. The rational processing system is slow, conscious, demands considerably more effort [10], and employs strategies such as reappraisal [83], cognitive as well as attention control [86] while "is involved in causal search and emotion labelling" [85]. Contrarily, the experiential processing is prompt, unconscious and vague, encompassing immediate intuition and automatic emotional reactions [7, 75]. As far as these viewpoints are concerned, emotion is considered an experiential mechanism that individuals should frequently overcome so that they may rationalise their intuitive choices [3, 79]. Generally, the Dual-Process Theory clarifies that rational processes prevail over experiential without, however, considering the impact of the inferences**,** that intuitive processes have on reasonable conclusions [79].

Considering that the association between emotion and reasoning is complicated, the current study is intended to investigate how emotional tolerance may affect the way emotions interact with reasoning. This research emphasises the two parts of the emotion-generative process that includes individuals' emotional response inclinations and their further modification. Therefore, this paper aims to contribute to this growing investigation area and attempts to enhance the understanding of how emotions influence individuals' information processing style and subsequently their reasoning. In particular, it is examined whether emotional expressiveness predicts individuals' potential for rational or experiential style of thinking by employing the Berkeley Expressivity Questionnaire (BEQ); a measurement with good psychometric properties indicating convergent validity [87]. Finally, this questionnaire evaluates both the strength of emotional response inclinations and the degree to which they are behaviourally articulated [71].

The Aim of This Study

In a nutshell, the proposed study aims to identify the functional relationship between Analytic Cognitive Ability (ACA), Working Memory Capacity (WMC), Logical Deduction Problem-Solving Ability (LDPA), Counterfactual Thinking Ability (CTA), Actively Open-Minded Thinking Disposition (AOTD) and Emotional Expressiveness (EE) on individuals' potential

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for Rational and Experiential Style of Thinking. Specifically, this research intends to find the equation that best predicts individuals' potential for Rational or Experiential Style of Thinking. In contrast with previous studies, this study employs various measurement techniques such as self-report measurements, abstract syllogistic reasoning problems, everyday counterexample generating tasks as well as a combined measurement of working memory capacity and information processing.

Hypothesis

Emotional Expressiveness, Analytic Cognitive Ability, Working Memory Capacity, Logical Deduction Problem-Solving Ability, Counterfactual Thinking Ability and Actively Open-Minded Thinking Disposition predict individuals' potential for Rational or Experiential Style of Thinking.

Method

Design

The experimental method was employed, and a correlation design was adopted in order to predict categorical outcomes from categorical and continuous predictors (nominal and scale levels of measurement, respectively) [88]. In this correlation study there were six predictors and one outcome (binomial nominal variable). Predictors included Emotional Expressiveness, Analytic Cognitive Ability, Working Memory Capacity, Logical Deduction Problem-Solving Ability, Counterfactual Thinking Ability, and Actively Open-minded Thinking. The measured outcome was the potential for Rational or Experiential Style of Thinking.

Participants

This research utilised introspective G*Power analysis in order to calculate the total sample size required. According to the calculations of G*Power software, the number of participants should be at least 250. To that end, 258 students and teachers were recruited from the National Technical University of Athens, the National Kapodistrian University of Athens, the University of West Attica and the Mediterranean College of Athens, Greece, through opportunity sampling (113 males, 142 females, M= 23.14, SD=5.56), aged 18-49 years, from various faculties (Psychology, Social Work, Education, Computer Science, Tourism & Hospitality, Business and Engineering). Inclusion criteria have stipulated that participants should be over 18 and under 50 years old, able to see and hear sufficiently to participate in computer-based cognitive tasks and with a competency in English sufficient for assessment. Participants with significant cognitive decline over the course of 5 years, known organic medical or psychiatric condition affecting cognition were excluded from this study.

Materials

Rational-Experiential Inventory (REI-40) [31].

The ability for rational and experiential style of thinking was measured by the Rational-Experiential Inventory (REI-40) [31]. The Dual-Process Theory, where intuitive and rational processes coexist simultaneously, is depicted in the Cognitive-Experiential Self Theory (CEST) [3, 5] while it is later evident in the Rational and Experiential System Model respectively [38, 89]. This theory is the backbone of the Rational-Experiential Inventory (REI) scale which evaluates the desire for cognition and trust in intuition [27]. These two subscales showed that an individual can exhibit both high Rational and high Experiential skills [90], capturing two distinguished dimensions of individual information processing (Rational Ability, Rational Engagement, Experiential Ability and Experiential Engagement) [34]. The REI encompasses two independent components, that is, the rational dimension of 20 items, and the experiential dimension of another 20 items. These dimensions are scored on a 5-point Likert scale ranging from 1 ("definitely not true of myself") to 5 ("definitely true of myself") [33], where there are some items which are negatively assessed [32]. Intuition may have access to subconscious memory and assimilated learning which comes from experience and can function as rational process at the same time. The key aspect of intuition lies in individuals' actively learning from experience while subconsciously and automatically recalling this learning. This meas-

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urement regards intuition and deliberation as abilities while the other instruments considered them as stable references, styles or tendencies [32]. REI-40 is a reliable (Cronbach's alpha: 0.86-0.91) [33], high internally consistent (Cronbach's alpha: 0.78-0.86) self-declarative measurement with good cross-cultural stability [35].

Cognitive Reflection Tests (CRT) [5, 91, 92].

Analytic cognitive ability was assessed by Cognitive Reflection Test- an additional reliable 7-item problem-solving test [9], which entails three reworded items from the original CRT [91] and the 4-item non-numeric CRT [92] both combined by Bronstein et al. [5] (Cronbach's alpha: 0.88). The total score reflected the number of the correct responses [36, 40]. Also, these responses were classified in the following way: "intuitive answer" and "correct answer". Namely, intuitive answer represents an intuitive, quick response that first springs to the participant's mind. However, it is considered incorrect while a correct answer is the one that requires its suppression and/or evaluation, originally coming to the participants' mind [76, 78].

Deductive reasoning task [23].

Logical deduction problem-solving ability was evaluated by eight syllogistic reasoning problems proposed by Kokis et al. [23]. Participants were asked to draw inferences based on premises, both consistent and inconsistent with real word validity. Specifically, they were provided with the following script:

"Imagine that an alien coming from the outer space has just visited Earth. Although alien's thought processes are orthological, its knowledge about Earth is minimal. Despite the fact that the alien will be informed about a series of things happening on Earth, this information may be false or untrue". Afterwards, participants were asked to choose between "yes" or "no" to demonstrate what, in their opinion, this logical alien could conclude based on the information it was given. The answers given in four of the questions were consistent with real world validity (e.g., The alien is told: All birds have feathers. Robins are birds. As a result, the logical alien would come to the conclusion that: Robins have feathers). With regards to the four remaining questions, however, the correct answer was inconsistent with human reality (e.g., The alien is told: All mammals walk. Whales are mammals. Thus, the logical alien would come to the conclusion: Whales walk)" [23]. Correct answers were coded 1, showing a logical, rational and valid response while incorrect answers were coded 0. Hence, each participant's total score ranged from 0 to 8, with higher scores indicating greater deductive reasoning ability. Cronbach's a for this 8-items deductive problem-solving task was 0.83 [23].

Actively Open-minded thinking Scale (AOT) [22].

Thinking disposition was measured by a shortened 8-item version of the Actively Open-minded thinking Scale (AOT) [22]. The original 41-item AOT scale initially introduced by Stanovich & West [22], evolved from previous scales: the openness-values facet of the Revised NEO Personality Inventory, the flexible thinking scale [28], categorical thinking subscale, counterfactual thinking scale, constructive thinking inventory, belief identification scale and dogmatism [78].Wishing to minimize participants' inattention eight items were selected from the 41-item scale based on the research conducted by Bronstein et al. [4, 5]. The measure includes a 6-point Likert response scale ranging from 1 ("Strongly disagree") to 6 ("Strongly agree"), which participants were asked to choose from. The total score reflected the sum-up of the 8-item responses. This, however, was obtained after reversing the score of some specific questions, as this depicted an inclination towards AOT. AOT has internal reliability coefficient 0.7-0.88 [75].

Berkeley Expressivity Questionnaire (BEQ) [84, 87].

Emotional expressiveness was explored by Berkeley Expressivity Questionnaire, BEQ [84, 87]. BEQ examines the extent to which participants outwardly articulate their emotions ("dispositional tendencies") [40] using three facets of emotional expressivity "negative expressivity", "positive expressiv-

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ity", and "impulse strength". Participants showed their agreement with each item on BEQ using a 7-point scale. That is, 1 (Strongly disagree), 4 (Neutral) and 7 (Strongly agree) [93]. BEQ is a measurement with good psychometric properties indicating convergent validity (Cronbach's alpha: 0.81). Internal consistency for the total scale ranged from 0.82 to 0.86.

Counterexample generation task [43, 44].

Counterfactual thinking ability was examined by a Counterexample Generation Task, in which participants generated counterexamples for a set of conditionals. Particularly, eight ordinary, causal conditionals, that expressed familiar causal relations, were employed from the pilot generation studies of De Neys et al. and Dieussaert et al. [43, 44]. In this case, half of the conditionals were classified as having many possible alternatives while the other half had fewer possible counterexamples [43, 44]. For instance, in the following scenario participants were requested to provide as many alternatives (counterexamples) as they could, so as to make it possible: "Rule: If the air conditioner is turned on, then you feel cool. Fact: You feel cool, but the air conditioner was not turned on". The instructions provided to the participants underlined the significance of generating brief counterexamples that were reasonable, realistic and different from each other (e.g., "taking off coat" or "taking off sweater"). However, such answers would be scored as a single item. Finally, the total score was obtained depending on the counterexamples given by the participants.

Operational Span Test (OSPAN) [62, 84].

Working memory ability was assessed through the Operational Span Test, OSPAN [62, 84]. This test asks participants to solve a number of computerised mathematics equations while trying to recall a set of unrelated letters. Specifically, the OSPAN incorporates the temporary storage of a set of information (e.g., letters) and concurrently the information processing (e.g., verify a math problem: (8 / 2) + 3 = 8 True or False) while focusing on the interrelation of WM and reasoning [61, 62]. Ultimately, the participants' OSPAN score was calculated by adding up the number of the correct recalled letters and the correct mathematic responses [62].

Finally, the data will be analysed using the Statistical Package for the Social Sciences (SPSS statistical software-version 26.0).

Procedure

The proposed study was conducted in accordance with the British Psychological Association Code of Ethics and Conduct. Ethical approval was provided by the scientific committee of the National Technical University of Athens, the National Kapodistrian University of Athens, the University of West Attica and the Mediterranean College of Athens for the conduction of this research. Initially, all participants were asked to read and sign a consent form ahead of the study containing a checklist to make sure that they fully understand the objectives and the structure before giving their consent. Subsequently, participants were informed thoroughly about the aims of the study and the requirements of the experimental procedure. The Informed consent has been consistent with Ethics Considerations, protecting participants' confidentiality and anonymity. Afterwards, they were kindly requested to complete a 7-section booklet containing the self-declarative questionnaires and problem-solving tasks. At the end of the study, all participants were given debriefing forms involving the precise reasons for carrying out this experiment and simultaneously were provided with additional resources in order to get further information about the existing literature regarding the present study. Additionally, they were thanked for their participation and were aware of their right to withdraw their data in a period of two weeks after their participation.

Withdrawal from the investigation

The participants were informed about their right to withdraw through the participant information sheet. Participants will be granted a period of two weeks to withdraw their data from the study by communicating with the researcher via e-mail. This procedure was carried out anonymously through the use of participants' personal codes which consisted of the first three letters of their surnames

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and the last three digits of their mobile phone numbers. Finally, data could be permanently erased from SPSS spreadsheet upon request.

Data protection

Data protection have fallen within the Data Protection Act and the University's Good Scientific Practice http://www.derby.ac.uk/research/policy-and-strategy. Data have been stored in the researcher's SPSS spreadsheet for a two-year period, in case there will be replication or publication needs. After this period of time, the aforementioned researcher's spreadsheet will be erased and all the contained data will be consequently destroyed.

Results

Parametric Assumption Testing

Prior to conducting the proper inferential statistical analysis, data screening was performed in order to ensure the eligibility of parametric assumptions. The transformation of scores to Z_{score} and $Z_{residual}$ scores investigated the presence of potential outliers (Criterion +/− 3.29 for sample>250, N=255) [88]. By doing so, four outliers were detected (participants 20;84;109;214) within the dataset of WM variable and were further identified by the Q-Q plots and Boxplots. Subsequently, these outliers were replaced by using the method of winsorization, which according to Field [88], is a robust transformation statistic method ensuring the protection of value's information between the highest and lowest values in a distribution dataset. Additionally, dataset was explored for skewness and kurtosis by calculating $Z_{skewness}$ and $Z_{kurtosis}$ values and observing the histograms. Skewness and Kurtosis calculations also revealed one problematic value (Criterion +/− 3.29 for N>250, N=255). The distribution for WM variable seemed negatively skewed ($Z_{SkewnessR}$ =−4.15) and exceeded the +/−3.29 range. Contrastingly, *Zresiduals* examination revealed no problematic values. Q–Q plots for $Z_{residuals}$ indicated linearity, however, the scatterplot displayed heteroscedasticity. The Kolmogorov-Smirnov (K-S) and Shapiro-Wilk (S-W) normality tests yielded significant results for most predictor variables, with only EE showing normality and only for S-W test (see table 1).

Table 1: Results for Kolmogorov-Smirnov and Shapiro-Wilk tests for normality

	Kolmogorov Smirnov	Shapiro-Wilk
CTA	0.10 (p=0.00)	0.97(p=0.00)
LDPA	0.16 (p=0.00)	0.92 (p=0.00)
WMC	0.12 (p=0.00)	0.93 (p=0.00)
EE	0.02 (p=0.06)	0.98 (p=0.02)
AOTD	0.08 (p=0.00)	0.97 (p=0.00)
LDPA	0.13 (p=0.00)	0.93 (p=0.00)

Note: CTA= Counterfactual Thinking Ability, LDPA= Logical Deduction Problem-Solving Ability, WMC= Working Memory Capacity, EE= Emotional Expressiveness, AOTD= Actively Open-Minded Thinking Disposition, LDPA= Logical Deduction Problem-Solving Ability.

Additionally, normality tests yielded significant results for standardised and unstandardised residuals [D(255) = 0.19, p = 0.00 < a = 0.05; W(255) = 0.86, p = 0.00 < a = 0.05]. Deviations were observed for all the predictor variables suggesting that they were not approximately normally distributed. Hence, the assumption of normal distribution was violated. However, logistic regression does not typically require a linear relationship between the predictor and outcome variables; the residuals do not entail to be normally distributed and the homoscedasticity is not considered indispensable [88].

Nonetheless, some additional assumptions should be applied. Specifically, Binomial Logistic Regression requires the outcome variable to be binary and ordinal. Moreover, this analysis assumed linearity of the outcome variable as well as log-odds, entailing that the predictor variables was linearly related to the log-odds [88]. Lastly, Logistic Regression generally requires a large sample size. Bujang et al. [94] suggest that a minimum sample size of 500 (e.g., N=255<500) could have represented the parameters in the target population. However, for medium to large effect sizes, a smaller sample may be adequate.

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The Durwin-Watson diagnostic showed acceptable results (DW=1.83, Criterion 1<DW<3) indicating no autocorrelation issues. Thus, the assumption of independent errors was met [88]. Subsequently, The VIF test examined collinearity within the dataset, demonstrating no multicollinearity issues (Tolerance=ranged from 0.61-0.95, VIF=ranged from 1.04-1.63 <10).

The above table displays the values of Pearson correlation coefficients between every combination of variables and the one tailed significance of each correlations. In general, values revealed weak correlations. However, a medium positive correlation between ACA and CTA (R=0,49, p=0,00<a=0,05), ACA and WMC (R=0,38, p=0,00<a=0,05), ACA and AOTD (R=0.34, p=0,00<a=0,05), CTA and AOTD (R=0.34, p=0,00<a=0,05) as well as a medium negative correlation ACA and EE (R=-0.39, p=0,00<a=0,05) were noted.

Logistic Regression Analysis and Model Fitting

Data were processed employing a Binomial Logistic Regression inferential test to predict RST or EST. The Enter Method was utilised, thus all the predictor variables were distributed simultaneously in the Model involving six predictors and one binary outcome. The regression equation generated a small effect size (R=0.09, R^2Adj =0.64) (Based on Cohen's (1988) suggestion) and a weak uphill positive linear relationship between the Model's predictors (R=0.29). The Model significantly predicted the ST [$X^2(7)=27.01$, p=0.00<a=0.05, one-tailed]. So, the results indicated that EE, ACA, WMC, LDPA, CTA, AOTD explained a small, but statistically significant amount of the variance of ST. Specifically, the Model accounted for between 10% and 13% of the variance in ST, with 68.3% of those have RST being correctly predicted, 58.6% of those having EST being correctly predicted, and 63.9% overall. LDPA and EE were the only individual variables to significantly predict the ST.

There was a significant negative relationship between LDPA and ST [t(254)=-2.46, p=0.01<a=0.05, one-tailed], as the Model predicted that one-unit change in number of LDPA results to 0.04 change of ST. Similarly, there was a significant positive relationship between EE and ST [t(254)=1.95, p=0.05=a=0.05, one-tailed] while the Model predicted that one-unit change in number of EE results to 0.004 change of ST. Contrarily, ACA, CTA, WMC and AOTD were not significant predictors of ST [$t_{ACA}(254)=-1.81$, p=0.07>a=0.05, one-tailed; $t_{CTA}(254)=-0.57$, p=0.56>a=0.05, one-tailed; $t_{WMC}(254)=-0.68$, p=0.94>a=0.05, one-tailed; $t_{AOTD}(254)=0.98$, p=0.32>a=0.05, one-tailed].

Due to the lack of previous research in this field, data were further processed employing empirical strategies in order to determine whether predictors should be entered or re-

Table 2: Correlations coefficients (and significance levels) for the predictors and outcome variables.

	ACA	CTA	LDPA	WMC	EE	AOTD
REST	-0.21 (p=0.00)	-0.14 (p=0.01)	-0.17 (p=0.00)	-0.09 (p=0.07)	0.19 (p=0.00)	-0.03 (p=0.31)
ACA		0.49 (p=0.00)	0.12 (p=0.02)	0.38 (p=0.00)	-0.39 (p=0.00)	0.34 (p=0.00)
CTA	0.49 (p=0.00)		0.17 (p=0.00)	0.29 (p=0.00)	-0.22 (p=0.00)	0.34 (p=0.00)
LDPA	0.12 (p=0.02)	0.17 (p=0.00)		-0.01 (p=0.41)	-0.01 (p=0.40)	0.11 (p=0.03)
WMC	0.38 (p=0.00)	0.29 (p=0.00)	-0.01 (p=0.41)		-0.30 (p=0.00)	0.24 (p=0.00)
EE	-0.39 (p=0.00)	-0.22 (p=0.00)	-0.01 (p=0.40)	-0.30 (p=0.00)		-0.10 (p=0.05)

Note: ACA= Analytic Cognitive Ability, CTA= Counterfactual Thinking Ability, LDPA= Logical Deduction Problem-Solving Ability, WMC= Working Memory Capacity, EE= Emotional Expressiveness, AOTD= Actively Open-Minded Thinking Disposition, REST= Rational and Experiential Style of Thinking.

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moved from the Model [95]. Specifically, Forward and Backward Stepwise methods were further utilised for fitting regression models in which the choice of predictive variables was made by an automatic procedure. The results showed that the strongest predictors of this Model were the ACA, LDPA and *EE* while WMC, CTA, AOTD were the weakest contributors. Finally, considering the idea of parsimony, data were also analysed using the Hierarchical Method. In scientific context, the statistical implication of employing parsimony heuristic is that the models do not include predictors unless they have had explanatory benefit [88].

The Model significantly predicted the ST [$X^2(7)=22.63$, $p=0.00<a=0.05$, one-tailed]. The results indicated that EE, ACA, LDPA and AOTD explained a small, but statistically significant amount of the variance of ST. Specifically, the Model accounted for between 8.6% and 11.5% of the variance in ST, with 74% of those have RST being correctly predicted, 50.9% of those having EST being correctly predicted, and 63.5% overall.

Discussion

This study aimed to identify the functional relationship that best predicts individuals' potential for RST or EST. In this respect, a binomial logistic regression inferential analysis was employed to examine whether individuals' demonstration of ACA, CTA, LDPA, WMC, EE and *AOT*D would predict their potential for RST or EST. The hypothesis was verified by the findings indicating a significant relationship between the conjunction of the predictors and the binary outcome while the Model significantly predicted the Style of Thinking. Hence, the results revealed that EE, ACA, WMC, LDPA, CTA and AOTD explained a small but statistically significant amount of the variance of ST. In particular, the Model accounted for between 10% and 13% of the variance in ST, with 68.3% of those having RST being correctly predicted while 58.6% of those having EST being also correctly predicted, and 63.9% overall.

Due to the lack of previous research in this field, data were further processed with the use of empirical strategies in order to determine whether predictors should be entered or removed from the Model [95]. The results showed that the strongest predictors of this Model were the ACA, LDPA and *EE* while WMC, CTA and AOTD were the weakest ones. Considering, however, the idea of parsimony, according to which, models should not include predictors unless they have some explanatory benefit [88], data were further processed using the Hierarchical Method. In this case, the Model significantly predicted the ST. Thereby, the results revealed that EE, ACA, LDPA and AOTD explained a small but statistically significant amount of the variance of ST with 74% of those having RST being correctly predicted, 50.9% of those having EST being correctly predicted, and 63.5% overall. LDPA and EE were the only individual variables to significantly predict the ST.

Gyurak et al. [85] combined the Dual-Process Framework with emotion regulation. In their study, they specified that people regulate their emotions by capturing two distinguished dimensions of personal information processing, which are bidirectionally interactive, that is, the rational and experiential process. In terms of thinking, individuals adopt strategies stemming from their emotional recognition and generation [82]. Success in emotion regulation could be predicted by individuals' differences in their cognitive ability [83]. This research focused on the two parts of the emotion-generative process, that includes individuals' emotional response inclinations and their further behavioural expression. In general, emotion is considered an experiential mechanism that individuals should frequently overcome, so that they may rationalise their intuitive choices [3]. This, however, is something which this particular study comes to contradict. Nonetheless, these findings may be considered encouraging since little empirical research has paid direct attention to the examination of the correlation between emotional expressiveness and reasoning [81]. Therefore, it can be concluded that the association between emotion and reasoning is indeed complicated [79].

Regardless, there are two prevalent inherent challenges when evaluating the activity of the experiential system. The first lies in the implicit intricacy of examining the experiential-system processing through self-declarative psychomet-

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ric tools. According to CEST [3], the experiential mechanism is unconsciously activated, and thus significant distortions may surface, when attempting to verbalise these processes, especially through self-report measurements. An additional complex aspect is that the experiential mechanism operates under specific contextual conditions depending on individuals' previous knowledge and experience [8, 11, 43]. Hence, the contexts constructed in reasoning tasks (e.g. counter-example generating task) in this research may be irrelevant to some participants due to individual different encounter inputs. Finally, Evans [13] assumes that the experiential system may constitute a set of systems, and this study might focus merely on existing aspects of them. Further research should explore more unidentified systems' dimensions.

In this study, REI examines analytical and experiential reasoning, considering individuals' personal levels of reasoning use while deriving from their beliefs, confidence and preference [32]. The disposition in the analytic processing is associated with normative rationality while the disposition in the intuitive processing is associated with heuristics and subsequent biases [4, 5, 11, 14]. In this regard, preferring a specific information processing system over the other leads to beliefs and values in favour of this specific type of reasoning and thus this ability is being gradually established [20, 21, 27]. This, however, assumes that those with advanced cognition could systematically and successfully explore their thoughts and their efficiency (metacognition) [7]. Although beliefs and values endorse the rational type of reasoning, it should not be taken for granted that there are developed cognitive skills, which people are aware of and use correctly. For this reason, the degree to which REI measurements represent a cognitive profile or simply reflect a disposition towards it should be further determined. Consequently, it is difficult to observe the syllogistic processing used, since the participants were not required to justify their answers in this Inventory. With regards to future studies, it would be essential for participants to justify their answers to problems, so as to identify the type of reasoning used.

The CRT used in this study is an exceptionally powerful measurement of reflective thinking and has been broadly employed in the examination of heuristics and biases [5, 36, 40, 92]. The findings indicated that a large number of the participants may have already been exposed to these questions. Consequently, that prior exposure might have produced higher scores and reduced the effect size [36, 92], which can potentially undermine the validity of the test, although this is not ultimately confirmed. Despite the fact that CRT relies on numeracy to a great extent, thus not including separate parameters (e.g. linguistics) and generating issues for specific theoretical purposes, this study has used a reword combination of CRT [4, 5], overcoming this limitation. In addition, this combination measured the same constructs as the original CRT, thus adding to its validity [92]. Furthermore, including combined questions in an original CRT scale further contributes to the internal reliability of this test. The validity of this conjunction is also confirmed by the fact that it predicts performance on the same cognitive measures as those of the CRT [5].

Limitations, Strengths and Future Directions

The statistics design employed in this study may have had some potential flaws. Firstly, the self-reporting questionnaires employed may have caused participants to provide socially desirable or socially approved answers consistent with expected norms ("social approval bias") [96]. Nevertheless, in order to reduce such bias effect, apart from the self-declarative questionnaires, problem-solving and decision-making tasks were also administered to examine a variety of cognitive abilities founded on the tenets of the Dual-Process theory. However, the social approval biases can further serve as an informative source in this study. In this respect, according to Evans [14], Norman et al. [25] and Scherer et al. [26], effectively avoiding social approval biases indicates the suppression of experiential system tendency which consequently leads to the transition and uses of rational system. Hence, participants expressing such biases can further shed light to their original preference for one of two systems.

Secondly, this study was conducted exclusively in English, as the participants were considered to be fluent in this language despite their being Greek. However, due to the fact that they were not native speakers, they may have experi-

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enced difficulties in efficiently expressing themselves. In addition, the validity of the instruments used may have been compromised, as they had been originally devised for western cultures, thus further affecting the credibility of the findings. Additionally, some of the questionnaires comprised a combination of other standardised instruments while some items were extracted from their original context. Thus, this diversified function of the instruments may have also influenced the reliability of the final outcome.

Logistic regression typically demands a large sample size. Specifically, Bujang et al. [94] proposed that a sample size of at least 500 participants indicate the parameters in the target group. Respectively, a smaller group of 258 participants was used in this study, which is another limitation. This, however, was attributed to the G*Power analysis requiring a minimum sample of 250 participants and the strict research time restrictions, which negatively affected recruitment. Therefore, caution is suggested in generalisation of the results.

All things considered, this study took a first step in devising a predictive model in order to investigate potential intellectual reasoning abilities, thinking dispositions and decision-making skills grounded in the principles of the Dual-Process theory that may shed light to the information processing style of thinking. More specifically, this study explored multiple aspects of human information processing, employing a wide range of assessment strategy tasks. That is, self-report measurements and syllogistic reasoning problems with abstract components were utilised, to avoid the previous familiarity, experience or emotion interference [23]. Additionally, everyday reasoning tasks (e.g., counter-example generating tasks) were used, which demanded background knowledge retrieval [67]. A combination of WM capacity and the information processing measurement was also employed, namely, OSPAN [62]. This considers the aggregate resource allocation, the ability to control attention as well as the capability of interference handling [53] while focusing on the interrelation of WM and problem-solving ability [61, 62]. Although the findings of this study are novel, they should be cautiously interpreted, as the sample was smaller than the one typically proposed for the logistic regression models [94]. Despite the minimal practicality of the proposed Model, which was due to the small variance indicated by the predictor variables, it follows a methodological design originating from the Dual-Process Theory, that can be further exploited in future studies. More than 80% of the variance can be explained by predictors different from those used. Although a range of cognitive abilities was examined, there is still great potential for future exploration through several variables proposed in the existing literature, due to the complexity of the information processing style of thinking. However, there should be more instruments translated in Greek and standardised for the Greek population, so that they are in line with this specific culture, thus leading to safer conclusions and ultimately adding to the validly and reliability of future studies (This is further reflected in the questionnaires' reliability analysis, Cronbach's a: 0.4 for REI, Cronbach's a: 0.6 for AOT, Cronbach's a: 0.9 for BEQ)

Theoretical and Practical Implementations

The Dual-System Framework can have several implementations in a variety of psychological disciplines. In this direction, it may contribute to the resolution of certain tensions in psychology and clarify the types of irrationality. These types entail mental division and conflict such as self-deception, belief–behaviour dissociations and acracy [1]. Additionally, Dual-System Theory could be further employed in moral psychology. More specifically, this theory can bring about the conception of the interrelation between moral sentimentalism and rationalism as well as their influence on each other [97]. However, irrespective of which system an individual makes use of in order to judge or act, several conventional philosophical questions and paradoxes should be reformulated to allow for this information processing duality. This may eventually lead to debates over knowledge, responsibility, agency, autonomy and rationality [98].

Experimental psychologists should focus on the interaction of these systems and the degree to which the volitional process can be utilised in the rational system, so as to constrain the tense pragmatic inclinations to respond to the inference and cognitive biases coming from the experiential system [12, 14, 19, 28]. With regards to the transitivity

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of preference, it is crucial to devise models to demonstrate how these two systems may interact in the human brain and how their competition and conflict could be resolved for the sake of self-control behaviour. Despite the encouraging results, thorough research should be further conducted to enhance the understanding of the Dual-System neurological basis, since neuropsychological studies of reasoning are still in a primary stage.

Abbreviations

ACA	Analytic Cognitive Ability
CTA	Counterfactual Thinking Ability
LDPA	Logical Deduction Problem-solving Ability
WMC	Working Memory Capacity
EE	Emotional Expressiveness
AOTD	Actively Open-minded Thinking Disposition
RST	Rational Style of Thinking
EST	Experiential Style of Thinking
REI	Rational Experiential Inventory
OSPAN	Operation Span Test
BEQ	Berkeley Expressivity Questionnaire
AOT	Actively open-minded thinking

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