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## On the relationship between cognitive ability and field of study

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### Abstract

The present study was conducted to investigate the existence of any possible relationship between the cognitive reflection test (CRT), numeracy and academic majors. The statistical population of this study consisted of 117 freshmen studying under the faculties selected from the University of Tabriz. The generalised structural equation modelling technique was employed for data analysis. The research results indicated that CRT and numeracy had positive and significant effects on high school and university program selection. According to the research model and the higher CRT scores of engineering and medicine (two popular majors) than that of other majors, it appears that individuals with higher CRT and numeracy scores are more inclined to get accepted into these programs. Moreover, the relationship between CRT and numeracy was positive and significant, where CRT acted as the cause and numeracy as the effect. However, the reverse need not necessarily be true.

**Keywords:** Cognitive reflection, numeracy skill, academic majors, relationship.

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## 1. Introduction

In the past two decades, psychologists have distinguished between two intellectual systems with different capacities and processes (DeCoster, 2002; Evans, 2003, 2008; Kahneman, 2011; Kahneman & Frederick, 2002; Metcalfe & Mischel, 1999; Sloman, 1996; Strack & Deutsch, 2004), referred to as System 1 and System 2 (Frankish, 2010). System 1 is fast, automatic, effortless and unconscious. This system processes information through pattern recognition and experience association. In System 1, achieving outcomes may not even require a clear understanding of the underlying processes. However, System 2 is deliberate and requires effort, control and concentration. It is a gradual process based on rules and calculations.

More specifically, this analytical and reasoning system can refute and modify the intuitive and associative responses of the first system, allowing individuals to review their initial responses more accurately. Therefore, two models of dual process systems have been developed: the intuitive-reflexive model (Kahneman, 2011; Kahneman & Frederick, 2002) and the empirical-analytical model (Epstein, 1994; Slovic, Finucane, Peters & MacGregor, 2004). According to the first model, humans have limited capacities and abilities to control systematic or argumentative thinking due to their limited rationality, including certain constraints on information processing for the purpose of decision-making (owing to the lack of knowledge or information) and other constraints on access time and calculation capacities (Gigerenzer & Goldstein, 1996; Kahneman, 2003). According to the second model, individuals possess an empirically intuitive system, which acts holistically and nonverbally based on ideas, emotions and senses. In other words, this system is experiential. However, the analytical model is a logical-analytical system, which acts based on abstractions, symbols, words and numbers. Epstein, Pacini, Denes-Raj and Heier (1996) emphasised the persistent differences of individuals in employing each of these systems. For this purpose, Frederick (2005) introduced cognitive reflection test (CRT) in 2005 to analyse the performances of System 1 and System 2. Frederick utilised three apparently simple problems to present a criterion for measuring a kind of cognitive ability. Regarding such questions, individuals usually give the first intuitive response that occurs to them. In fact, these responses are fast, spontaneous and accessible but incorrect. The test was conducted on 3,400 participants. According to the results, nearly 50% of the participants gave incorrect intuitive responses to all three CRT items. Table 1 shows the CRT items.

**Table 1. Cognitive reflection test (CRT)**

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1. A bat and ball cost \$1.10 in total. The bat costs \$1.00 more than the ball. How much does the ball cost?---- cents
  2. If it takes five machines 5 minutes to make five widgets, how long would it take 100 machines to make 100 widgets?----minutes
  3. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to cover the entire lake, how long would it take for the patch to cover half of the lake? ---- days
- 

In response to the first item for instance, the first number that comes to mind is probably 10 cents. This response is just a quick, satisfying and incorrect guess. The in-depth review and analysis of the initial response indicate that if the ball is worth 10 cents, then the total price will be 1 dollar and 20 cents (10 cents for the ball and 1 dollar and 10 cents for the racket) and not 1 dollar and 10 cents. Therefore, the correct response will be 5 cents.

If respondents further ponder and revise their responses, they will have inevitably entered the realm of argumentative processes presented by System 2. In fact, providing the correct response to each item entails the systematic processing required to correct the intuitive response (System 1) (Frederick, 2005). Other studies show that individual differences in high- or low-CRT scores affect how individuals make judgments and decisions (Campitelli & Labollita, 2010; Cokely & Kelley, 2009; Hoppe & Kusterer, 2011).

Another cognitive skill is the numerical skill, known as numeracy, having a major role in decision-making and reasoning because many of the human decisions and judgments depend greatly on the basic concepts of mathematics. Numeracy refers to the ability to process basic probabilities and numerical concepts. In a study, Gurmankin, Baron and Armstrong (2004) showed that individuals with poor numeracy put more trust in the oral information provided by physicians on the risk of diseases. However, individuals with higher numeracy levels preferred to receive the information in numerical forms. Many studies have been conducted on the subject. Accordingly, individuals are distinctly different in terms of numeracy. Most of them are even unable to perform simple calculating tasks for daily decisions (Lipkus, Samsa & Rimer, 2001; Woloshin et al., 1999). In today's complicated and technological world, poor numeracy can be a serious barrier to making sound economic, financial and medical decisions. Different studies suggest that the poor numeracy can lead to a variety of cognitive biases and false deductions and affect individual decisions (Peters et al., 2006; Reyna & Brainerd, 2008). The numeracy test used in this study included 11 items in consistency with the study conducted by Lipkus et al. (2001) (Appendix A). These items evaluate numerical, calculation and counting processes of individuals with regard to the basic arithmetic operations, percentage and preliminary probability.

This study pursues two goals: to analyse the CRT and numeracy relationship and the relationships between these two factors and the high school and university majors of the participants.

## **2. Present research**

The main research hypothesis states that there are significant relationships between CRT, numeracy tests and majors. In other words, this study attempts to answer the following question: Will medical and engineering students, who have scored higher on the university entrance test, perform better on the CRT test in comparison with other students, such as those studying economics and the humanities. If so, can gender be considered a factor affecting cognitive abilities?

To protect the rights of respondents, all ethical principles and considerations were observed according to national and international guidelines and codes of ethics. The research permit was granted by the Ethics Committee of the University of Tabriz for this study. The permit was registered as IR.TBZMED.REC.1397.027 on the National Research Ethics Committee. Every participant was asked to fill out and sign the consent form prior to the research. The participants were reminded that participating in the study was optional and that their responses would be kept in strict confidence. This study commenced in December 2017 and lasted approximately 8 weeks. Every participant was paid a sum in consideration of filling out the research questionnaires. According to the participants, they faced the questions for the first time and had no previous experience of taking a similar test. Furthermore, the researchers had found no references or studies on such tests in Iran. Therefore, the study seemed to be the first research conducted on the subject.

## **3. Results**

The generalised structural equation modelling (GSEM) technique was employed to analyse the relationships between CRT, numeracy and majors at both high school and university. The CRT score was based on the three items asked of the participants. In other words, this index indicates the number of correct responses given by each participant. For instance, a score of 2 shows that a participant could answer 2 out of 3 questions correctly.

Regarding the numeracy index, the number of correct responses was regarded as the criterion for classifying the performances of participants. Hence, 11 was the highest score participants could achieve. If no questions were answered correctly, the score would be zero.

The random sampling method was used for selecting undergraduate students from faculties of medicine, engineering, mathematics, economics, and social sciences (the humanities) at the University

of Tabriz. The research sample consisted of 117 students (59 females and 58 males), aged between 17- and 31-year old. However, only two of the participants were 43- and 46-year old ( $m = 21.2$ ,  $SD = 3.82$ ).

According to Table 2, the high school major had a positive and significant effect on CRT. In other words, individuals who had studied mathematics and natural sciences obtained higher CRT scores than those who had studied the humanities. There was also a positive and significant relationship between the university major and CRT. Accordingly, engineering and medical students achieved higher CRT scores than the students of other programs (economics, social sciences and mathematics). In addition, gender had a positive and significant effect on CRT, in that men obtained higher CRT scores than women.

**Table 2. The GSEM results (reference: research findings)**

| Variables         |   |          | Coefficient | Statistics Z | p-value |
|-------------------|---|----------|-------------|--------------|---------|
| Sex               | → | CRT      | 0.28        | 3.63         | 0.000   |
| Medicine          | ← | CRT      | 0.25        | 2.58         | 0.01    |
| Engineering       | ← | CRT      | 0.16        | 1.7          | 0.08    |
| High school major | ← | CRT      | 0.37        | 2.81         | 0.005   |
| Cons              | ← | CRT      | 0.12        | 2.20         | 0.028   |
| CRT               | → | Numeracy | 0.29        | 2.79         | 0.005   |
| Mathematics       | ← | Numeracy | 0.3         | 2.12         | 0.034   |
| Medicine          | ← | Numeracy | 0.15        | 1.67         | 0.07    |
| Engineering       | ← | Numeracy | 0.31        | 2.67         | 0.008   |
| Cons              | ← | Numeracy | 0.34        | 6.70         | 0.000   |

Regarding the relationship between CRT and numeracy, Table 2 indicates that CRT had a positive and significant effect on numeracy.

In other words, individuals with higher CRT scores had higher numeracy scores with a correlation coefficient of 0.28, which is consistent with most studies reporting a correlation coefficient ranging between 0.3 and 0.5.

The research results are consistent with the findings of other studies conducted by Frederick (2005) and Zhang, Highhouse & Rada (2016).

There was also a positive and significant relationship between the university major and Numeracy. In comparison to students studying social sciences and economics, higher scores were obtained by engineering, medical and mathematics students.

The goodness of fit indices indicate that  $\chi^2 = 20.47$  and since its  $p$ -value is smaller than 0.05, the observed and predicted variance-covariance matrices were different.

This statistic is affected by the size of the research sample. It shows the good fitness of the model. The RMSEA was 0.02, a value which should have been smaller than 0.05 to show the acceptable goodness of fit (Browne & Cudeck, 1992). The CFI and TLI were 0.95 and 0.87, respectively. They both show that the good fitness of the model (Raykov & Marcoulides, 2006). Basically, the main goal of a regression analysis is to explain changes in the endogenous variables made by exogenous variables. Hence, a temporal model is considered a good model with the possibly high explanatory power.

#### 4. Discussion and conclusion

This study aimed to analyse the relationships between CRT, numeracy and majors both at the high school and university. Regarding the CRT and numeracy relationship, the direction of causation was from CRT to numeracy meaning that the students with higher CRT scores achieved higher numeracy

scores. However, the reverse is not necessarily true. That is, higher numeracy scores cannot necessarily result in higher CRT scores.

This might be due to the fact that numeracy is an acquired skill; however, CRT is an innate gift. For instance, mathematics students practicing mathematical problems in different lessons benefit from high numeracy scores, which do not necessarily affect their CRT scores.

Applicants scoring highly on the Iranian University Entrance Exam, known as the Konkour, often gravitate towards popular programs, such as medicine and engineering. It seems that this accomplishment is not just the result of diligence and superior high school education; rather, other factors, including personal talent and cognitive ability, are involved as well.

## Appendix A

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4. Imagine that we roll a fair, six-sided die 1,000 times. Out of 1,000 rolls, how many times do you think the die would come up even (2, 4 or 6)?  
\_\_\_\_\_ times
  5. In the BIG BUCKS LOTTERY, the chances of winning a \$10.00 prize are 1%. What is your best guess about how many people would win a \$10.00 prize if 1,000 people each buy a single ticket from BIG BUCKS?  
\_\_\_\_\_ people
  6. In the ACME PUBLISHING SWEEPSTAKES, the chance of winning a car is 1 in 1,000. What percent of tickets of ACME PUBLISHING SWEEPSTAKES win a car? \_\_\_\_\_ %
  7. Which of the following numbers represents the biggest risk of getting a disease? Choose only one of the following:  
\_\_ 1 in 100, \_\_ 1 in 1,000, \_\_ 1 in 10
  8. Which of the following represents the biggest risk of getting a disease? Choose only one of the following  
\_\_ 1%, \_\_ 10% and \_\_ 5%
  9. If Person A's risk of getting a disease is 1% in 10 years and Person B's risk is double that of A's, what is B's risk?  
\_\_\_\_\_
  10. If the chance of getting a disease is 10%, how many people would be expected to get the disease out of 100?  
\_\_\_\_\_ people
  11. If Person A's chance of getting a disease is 1 in 100 in 10 years, and Person B's risk is double that of A, what is B's risk?  
\_\_\_\_\_
  12. If the chance of getting a disease is 10%, how many people would be expected to get the disease out of 1,000?  
\_\_\_\_\_ people
  13. If the chance of getting a disease is 20 out of 100, this would be the same as having a \_\_\_\_% chance of getting the disease.
  14. The chance of getting a viral infection is 0.0005. Out of 10,000 people, about how many of them are expected to get infected?  
\_\_\_\_\_ people
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Numeracy scale items used in the study were adapted from the original scale by Lipkus et al. (2001).

## Reference

- Browne, M. W. & Cudeck, R. (1992). Alternative ways of assessing model fit. *Sociological Methods & Research*, 21(2), 230–258. doi:10.1177/0049124192021002005
- Campitelli, G. & Labollita, M. (2010). Correlations of cognitive reflection with judgments and choices. *Judgment and Decision Making*, 5(3), 182–191.

- Cokely, E. T. & Kelley, C. M. (2009). Cognitive abilities and superior decision making under risk: a protocol analysis and process model evaluation. *Judgment and Decision Making*, 4(1), 20–33. doi:10.1016/j.jbankfin.2009.04.001
- DeCoster, J. & Smith, E. R. (2002). Dual-process models in social and cognitive psychology. *Personality and Social Psychology Review* 4(2), 108–131, 41(Pt 2), 203–218. doi:10.1207/S15327957PSPRO402
- Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. *American Psychologist*, 49(8), 709–724. doi:10.1037/0003-066X.49.8.709
- Epstein, S., Pacini, R., Denes-Raj, V. & Heier, H. (1996). Individual differences in {Intuitive}-{Experiential} and {Analytical}-{Rational} thinking styles. *Journal of Personality and Social Psychology*, 71(2), 390–405.
- Evans, J. S. B. T. (2003). In two minds: dual-process accounts of reasoning. *Trends in Cognitive Sciences*, 7(10), 454–459. doi:10.1016/j.tics.2003.08.012
- Evans, J. S. B. T. (2008). Dual-processing accounts of reasoning, judgment, and social cognition. *Annual Review of Psychology*, 59(1), 255–278. doi:10.1146/annurev.psych.59.103006.093629
- Frankish, K. (2010). Dual-process and dual-system theories of reasoning. *Philosophy Compass*, 5(10), 914–926. doi:10.1111/j.1747-9991.2010.00330.x
- Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19(4), 25–42. doi:10.1257/089533005775196732
- Gigerenzer, G. & Goldstein, D. G. (1996). Reasoning the fast and frugal way: models of bounded rationality. *Psychological Review*, 103(4), 650–669. doi:10.1037/0033-295X.103.4.650
- Gurmankin, A. D., Baron, J. & Armstrong, K. (2004). The effect of numerical statements of risk on trust and comfort with hypothetical physician risk communication. *Medical Decision Making*, 24(3), 265–271. doi:10.1177/0272989X04265482
- Hoppe, E. I. & Kusterer, D. J. (2011). Behavioral biases and cognitive reflection. *Economics Letters*, 110(2), 97–100. doi:10.1016/j.econlet.2010.11.015
- Kahneman, D. & Frederick, S. (2002). Representativeness revisited: attribute substitution in intuitive judgment. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and biases: the psychology of intuitive judgment*. New York, NY: Cambridge University Press. doi:10.1017/CBO9780511808098.004
- Kahneman, D. (2003). Maps of bounded rationality: psychology for behavioral economics. *American Economic Review*, 93(5), 1449–1475. doi:10.1257/000282803322655392
- Kahneman, D. (2011). *Thinking, fast and slow*. New York, NY: Farrar, Straus and Giroux.
- Lipkus, I. M., Samsa, G. & Rimer, B. K. (2001). General performance on a numeracy scale among highly educated samples. *Medical Decision Making*, 21(1), 37–44. doi:10.1177/0272989X0102100105
- Metcalfe, J. & Mischel, W. (1999). A hot/cool-system analysis of delay of gratification: dynamics of willpower. *Psychological Review*, 106(1), 3–19. doi:10.1037/0033-295X.106.1.3
- Peters, E., Västfjäll, D., Slovic, P., Mertz, C. K., Mazzocco, K. & Dickert, S. (2006). Numeracy and decision making. *Psychological Science*, 17(5), 407–413. doi:10.1111/j.1467-9280.2006.01720.x
- Raykov, T. & Marcoulides, G. A. (2006). A first course in structural equation modeling. *Structural Equation Modeling: A Multidisciplinary Journal*, 13. doi:10.1207/s15328007sem1301
- Reyna, V. F., & Brainerd, C. J. (2008). Numeracy, ratio bias, and denominator neglect in judgments of risk and probability. *Learning and Individual Differences*, 18(1), 89–107. <https://doi.org/10.1016/j.lindif.2007.03.011>
- Slooman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, 119(1), 3–22. doi:10.1037/0033-2909.119.1.3
- Slovic, P., Finucane, M. L., Peters, E. & MacGregor, D. G. (2004). Risk as analysis and risk as feelings. *Risk Analysis*, 24(2), 311–322. Retrieved from papers2://publication/uuid/F4B3EA59-C2F7-4F62-9223-701C27F152C2
- Strack, F. & Deutsch, R. (2004). Personality and social psychology review. *Personality and Social Psychology Review*, 8(3), 220–247. doi:10.1207/s15327957pspr0803
- Woloshin, S., Schwartz, L. M., Black, W. C., Welch, H. G., Woloshin, S., Schwartz, L. M., ... Welch, H. G. (1999). Studies in breast cancer women ' s perceptions of breast cancer risk : *Medi*, 19(3), 221–229. doi:https://doi.org/10.1177/0272989X9901900301

Deldoost, M. H., Mohammadzadeh, P., Akbari, A. & Saeedi M. T. (2019). On the relationship between cognitive ability and field of study. *Global Journal of Psychology Research: New Trends and Issues*. 9(1), 001-007.

Zhang, D. C., Highhouse, S. & Rada, T. B. (2016). Explaining sex differences on the cognitive reflection test. *Personality and Individual Differences*, 101(October), 425–427. doi:10.1016/j.paid.2016.06.034