

# The Interference of Introversion–Extraversion and Depressive Symptomatology with Reasoning Performance: A Behavioural Study

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**Abstract** The objective of this study was to investigate the link between the Eysenck Personality Questionnaire (EPQ) scores and depressive symptomatology with reasoning performance induced by a task including valid and invalid Aristotelian syllogisms. The EPQ and the Zung Depressive Scale (ZDS) were completed by 48 healthy subjects (27 male, 21 female) aged  $33.5 \pm 9.0$  years. Additionally, the subjects engaged into two reasoning tasks (valid vs. invalid syllogisms). Analysis showed that the judgment of invalid syllogisms is a more difficult task than of valid judgments (65.1% vs. 74.6% of correct judgments respectively,  $p < 0.01$ ). In both conditions, the subjects' degree of confidence is significantly higher when they make a correct judgment than when they make an incorrect judgment ( $83.8 \pm 11.2$  vs.  $75.3 \pm 17.3$ ,  $p < 0.01$ ). Subjects with extraversion as measured by EPQ and high sexual desire as rated by the relative ZDS subscale are more prone to make incorrect judgments in the valid syllogisms, while, at the same time, they are more confident in their responses. The effects of extraversion/introversion and sexual desire on the outcome measures of the valid condition are not commutative but additive. These findings indicate that extraversion/introversion and sexual desire variations may have a detrimental effect in the reasoning performance.

**Keywords** Reasoning · Personality · Introversion · Extraversion · Aristotle syllogism · EPQ · ZDS

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## Introduction

Reasoning is central to science, society, and the solution of practical problems. It starts with premises, which can be statements, perceptions or beliefs. Ideally, it yields a valid conclusion that is not explicit in the premises. However, the intervening processes are mysterious. Aristotle endeavoured to answer these questions by providing the first logical system: the theory of the syllogism. Syllogisms involve two premises, such as, “All men are mortal”; “All Athenians are men”. Aristotle argued that these premises imply with absolute certainty that “All Athenians are mortal”. In the case in point, a series of relationships that are described by the predicative linking verb “are” and specified by the quantifier “all”, constitute the logical form of the inference, determining the validity of the particular syllogism (Aristotle, *Prior Analytics*, Books I-II; Aristotle, *Posterior Analytics*).

Researchers raised several approaches for the mechanisms implicated in reasoning. In a rough outline, it has been suggested that reasoning involves dual control (Evans 2003; Sloman 1996; Stanovich and West 2000), with different neural processes at the base of each system (Goel and Dolan 2003). In this framework, it is assumed an evolutionarily old and intuitive system 1, having processes that are rapid and automatic in nature and an evolutionarily new system 2, allowing reasoning according to logical rules demanding people’s mental resources. This system 2 is believed to be explicit, slow, and volitional in nature (Evans 2003; Stanovich and West 2000). For system 1, only the product of reasoning becomes available to consciousness whereas, within system 2, we have conscious insight into both the outcome and the means by which we reason (Evans 2003; Goel and Dolan 2003; Sloman 1996; Toates 2006). Human reasoning is characterized by the interplay between system 1 and system 2 (Evans 2003; De Neys 2006).

In this debate a fundamental unresolved question is whether personality features and/or psychopathology symptoms are involved in the syllogistic procedure and have an effect on performance. In line with this view, it is useful to bring in mind the statement of Aristotle: “Now the proofs furnished by the speech are of three kinds. The first depends upon the moral character of the speaker, the second upon putting the hearer into a certain frame of mind, the third upon the speech itself, in so far as it proves or seems to prove.” (Aristotle, *Rhetoric*, Book I, 2, 1356a, pp. 1–35). Although Aristotle emphasized explicitly the involvement of both personality and the emotional state during the procedure of reasoning, however, this line of thought has not been extensively investigated.

In a study focusing on the effects of depressed affect on functioning measured by behavioural tasks pertaining to abstract reasoning, in relation to Cluster B personality disorder features (i.e., antisocial, borderline, histrionic, narcissistic) in a clinical sample, borderline personality disorder was negatively related to abstract reasoning, but only in the depressed affect condition (Miller et al. 2009).

In another study subjects with active or remitted paranoid delusions, depressed and healthy adults performed two novel heuristic reasoning tasks that varied in emotional valence. The aim was to examine the social reasoning in regard to the form of decision-making in daily life. The results showed that clear similarities existed between the currently paranoid group and the depressed group in terms of their reasoning about the likelihood of events happening to them, with both groups tending to believe that pleasant things would not happen to them (Corcoran et al. 2006).

More recently, De Neys et al. (2010) showed that dealing with conflicting logical and intuitive responses during reasoning is accompanied by an increase in autonomic arousal. Particularly, the study focused on conflict-related autonomic nervous system modulation during biased reasoning. Participants’ skin conductance responses (SCRs) were monitored

while they solved classic syllogisms, in which a cued intuitive response could be inconsistent or consistent with the logical correct response. Results indicated that all reasoners showed increased SCRs when solving the inconsistent conflict problems. This autonomic arousal boost was absent when people were not engaged in an active reasoning task.

Cortical arousal has been postulated as the primary neurobiological substrate underlying the personality dimension of Introversion–Extraversion (I–E) (Eysenck 1967). Eysenck proposed that Introverts and Extraverts are characterized by different levels of basal arousal function along this curve. Eysenck’s model proposes that this activation system is maintained at a significantly higher level of tonic arousal in Introverts relative to Extraverts. Considerable theoretical and empirical evidence suggests that individual differences in the trait of I–E are reflective of trait levels of cortical arousal.

Taking into account the above considerations, the present study was designed to investigate the implication of personality features and/or depressive symptoms in valid and invalid syllogisms. Valid and invalid syllogisms are involved in most deductive arguments, both in formal settings and in everyday reasoning, since it underlies the drawing of explicit forecasts and expectations that drive behaviour (Carroll 1983).

## Methods

### Participants

A total of 48 individuals were included in the study and their native language was Greek. Criteria for the admission of the participants in the initial group of the study were to be physically healthy, without a history of neurologic or psychiatric disorder, or reading disabilities and no reported history of illicit substance abuse or alcohol dependency. They had normal or corrected to normal visual acuity. Their demographic characteristics were: 48 subjects (27 male, 21 female) aged  $33.5 \pm 9.0$  years. The study was approved by the Ethics committee of University Mental Health Research Institute (UMHRI) and informed consent was obtained from the subjects studied.

### Behavioural Procedures

The participants were seated comfortably 1 m in front of a computer screen in an electro-magnetically shielded room. Instructions were presented first, and tests were carried out as a training exercise. Once the experimental task was comprehended by the participants, the participants were then permitted to enter the formal experimental session.

The sentence appeared on the computer monitor accompanied by the question “true or false”. The duration of the presented sentence was proportionate to the letters involved in each sentence. Then the sentence with its question disappeared being followed by a period of 1,000 ms from the presentation of each sentence, a warning stimulus of 65 dB, 500 Hz, and 100 ms duration was given, followed by the same warning stimulus after an interval of 900 ms. Participants were asked to respond after the second warning stimulus. Each condition of the task contained 39 sentences. The participants were asked to judge them as either correct or incorrect.

The response in each of the 39 valid syllogisms was marked as correct if the subject considered it to be valid and incorrect if the subject considered it to be invalid. Likewise the response in each of the 39 invalid syllogisms was marked as correct if the subject considered it to be invalid and incorrect if the subject considered it to be valid. It is obvious that for each

**Table 1** Sequence of events in each experimental trial

Sequence of actions	Duration of actions
Valid or invalid sentence (visual presentation)	Duration according to the numbers of the letters in the sentences e.g. a sentence involving 92 letters presented 11,04 s
Wait period	1,000 ms
Warning stimulus	100 ms
Interval between the warning stimuli	900 ms
Warning stimulus repetition	100 ms
Response onset	Within 5 s
Period between response completion and onset of next sentence presentation	4–9 s

subject the correct and incorrect responses, both in the valid and invalid syllogisms, add up to 39. Also for each subject the degree of confidence in his/her judgment in each trial was recorded as a number varying from 100 (absolutely certain) to 0 (not at all certain).

For avoiding habituation with the conditions of the test, the onset of the presentation of the next sentence fluctuated from 4–9 s following completion of the previous oral response. A complete example of trials is showed in Table 1.

Following are two indicative examples of the sentences presented; one valid and one invalid:

*All men are animals. All animals are mortal. Hence, All men are mortal (valid).*

*All boys are aliens. Some explorers are aliens. Some explorers are not boys (invalid).*

### Psychometric Procedures

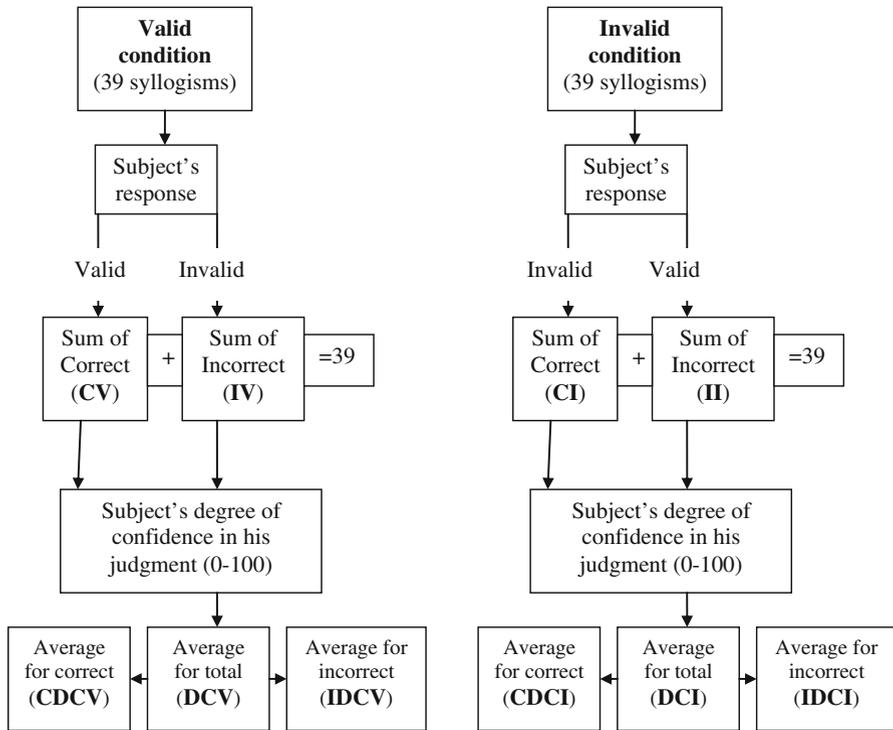
For measurement of the Eysenck's personality traits, the Greek standardization (Dimitriou 1986) of the EPQ (Eysenck and Eysenck 1975) was applied. The questionnaire follows a dichotomous approach (yes/no answers) and the dimensions evaluated are extraversion (EPQ-E), neuroticism (EPQ-N), psychoticism (EPQ-P), and lie (EPQ-L).

The Zung Depression Scale (ZDS) (Zung 1965) was also used in this study. The ZDS is a self-report test designed to quickly and easily quantify the presence and severity of depressive symptomatology on a total of 20 items. The Greek translation of this assessment, has been found to be quite reliable (Fountoulakis et al. 2001).

### Statistical Analysis

The two experimental conditions and the outcome variables are outlined in Fig. 1. The dependent variables for each subject were the number of correct valid (CV), incorrect valid (IV), correct invalid (CI) and incorrect invalid (II) responses. The Kholmogorov-Smirnov test showed that all dependent variables follow the normal distribution. CV and CI were tested for equality of means with the paired *t*-test, while correlations between the four variables were calculated.

Also, for each subject and condition the grand average of his degree of confidence in his judgments was calculated (DCV for the valid syllogisms and DCI for the invalid condition). These two variables were subsequently split into four, depending on whether the subject's



**Fig. 1** Outline of the two experimental conditions and the outcome variables

responses were correct and incorrect (CDCV and IDCV for the valid condition, CDCI and IDCI for the invalid condition). These variables were also checked with the paired *t*-test.

The extravert dimension from the Eysenck questionnaire is a continuous variable, which was dichotomized at the median value of 16, giving a group of 26 subjects with high extravert scores and a group of low extraversion (i.e. introversion). The outcome measures were tested for equality of means against the two extraversion levels (extraversion vs. introversion) with the independent samples *t*-test.

Regarding the subjects' answers to Zung's item #6 ("I am still interested in sex") 31 subjects responded "Always" and were classified in the high sexual desire group, 16 answered "Often" and only one subject answered less than often. These 17 subjects were classified in the normal sexual desire group. Once again, the outcome measures were tested for equality of means against the two sexual desire levels with the independent samples *t*-test. The association between the extraversion levels and sexual desire levels was tested with the chi-square test, reporting also the odds ratio (OR) with its 95% confidence intervals (CI).

Finally, the two extraversion/introversion levels and the two sexual desire levels were united into a single independent factor (EISD) having four levels (1. Introversion and normal sexual desire, 2. Extraversion and normal sexual desire, 3. Introversion and high sexual desire and 4. Extraversion and high sexual desire). The outcome measures were tested for equality of means with EISD as the independent factor using the ANOVA procedure followed by post-hoc pair wise comparisons with Bonferroni corrections. The level of statistical significance was set at 0.05.

## Results

Table 2 shows the means and standard deviations for the four dependent variables CV, IV, CI and II in absolute and percentage form. The proportion of incorrect responses in the valid syllogisms is far from negligible (25.4%) and it is even more notable in the invalid syllogisms (34.9%). The difference of the correct responses between the valid and the invalid condition, as the paired *t*-test shows, is statistically significant ( $t = 2.35$ ,  $df = 47$ ,  $p = 0.023$ ).

The subject's degree of confidence was significantly higher in their correct judgments than in their incorrect judgments, both in the valid (CDCV =  $83.8 \pm 11.2$ , IDCV =  $75.3 \pm 17.3$ ,  $t = 4.3$ ,  $df = 47$ ,  $p < 0.001$ ) and the invalid (CDCI =  $83.3 \pm 15.1$ , IDCI =  $74.2 \pm 14.9$ ,  $t = 6.1$ ,  $df = 47$ ,  $p < 0.001$ ) conditions.

There is a significant negative correlation between CV and CI ( $r = -0.469$ ,  $p < 0.01$ ). Due to the fact that correct+incorrect responses=39, the same significant correlation with a positive sign exists between CV and II ( $r = 0.469$ ,  $p < 0.01$ ). Likewise, the correlation between IV and CI is  $r = 0.469$ ,  $p < 0.01$  and the correlation between IV and II is  $r = -0.469$ ,  $p < 0.01$ . The interesting fact is that the numbers of correct responses in the valid and invalid syllogisms are negatively correlated as a consequence of the fact that the number of valid syllogisms judged as valid is positively correlated with the number of invalid syllogisms judged as valid. Therefore, if a subject scores high in the valid syllogisms, he or she will score low in the invalid syllogisms and vice versa.

Table 3 shows the significant differences between the extraversion and introversion group (according to the Eysenck questionnaire) of the outcome variables from the valid condition. No such differences were observed in the invalid condition. Subjects with extraversion make significantly more incorrect judgments than subjects with introversion, but, at the same time, they have significantly higher degree of confidence in their judgment.

The mean score for the Zung questionnaire was  $34.5 \pm 7.0$  with a maximum value of 49, meaning that the sample came from a healthy population with no obvious depression symptoms. Furthermore the total Zung score did not correlate with any of the parameters either in the valid or in the invalid condition.

However, when each of the dependent variables for the valid condition was regressed using as predictors the answers to all the 20 Zung Depressive Subscales (ZDS), with both the enter and the stepwise methods (both forward and backward), in all cases the only parameter that entered the regression equations in a significant manner was item 6, i.e. the one that relates to sexual desire. This was not observed for the invalid condition.

On studying the correlation matrix of the 20 items of the Zung questionnaire, item 6 had the smallest correlations with the other items. This was confirmed subsequently by factor analysis of the 20 items, where it was found that item 6 stood as the odd-man-out, not grouping with any of the other 19 items. This means that items 6 was answered in quite a different manner from the rest of the items in the questionnaire.

Regarding the subjects responses to this item, Table 4 shows the significant differences between the high and normal sexual desire group for the outcome variables in the valid

**Table 2** Means and standard deviations for the four dependent variables CV, IV, CI and II in absolute and percentage form

	Valid syllogisms		Invalid syllogisms	
	CV (correct)	IV (incorrect)	CI (correct)	II (incorrect)
Absolute	$29.1 \pm 5.7$	$9.9 \pm 5.7$	$25.4 \pm 6.7$	$13.6 \pm 6.7$
Percentage	$74.6 \pm 14.6$	$25.4 \pm 14.6$	$65.1 \pm 17.2$	$34.9 \pm 17.2$

**Table 3** Comparisons of the means of the outcome measures from the valid condition between the extraversion and introversion groups

Extraversion versus introversion Parameter	Introversion		extraversion		<i>p</i> ( <i>t</i> -test)
	Mean	SD	Mean	SD	
Correct judgments (CV)	31.5	4.1	27.0	6.1	0.006
Incorrect judgments (IV)	7.5	4.1	12.0	6.1	0.006
Average degree of confidence (DCV)	78.1	13.9	85.9	7.2	0.016
Average degree of confidence for correct judgments (CDCV)	80.2	13.7	86.9	7.5	0.039
Average degree of confidence for incorrect judgments (IDCV)	68.1	20.1	81.4	11.8	0.007

**Table 4** Comparisons of the means of the outcome measures from the valid condition between the high and normal sexual desire groups

Sexual desire Parameter	Normal		High		<i>p</i> ( <i>t</i> -test)
	Mean	SD	Mean	SD	
Correct judgments (CV)	32.5	2.5	27.2	6.1	0.001
Incorrect judgments (IV)	6.5	2.5	11.8	6.1	0.002
Average degree of confidence (DCV)	77.0	12.4	85.3	9.8	0.015
Average degree of confidence for correct judgments (CDCV)	79.0	12.3	86.5	9.8	0.025
Average degree of confidence for incorrect judgments (IDCV)	67.1	21.6	79.9	12.7	0.013

condition. No such differences were observed in the invalid condition. Subjects with higher sexual desire make significantly more incorrect judgments than subjects with normal sexual desire, but, at the same time, they have significantly higher degree of confidence in their judgment.

Table 5 shows the  $2 \times 2$  contingency table between the levels of extraversion/introversion and sexual desire variable. The association between the two attributes is significant ( $\chi^2 = 6.5$ ,  $df = 1$ ,  $p = 0.011$ ). Within subjects with normal sexual desire the percentage of extraverts is only 29.4%, while within subjects with high sexual desire the percentage of extraverts is as high as 67.7%. Likewise, within subjects with introversion only 45.5% have high sexual desire, while within subjects with extraversion this percentage is as high as 80.8%. The significant odds ratio of 5.0 (95% CI 1.4–18.2) means that the odds of having extraversion rather than introversion are five times more among subjects with high sexual desire than among subjects with low sexual desire. Likewise, the odds of having high sexual desire to having normal sexual desire are five times more among extraverts than among introverts.

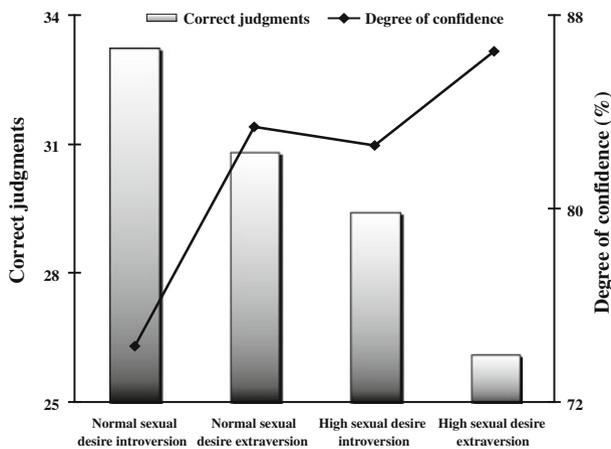
Table 6 shows the means and the standard deviations of the outcome measures from the valid condition among the four levels of the EISD factor. As the ANOVA results show, practically all the outcome measures are dependent on the EISD factor. As the post-hoc comparisons reveal statistically significant differences ( $p < 0.05$ ) are achieved only between the normal sexual desire—introversion and the high sexual desire—extraversion levels. This is clearly exemplified in Fig. 2, where it is shown that subjects with only one attribute (either sexual desire or extraversion) at the high level have intermediate values, but the greatest differences from the normal level are achieved only when both attributes are high.

**Table 5** Contingency table between the levels of libido (sexual desire) and extraversion/introversion

Sexual desire	Extraversion/introversion		Total
	Introversion	Extraversion	
<i>Normal</i>			
Count	12	5	17
% within sexual desire	70.6	29.4	
% within extraversion/introversion	54.5	19.2	
<i>High</i>			
Count	10	21	31
% within sexual desire	32.3	67.7	
% within extraversion/introversion	45.5	80.8	
Total	22	26	48

**Table 6** Comparisons of the means of the outcome measures from the valid condition between the sexual desire-extraversion/introversion levels

	Normal sexual desire and introversion	Normal sexual desire and extraversion	High sexual desire and introversion	High sexual desire and extraversion	<i>p</i> ( <i>F</i> -test)
Correct judgments (CV)	33.2 ± 2.5	30.8 ± 1.6	29.4 ± 4.8	26.1 ± 6.5	0.004
Incorrect judgments (IV)	5.8 ± 2.5	8.2 ± 1.6	9.5 ± 4.9	12.9 ± 6.5	0.004
Average degree of confidence (DCV)	74.3 ± 12.8	83.4 ± 9.9	82.6 ± 14.5	86.5 ± 6.6	0.026
Average degree of confidence for correct judgments (CDCV)	76.5 ± 12.4	85.0 ± 10.5	84.7 ± 14.4	87.3 ± 6.9	0.057
Average degree of confidence for incorrect judgments (IDCV)	62.5 ± 22.4	78.0 ± 16.5	74.9 ± 15.4	82.2 ± 10.8	0.013



**Fig. 2** Mean values of the correct judgments and the degree of confidence of the subjects in the valid condition depending on the sexual desire-extraversion/introversion levels

In addition, the EPQ dimensions of psychoticism, neuroticism and lie, as well as the remaining depressive symptoms of ZDS show no association with reasoning performance.

## Discussion

The proportions of incorrect responses, i.e. judging valid syllogisms to be invalid and invalid responses to be valid are noteworthy. Also, it appears that the judgment of invalid syllogisms is a more difficult task than that of valid judgments. Nevertheless, the overall pattern provides evidence of the subjects' adequate discrimination ability between valid and invalid syllogisms. In both conditions, the subjects' degree of confidence is significantly higher when they make a correct judgment than when they make an incorrect judgment. Interestingly, this degree of indecisiveness is roughly the same in both conditions.

These findings appear to be in agreement with the study by [Evans et al. \(1983\)](#) reporting a variation of reasoning performance. They found that subjects perform better (96%) on syllogistic reasoning tasks when the value of a conclusion (true or false) coincides with the logical relationship between premises and conclusion (valid or invalid). By contrast, a logical argument with an unbelievable conclusion is accepted as valid only at 46%. They attributed these findings to the consistency of the beliefs about the world and their agreement with the conclusion in question. Hence, it is hypothesized that if the logical conclusion is consistent with beliefs about the world, the beliefs are facilitatory to the logical task. By contrast, if the logical conclusion is inconsistent with beliefs about the world, the beliefs are inhibitory to the logical task. Performance on arguments that are belief-neutral usually falls between these two extremes ([Evans et al. 1983, 2001](#)).

Some recent work taking into account the 'dual-process' theory concerning reasoning has shown that cognitive load impairs performance on reasoning ([De Neys 2006](#)). Activating and engaging conscious processing improved logical reasoning performance, whereas hampering that system via cognitive load recorded impairment of performance.

A specific source of erroneous judgments, as the present findings reveal, could be attributed to the fact that subjects tend to follow certain behavioural patterns in their responses i.e. they exhibit, either an inclination towards judging both valid and invalid syllogisms to be valid, or a preference to judge both valid and invalid syllogisms as invalid. It follows that this bias in judgment will invariably lead to enhancement of performance at the one condition and to its impairment at the other.

It seems legitimate to assume that the inclination of the subjects to exhibit a homomorphism with regard to confidence in their judgement is attributable to the dual mechanism theory of reasoning, especially its system 1, since dual-process theorists generally agree that system 1 is implicit, rapid and automatic ([Evans 2003](#); [Stanovich and West 2000](#); [Toates 2006](#)).

The emergence of an association between the extraversion/introversion level and the outcome measures in the valid condition is indeed quite noteworthy. In general, this finding is consistent with Eysenck's theory of Introversion–Extroversion (I–E) ([1967](#)), according to which, introverts demonstrate higher levels of basal activity within the reticular-thalamic-cortical loop, yielding higher tonic cortical arousal than extraverts, who are described conversely as chronically under-aroused and easily bored. In this sense, studies focusing on the link between personality features and academic performance reported that introverts appear to have an advantage over extraverts in terms of being more focused, more systematic in their study habits, and better able to consolidate their learning ([Chamorro-Premuzic and Furnham 2003a,b](#); [Petrides et al. 2005](#)).

Interesting also is the finding that the sexual desire levels exhibit quite similar effects on the outcome measures in the valid condition. Subjects with high sexual desire appear to be more prone to make incorrect judgments in the valid syllogisms, while, at the same time, they are more confident in their responses. Of course, one could argue that a single item out of a total 20-item questionnaire may become significant by chance. However, as analysis has shown, the item referring to sexual desire stands as the odd-man-out from the rest of the items of the Zung questionnaire, while at the same time it correlates well with Eysenck's extraversion/introversion scale. Moreover, it should not be forgotten that the sample comprised healthy individuals, which was corroborated by their low total scores in the Zung questionnaire.

In addition further analysis has shown that the effects of extraversion/introversion and sexual desire on the outcome measures of the valid condition are not commutative but additive. This observation might be better understood considering the Eysenck's notions on this issue. Based on the arousal theory, Eysenck (1990) provides a biological explanation concerning the differences of certain characteristics between introverts and extraverts. According to the theory, introverts have higher levels of cortical arousal, show conditioning superiority under specifiable circumstances and extinguish slower than extroverts (Eysenck 1967). Hence, it follows that the introvert is viewed as having been conditioned so effectively during the upbringing process that he grows up socially and sexually inhibited and anxious. The extrovert, conversely, grows up socially and sexually uninhibited due to his poorer social conditioning (Eysenck 1971). In other words, quantitative differences between extraverts and introverts are related to different level of arousal and conditioning between these two personality directions. In this sense, contrary to what intuition or common sense would indicate, the putative effect this has on behaviour is such that the introverts seek lower levels of stimulation. Conversely, the extraverts seek to heighten their arousal to a more favourable level (as predicted by the Yerkes–Dodson Law) by increased activity, social engagement and other stimulation-seeking behaviours.

Several limitations should be kept in mind when interpreting these results. Replication with a larger sample will be necessary to examine whether the present findings are stable and whether other aspects of personality may interact with the reasoning performance. The dimensions examined in this study are not exhaustive of the entire personality domain. There exist many other personality-related variables (e.g. aspirations, interests, motivation) that may also influence reasoning performance, perhaps incrementally over the Eysenckian dimensions. Similarly a single item of the Zung inventory may not be satisfactory to reveal all possible associations between sexuality and reasoning. However, in spite of these limitations, the findings of this study indicate that personality structure should be taken into consideration in prospective studies investigating reasoning performance.

## Conclusion

The present study supports the potential importance of introversion-extraversion and sexual desire variations in the reasoning performance. Future studies are necessary to investigate whether the present effects can be replicated and whether other aspects of personality and/or variations of sexuality may interact with the reasoning performance.

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## References

- Aristotle. (1984). *Prior Analytics*. In J. Barnes (Ed.), *The complete works of Aristotle*. The revised Oxford translation (Vol. 1, pp. 39–113). NJ: Princeton University Press.
- Aristotle. (1984). *Posterior Analytics*. In J. Barnes (Ed.), *The complete works of Aristotle*. The revised Oxford translation. (Vol. 1, pp. 114–166). NJ: Princeton University Press.
- Aristotle. (1984). *Rhetoric*. In J. Barnes (Ed.), *The complete works of Aristotle*. The revised Oxford Translation. (Vol. 1, pp. 2155–2156). NJ: Princeton University Press.
- Carroll, J. B. (1983). Studying individual differences in cognitive abilities: Through and beyond factor analysis. In R. F. Dillon & R. R. Schmeck (Eds.), *Individual differences in cognition* (Vol. 1, pp. 1–33). London: Academic Press.
- Chamorro-Premuzic, T., & Furnham, A. (2003b). Personality predicts academic performance: Evidence from two longitudinal university samples. *Journal of Research in Personality*, *37*, 319–338.
- Chamorro-Premuzic, T., & Furnham, A. (2003b). Personality traits and academic exam performance. *European Journal of Personality*, *17*, 237–250.
- Corcoran, R., Cummins, S., Rowse, G., Moore, R., Blackwood, N., Howard, R., Kinderman, P., & Bentall, R. P. (2006). Reasoning under uncertainty: Heuristic judgments in patients with persecutory delusions or depression. *Psychological Medicine*, *36*(8), 1109–1118.
- De Neys, W. (2006). Dual processing in reasoning: Two systems but one reasoner. *Psychological Science*, *17*, 428–433.
- De Neys, W., Moyens, E., & Vansteenw, D. (2010). Feeling we're biased: Autonomic arousal and reasoning conflict. *Cognitive, Affective, & Behavioral Neuroscience*, *10*(2), 208–216.
- Dimitriou, E. (1986). The personality questionnaire (EPQ). (Eysenck personality questionnaire): Standardization for the Greek population, adults and children. *Encephalos*, *23*, 41–54 (Gr).
- Evans, B. T. (2003). In two minds: Dual-process accounts of reasoning. *Trends in Cognitive Sciences*, *7*, 454–459.
- Evans, J. S., Handley, S. J., & Harper, C. N. (2001). Necessity, possibility and belief: A study of syllogistic reasoning. *Quarterly Journal of Experimental Psychology A*, *54*(3), 935–958.
- Evans, J. S. B. T., Barston, J., & Pollard, P. (1983). On the conflict between logic and belief in syllogistic reasoning. *Memory and Cognition*, *11*, 295–306.
- Eysenck, H. J. (1967). *The biological basis of personality*. Springfield: Thomas.
- Eysenck, H. J. (1971). Personality and sexual behavior. *British Journal of Psychiatry*, *118*, 593–608.
- Eysenck, H. J. (1990). Biological dimensions of personality. In L. A. Pervin (Ed.), *Handbook of personality: Theory and research* (pp. 244–276). New York: Guilford.
- Eysenck, H. J., & Eysenck, S. B. G. (1975). *Manual of the Eysenck personality questionnaire*. London: Hodder and Stoughton.
- Fountoulakis, K. N., Iacovides, A., Samolis, S., Kleantous, S., Kaprinis, S. G., Kaprinis, G., & Bech, P. (2001). Reliability, validity and psychometric properties of the Greek translation of the Zung depression rating scale. *BMC Psychiatry*, *1*, 6.
- Goel, V., & Dolan, R. J. (2003). Explaining modulation of reasoning by belief. *Cognition*, *87*, B11–B22.
- Goel, V., Byrnel, R. M. J., Johnson-Laird, P. N., Sommer, M., Döhnel, K., Sodian, B., Meinhardt, J., Thoermer, C., & Hajaka, G. (2007). Neural correlates of true and false belief reasoning. *NeuroImage*, *35*, 1378–1384.
- Miller, J. D., Gaughan, E. T., Pryor, L. R., & Kamen, C. (2009). Consequences of depressive affect on functioning in relation to cluster B personality disorder features. *Journal of Abnormal Psychology*, *118*(2), 424–429.
- Petrides, K. V., Chamorro-Premuzic, T., Frederickson, N., & Furnham, A. (2005). Explaining individual differences in scholastic behaviour and achievement. *British Journal of Educational Psychology*, *75*, 239–255.
- Sloman, S. A. (1996). The empirical case for two systems of reasoning. *Psychological Bulletin*, *119*, 3–22.
- Stanovich, K. E., & West, R. F. (2000). Individual differences in reasoning: implications for the rationality debate. *Behavioral and Brain Sciences*, *23*, 645–665.
- Toates, F. (2006). A model of the hierarchy, cognition, and consciousness. *Consciousness and Cognition*, *15*, 75–118.
- Zung, W. (1965). A self-rating depression scale. *Archives of General Psychiatry*, *12*, 63–70.