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Psychometric properties of an aptitude test administered to Sri Lankan first-year medical students

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Abstract

Introduction: Selection for basic medical training is highly contextual. The use of cognitive aptitude tests, which commonly supplement measures of prior academic achievement in the selection process of medical schools internationally, is rarely reported from resource-constrained settings in South Asia. We report on the psychometric properties of an aptitude test designed based on the UCAT format, administered to first-year medical undergraduates to determine its utility.

Methods: The aptitude test was administered online to first-year medical students shortly after their admission to two medical faculties in Sri Lanka (n=328). The reliability of the test was determined using Cronbach's alpha. Overall and subtest scores were computed, and the scores of different demographic groups were compared using the t-test. Factor analysis of the subtests was performed.

Results: The internal consistency of the test was 0.63. The difficulty and discrimination indices were within the acceptable range. The mean score of the aptitude test (AT) was 70.9/100 (SD 8.88). The mean score for females was higher than for males (p=0.04). No statistically significant differences in AT scores were observed between different ethnicities or religions. The entry academic scores demonstrated a weak correlation with the overall AT score (Pearson's correlation coefficient r=0.27), verbal reasoning (r=0.24), the human body (r=0.19), quantitative reasoning (r=0.18), and situational judgement (r=0.128). Factor analysis indicated items that need revision.

Conclusion: The results indicate the potential value of aptitude tests in Sri Lanka and in similar jurisdictions where selection criteria have yet to expand beyond prior academic performance. A way forward in introducing such tests has been outlined.

Keywords: *Medical Student Selection, Medical Student Admission, Selection Criteria*

Practice Highlights

- Aptitude tests assess cognitive and non-cognitive attributes desirable for healthcare professionals.
- The use of aptitude tests is rarely reported from resource constrained settings in South Asia.
- Sri Lanka uses only the national high school examination performance for medical school admission.
- This study indicates the potential value of aptitude tests in Sri Lanka and in similar jurisdictions.

I. INTRODUCTION

Selection for basic medical training is highly contextual and influenced by educational, geographical, socioeconomic, and political factors (Dharmaratne & Ponnamperuma, 2020; Patterson et al., 2018). High academic achievement has long been considered an appropriate criterion for ranking candidates for medical school (McManus et al., 2013; Patterson et al., 2017). However, this approach has been contested due to the low predictive validity of pre-university performance for

medical school success (McManus et al., 2013; Prideaux et al., 2011).

Aptitude tests have emerged to assess cognitive and non-cognitive traits desirable for medical and healthcare professions (Gliatto et al., 2016; Greatrix & Dowell, 2020; Powis et al., 2021). Despite evidence on their potential to improve selection processes (Bala et al., 2022; Greatrix et al., 2021), most resource-constrained jurisdictions, including Sri Lanka, rely solely on prior academic achievement (Soemantri et al., 2020; University Grants Commission, 2023). This study represents an initial step in Sri Lanka toward introducing aptitude tests and reports on the psychometric properties of a test developed to measure cognitive attributes.

The Sri Lankan medical school admission system uses national high school examination results (G.C.E. AL) as the only criterion for admission (Dharmaratne & Ponnamperuma, 2020; University Grants Commission, 2023). The results of three AL subjects (Chemistry, Physics, and Biology) are considered, and an average Z score is used to rank individuals (University Grants Commission, 2023). A minimum of two credit passes and one simple pass is required for eligibility. A few candidates with foreign examination results equivalent to the G.C.E. AL Examination and meeting equitable minimum requirements are also admitted (University Grants Commission, 2023).

G.C.E. AL examination results have shown a mild correlation with subsequent undergraduate performance, with a maximum predictive correlation coefficient of 0.37 (de Silva et al., 2004, 2006; Hewage et al., 2011; Mettananda et al., 2006). These low figures may underestimate the true relationship, as range restriction among high-achieving candidates can affect the statistical accuracy of predictive validity measures (Zimmermann et al., 2017). Studies in the UK, addressing range restriction, found that prior academic performance is the best predictor of subsequent performance, accounting for 65% of the variance in undergraduate performance (McManus et al., 2013). However, this leaves 35% of the variance unexplained.

Aptitude tests are used worldwide to support medical student selection. The United Kingdom Clinical Aptitude Test (UKCAT), now named UCAT, has been used for nearly two decades (Greatrix & Dowell, 2020). The UCAT consists of 200 items in five subtests delivered over two hours (Paton et al., 2022). Results of the UKCAT and UCAT have been used to discriminate between high-achieving students during selection and predict undergraduate and postgraduate performance (Bala et al., 2022; MacKenzie et al., 2016; McManus et al., 2013; Paton et al., 2022).

However, there are additional qualities beyond academic readiness (prior academic performance and cognitive traits) that are necessary qualities of medical professionals that include desirable behaviours and attitudes that could indicate successful development as healthcare practitioners in the future (Patterson et al., 2018). The Ottawa consensus statement recommends that best practice selection should involve the use of selection criteria based on multi-source multi-method job analysis studies (Patterson et al., 2018). This necessitates the use of other selection processes such as structured interviews or multiple mini interviews (MMI).

This study aims to evaluate the psychometric properties of an aptitude test based on the UCAT format, administered to first-year medical undergraduates at two medical faculties in Sri Lanka. Specifically, the objectives are to evaluate the psychometric properties of the test, determine the relationship between Z scores at the AL examination and aptitude test scores, and compare the performance of different demographic groups in the aptitude test.

II. METHODS

A cross-sectional observational study was conducted in the faculties of medicine at the universities of Kelaniya and Jaffna, Sri Lanka. Including these two faculties allowed for the recruitment of an adequate number of students from the three main ethnic groups (Sinhala, Tamil, and Sri Lankan Moors) and a wider range of Z scores. All first-year students in 2023 from these faculties were invited to participate. Students admitted through selection criteria other than Sri Lankan advanced level performance were excluded. We obtained a sample size of 328 students who consented to participated in the study (response rate of 80.8%).

The aptitude test comprised 50 items across six subtests: abstract reasoning (8 items), the human body (8 items), quantitative reasoning (8 items), decision-making (8 items), verbal reasoning (8 items), and situational judgment (10 items). Except for the "the human body" subtest, all others were modelled after the UKCAT examination. The "human body" subtest was designed to assess advanced-level knowledge of human biology from the Sri Lankan school curriculum. Test items were selected by a panel of experts in psychology and medical education from the Faculty of Medicine, University of Kelaniya with the help of disability studies experts who use a similar test for selection to their course. These experts, being native Sri Lankans, ensured the items were

culturally relevant and conceptually and semantically equivalent (Hambleton & Zenisky, 2010). Similar methods were used to finalise the Sinhala and Tamil versions of the test, translated by competent translators. Appendix 1 shows sample test items from each subtest. The test was piloted on 15 students and identified issues were corrected.

The test was administered via the online learning management system (LMS) of the respective faculties under examination conditions, with invigilators ensuring adherence to university examination protocols. Students had one hour to complete the test, available in English, Sinhala, and Tamil. Participants could choose the language they were most comfortable with to simulate AL examination conditions and to minimise interpretation errors.

Descriptive statistics and internal consistency (Cronbach's alpha) were calculated for the test and each subtest and item analysis (Paniagua & Swygert, 2016) was performed. Correlations between the aptitude test score, subtest scores, and Z scores were calculated using Pearson's correlation coefficient, and relationships to other demographic factors were analysed using Student's t-test. Factor analysis was performed using R statistical package.

Written informed consent was obtained from the students before the test administration. Ethics approval was granted by the ethics review committee of the Faculty of Medicine, University of Kelaniya, and permission for the study was obtained from the deans of the respective medical faculties.

III. RESULTS

328 students participated in the study, yielding an overall response rate of 80.8%. The descriptive statistics of these students are presented in Table 1. The male-to-female ratio of the sample (31.7% to 68.3%) closely mirrors the demographics of the national cohort of medical undergraduates from the previous academic year (34% to 66%), as reported by the University Grants Commission, Sri Lanka (University Grants Commission, 2022).

Total group n=328	**n**	**(%)**
Gender		
Male	104	(31.7)
Female	224	(68.3)
Ethnicity		
Sinhala	161	(49.1)
Tamil	123	(37.5)
Moor	43	(13.1)
Other	1	(0.3)
Religion		
Buddhism	143	(43.6)
Hinduism	108	(32.9)
Islam	43	(13.1)
Christianity	34	(10.4)
University		
Jaffna (response rate)	186	(90.7)
Kelaniya (response rate)	142	(70.6)

Table 1. Descriptive statistics of the demographic variables of the sample

The overall mean aptitude test (AT) score was 70.9 (SD 8.88), with a median of 72. Female students had a higher mean AT score than male students (p=0.044, Table 2), while there was no statistically significant difference in the Z scores between genders (p=0.122). No significant differences in mean AT scores were found between ethnicities and religions. The Faculty of Medicine, University of Kelaniya, had a higher mean AT score (73.7, SD 8.7) than the Faculty of Medicine, Jaffna (68.8, SD 8.4, p=0.000). Similarly, the mean Z score at Faculty of Medicine, University of Kelaniya (2.10, SD 0.07) was higher than at Jaffna (1.89, SD 0.13, p=0.000).

	AT score		**Z score**	
	Female	Male	Female	Male
Mean	71.6	69.4	1.99	1.96
Median	72.0	72.0	2.06	1.99
Standard Deviation	8.4	9.7	0.15	0.16

Table 2. Comparison of means of AT scores and Z scores between males and females

The internal consistency of the test was 0.628 and the subscales ranged between 0.2 to 0.47 (Table 3).

	Mean	SD	Cronbach's alpha
Abstract Reasoning	13.4	2.32	0.339
The Human Body	14.6	1.72	0.248
Quantitative Reasoning	13.5	2.31	0.411
Decision Making	10.3	2.61	0.197
Verbal Reasoning	10.2	3.17	0.433
Situational Judgment	8.8	3.93	0.473

Table 3. Data regarding the subtests of the aptitude test

Difficulty and discrimination indices for each test item were calculated (Table 4). The difficulty index represents the proportion of students who answered each item correctly (Paniagua & Swygert, 2016). The mean difficulty index was 70.9% (SD 23.5), ranging from 19.2% to 99.4%. The discrimination index was calculated as the difference between the proportion of students who answered an item correctly in the top group (those who obtained the top 27% in the overall score) and bottom group (bottom 27% scorers) and measures an item's ability to differentiate between students who performed best and those who performed worst on the test (Paniagua & Swygert, 2016). The mean discrimination index was 19% (SD 12) and ranged from 0 to 50%. There was only one item with the lowest discrimination index of 0. It had a difficulty index of 99.4% indicating that most students had scored it correctly. Items that adversely affected the reliability of the subtests were identified (Appendix 2).

Difficulty Index	Proportion of questions (%)
0 - ≤ 30	8
30 - ≤ 70	32
> 70	60

Table 4. Distribution of the difficulty indices of the aptitude test questions

The correlation analysis revealed several key findings regarding the relationship between Z and AT scores. The correlation coefficient between Z score and AT score was 0.268 (p=0.000), indicating a weak correlation. The coefficient of determination (r^2) was calculated to be 0.072, suggesting that only 7.2% of the variability in AT scores could be explained by Z scores. This signifies a limited association between Z scores and overall AT performance. Further analysis was conducted on the correlation between Z scores and subtest scores. There was a weak but statistically significant correlation between Z scores and the subtests of verbal reasoning (r=0.24, p=0.000), human body (r=0.19, p=0.001), quantitative reasoning (r=0.18, p=0.001), and situational judgment (r=0.128, p=0.021). However, the correlations between Z scores and the subtests of abstract reasoning and decision-making were not statistically significant.

Factor analysis was performed using the most prominent two factors of each of the six subtests separately as they each measure well defined and different cognitive domains. The factor loading of abstract reasoning subtest is shown in figure 1. "Question 3" shows a strong positive loading on Factor 1, suggesting that this item heavily measures the trait most represented by this factor whilst "Question 5" shows a slight negative loading on Factor 1, indicating it measures a trait that is perhaps inversely related to what is captured by this factor. "Question 1" and "Question 2" are both located positively on Factor 2 but with minimal loading on Factor 1. This suggests that they are measuring traits more aligned with Factor 2. The items "Question 1", "Question 2" and "Question 3", appear to be critical for measuring distinct aspects of abstract reasoning as shown by their stronger loadings. "Question 5" shows a strong negative loading on Factor 2, suggesting that it measures a trait that contrasts with what Factor 2 represents. "Question 4", " Question 6", "Question 7", and "Question 8" are clustered around the origin. This indicates that these items have weaker loadings on both factors, meaning they may not strongly measure the traits represented by either factor, or they could be measuring a balanced mix of both traits. While these questions contribute to the test, they might need to be reviewed to enhance their discriminative power or clarity in measuring specific abstract reasoning skills.

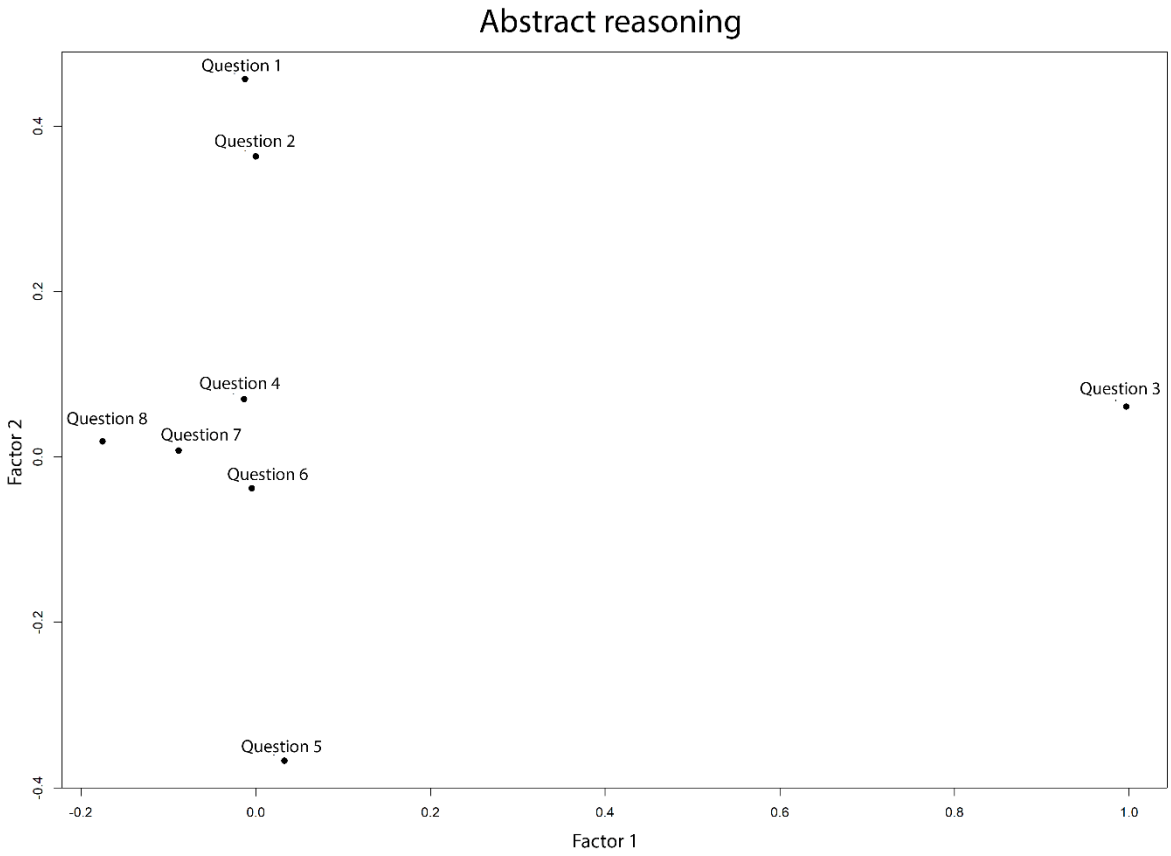

Figure 1. Two factor loading of the abstract reasoning subtest

The factor loadings of the other five subtests are shown in Appendix 3. Regarding the human body subtest, Factor 1 might represent knowledge or understanding of structural aspects of the human body, given the strong loading by "Question 11" and reasonable loading by other items. This factor could reflect knowledge regarding human biology whilst Factor 2 seems to capture a different dimension, suggested by the negative loading of "Question 15". In quantitative reasoning, most questions are clustered near the centre with a slight spread along Factor 1, indicating moderate influence by this factor across the items. "Question 19" and "Question 22" are slightly farther along Factor 1 suggesting a stronger influence by the trait measured by this factor. Regarding the subtests of decision making, verbal reasoning and situational judgment, Factor 1 and Factor 2 seemed to be capturing different dimension of these subtests thereby suggesting the need for revision of their items.

IV. DISCUSSION

This study aimed to design an aptitude test and investigate its psychometric properties among first-year medical students from two selected faculties of Medicine in Sri Lanka. The results indicate that overall internal reliability of the aptitude test was marginal (Cohen et al., 2018). However, the reliability of the UKCAT has been 0.86 or above overall and between 0.58 – 0.86 for the subtests (MacKenzie et al., 2016). These findings demonstrate the value of evaluating and reviewing aptitude tests locally. Further, reviewing test items that adversely affected the internal consistency of the subtests for clarity and improved alignment with the construct, could improve the overall validity. It is likely that the low number of test items has further contributed to the low-reliability score (Taber, 2018). The UKCAT consists of 200 test items, as opposed to the 50 items in the aptitude test employed by the current study. The item analysis indicated that most of the questions were easy, with 60% having a difficulty index of more than 70%. The discriminating capacity of the items was low (mean discrimination index was 19%). This could be attributed to the aptitude test being administered to students who have performed well in the advanced level examination and already have been selected to medical school.

There was a weak correlation between the aptitude test score and the Z score (0.27), indicating that the test assessed a significantly different aspect of cognitive skills compared to traditional AL examinations. This observation encourages exploring how the aptitude test may be incorporated into the selection process. Different selection authorities use aptitude scores differently (Greatrix & Dowell, 2020). Overall, among the universities which employ UKCAT, the weightage given for school leaver level academic performance in the selection process has increased, while the use of aptitude

test scores as an absolute or relative cutoff to be achieved also has increased over the period of 2008-2015 (Greatrix & Dowell, 2020). However, empirical evidence on a best way of using UKCAT or UCAT in the selection process is not available (Greatrix & Dowell, 2020). Therefore, implementing a valid aptitude test as a supplementary test and exploring predictive validities of such a test across a national sample is likely to provide more robust evidence of the utility of aptitude tests in the Sri Lankan context.

This study used an aptitude test developed and deployed systematically and modelled on a widely tested international aptitude test format for medical school selection. The sample was representative of demographics of the national cohort of medical students and included all three major ethnic groups and students with a wide range of Z scores. However, the limited number of test items may have offset these strengths. The authors did not have access to participants' raw scores at the advanced level examination, which may have provided a more appropriate measure of performance for statistical manipulation. In addition, the aptitude test was administered to students who have already been selected to medical school, whereas ideally, it should have been administered to medical school applicants. Despite the limitations, the aptitude test returned an acceptable internal reliability score, and further analysis demonstrated a way forward.

V. CONCLUSION

This study was the first time in the literature that an aptitude test was evaluated in medical education settings in the Sri Lankan context. Using an aptitude test to select students for medical school in Sri Lanka and similar settings, where admission processes have not diversified, is potentially valuable. However, further studies are necessary to establish evidence to support the adoption of such a test in the Sri Lankan and other similar resource-constrained contexts where prior educational achievement primarily informs selection decisions. In the Sri Lankan context, further evaluating the psychometric properties and the predictive validity of an improved aptitude test using a national cohort is recommended as the way forward.

Notes on Contributors

Dr. Sivapalan Sanchayan contributed to the development of the aptitude test, administering the test, collection of data, analysis and writing of the manuscript.

Dr. Sisira Dharmaratne contributed to the conceptualisation, study design, development of the aptitude test, data analysis and writing of the manuscript.

Ms. Shalika Pathirana took part in developing and administering the test, data collection and reviewing the manuscript.

Dr. Pavithra Godamunne contributed to the conceptualisation, study design, development of the aptitude test, data collection, analysis and revision of the manuscript.

Prof. Madawa Chandratilake took part in the conceptualisation, study design, data analysis and revision of the manuscript

Ethical Approval

Ethical clearance (P/223/12/2018) was obtained from the Faculty of Medicine, University of Kelaniya, Sri Lanka.

Data Availability

The datasets generated and/or analysed during the current study are not publicly available to preserve the confidentiality of the participants in this study but are available from the corresponding author on reasonable request.

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Declaration of Interest

The authors have no conflicts of interest to disclose.

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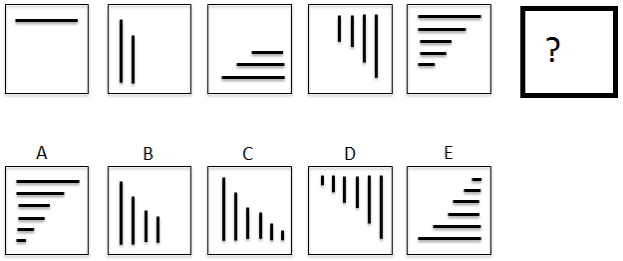
Appendix 1. Example questions from each subtest of the aptitude test

Part A: Abstract reasoning

Chose the appropriate option from A, B, C, D, E to complete the sequences



Part B. The human body

What is an important vitamin for the growth of the bones?

A. Vitamin B
B. Vitamin C
C. Vitamin D
D. Vitamin K
E. Vitamin E

Part C: Quantitative Reasoning

A certain recipe requires **three half cups** (1 ½) of sugar to make 30 cookies. Quantity A is the amount of sugar required for the same recipe, to make 40 cookies. Quantity B is 2 cups of sugar.
Which of the following statements is correct?

A. Quantity A is greater.
B. Quantity B is greater.
C. Quantity A is equal to Quantity B.
D. All above statements are wrong
E. The relationship cannot be determined from the information given.

Part D: Decision Making

A father needs to choose a school for his daughter who has got a scholarship. There are five schools for him to choose from. Let us assume the names of those schools are L, M, N, O & P. The schools L & N are mixed schools with graduate teachers. The schools N & O have between 1500 and 2000 students each and schools M & O maintain traditional values. The schools M & P have between 1000 and 1500 students each.
Which school maintains traditional values and has 1200 students?

A. L
B. M
C. N
D. O
E. P

Part E: Verbal reasoning

Sodium chloride, or salt, is essential for human life. Typically derived from the evaporation of sea water or the mining of rock salt deposits, salt has been used by humans for thousands of years as a food seasoning and preservative. The mineral sodium is an electrolyte. Electrolytes also help balance the body's fluid levels. A diet deficient in salt can cause muscle cramps, neurological problems and even death. Conversely, a diet high in salt leads to an increased risk of conditions such as hypertension, heart disease and stroke. Salt consumption has increased by 50% recently, with the average adult taking in more than double the amount of salt their body requires. For individuals wishing to reduce their sodium intake, the answer is not simply putting less salt on their food; 75% of the average person's salt consumption comes from food, such as bread, cereals, and cheese.
Which of the following is caused by a dietary deficiency in salt?

A. Muscle cramps
B. Obesity
C. Heart disease
D. Hypertension
E. Stroke

Part F: Situational Judgment

How should you respond to the situations given in the scenarios below?
Use the following key to rank the effectiveness of the responses given below.

A- Most effective
B- Effective
C- Somewhat effective
D- Ineffective
E- Most ineffective

You receive a poorer grade than you expected for an assignment. You worked very hard on this assignment and put in a great deal of effort. You feel that this grade does not accurately reflect your performance and effort.

41. Complain to your classmates and ask whether any others have been marked unfairly.
42. Ask the lecturer why you received such a poor grade and how s/he marked the assignment.
43. Explain to the lecturer how hard you worked for this assignment and ask him/ her to consider raising your grade.
44. Ask the lecturer for feedback on why you earned a low grade and how you can improve your performance in the future.
45. Write a letter of complaint regarding the lecturer's unfair grading to the relevant Head of the Department.

Appendix 2. Items adversely affecting the reliability of the subtests

Sub scale	Items adversely affecting the reliability of the subtests
Abstract Reasoning	4, 8
The human body	14, 15
Quantitative Reasoning	18
Decision Making	28, 30, 31
Verbal reasoning	37, 39
Situational Judgment	43, 46

Appendix 3. Two factor loading of the subtests of the human body, quantitative reasoning, decision making, verbal reasoning and situational judgement subtests

Note: Each point on the graphs below are labelled as "Response n" and represent the respective item (question) in the aptitude test.