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“It’s not rocket science” and “It’s not brain surgery”—“It’s a walk in the park”: prospective comparative study

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ABSTRACT OBJECTIVE

To compare cognitive testing scores in neurosurgeons and aerospace engineers to help settle the age old argument of which phrase—“It’s not brain surgery” or “It’s not rocket science”—is most deserved.

DESIGN

International prospective comparative study.

SETTING

United Kingdom, Europe, the United States, and Canada.

PARTICIPANTS

748 people (600 aerospace engineers and 148 neurosurgeons). After data cleaning, 401 complete datasets were included in the final analysis (329 aerospace engineers and 72 neurosurgeons).

MAIN OUTCOME MEASURES

Validated online test (Cognitron’s Great British Intelligence Test) measuring distinct aspects of cognition, spanning planning and reasoning, working memory, attention, and emotion processing abilities.

RESULTS

The neurosurgeons showed significantly higher scores than the aerospace engineers in semantic problem solving (difference 0.33, 95% confidence interval 0.13 to 0.52). Aerospace engineers showed significantly higher scores in mental manipulation and attention (−0.29, −0.48 to −0.09). No difference was found between groups in domain scores for memory (−0.18, −0.40 to 0.03), spatial problem solving (−0.19, −0.39 to 0.01), problem solving speed (0.03, −0.20 to 0.25), and memory recall speed (0.12, −0.10 to 0.35). When each group’s scores for the six domains were compared with

those in the general population, only two differences were significant: the neurosurgeons’ problem solving speed was quicker (mean z score 0.24, 95% confidence interval 0.07 to 0.41) and their memory recall speed was slower (−0.19, −0.34 to −0.04).

CONCLUSIONS

In situations that do not require rapid problem solving, it might be more correct to use the phrase “It’s not brain surgery.” It is possible that both neurosurgeons and aerospace engineers are unnecessarily placed on a pedestal and that “It’s a walk in the park” or another phrase unrelated to careers might be more appropriate. Other specialties might deserve to be on that pedestal, and future work should aim to determine the most deserving profession.

Introduction

“It’s not rocket science” and “It’s not brain surgery” are common phrases that describe concepts or tasks that are easily understood or performed. Other phrases such as “It’s a piece of cake” or “It’s a walk in the park” have similar meanings, but the two related to the aerospace industry and neurosurgery are unique in their association with professions.^{1–3} The phrase “It’s not rocket science” is thought to have originated in America in the 1950s when German rocket scientists were brought over to support the developing space programme and design of military rockets—both endeavours that were considered intellectually challenging.² By the 1970s “It’s not rocket science” had become embedded in American culture, when it started to appear in newspaper articles.² The origin of “It’s not brain surgery” is less clear. It is tempting to speculate that the pioneering techniques of the polymath and neurosurgeon Harvey Cushing captured the attention of the public and promulgated the phrase.⁴

The interchangeable use of “It’s not rocket science” and “It’s not brain surgery” and their association with professions renders comparison inevitable. In a sketch by UK comedians David Mitchell and Robert Webb,⁵ a boastful neurosurgeon is put in his place by a rocket scientist who says “Brain surgery . . . it’s not exactly rocket science is it?” Although some public debate has occurred as to which pursuit is more difficult,^{6,7} it seems that the two phrases have not been subjected to rigorous scientific scrutiny.

The main purpose of our study was to settle this debate once and for all and to provide rocket scientists and brain surgeons with evidence to support their self-assuredness in the company of the other party. We tested participants across several cognitive domains, including emotional discrimination and motor control. Instead of seeking an outright winner, we assessed

WHAT IS ALREADY KNOWN ON THIS TOPIC

The phrases “It’s not rocket science” and “It’s not brain surgery” are commonly and interchangeably used for tasks or concepts that are easy

Using such phrases suggests that both specialties are put on a pedestal of being difficult or requiring exceptional cognitive abilities

Whether they are appropriate phrases and, if so, which of the two is more suitable have not been subject to scientific scrutiny

WHAT THIS STUDY ADDS

Aerospace engineers and neurosurgeons showed no difference in four of six validated cognitive domains; neurosurgeons showed better semantic problem solving abilities, whereas aerospace engineers showed better mental manipulation and attention abilities

Most of the domain scores for both groups were within the range of those in the general population

Both specialties might therefore be unnecessarily placed on a pedestal, and other phrases such as “It’s a walk in the park” might be more appropriate

the cognitive characteristics of each specialty using a validated online test, the Great British Intelligence Test (GBIT) from the Cognitron platform. This test had been used to measure distinct aspects of human cognition, spanning planning and reasoning, working memory, attention, and emotion processing abilities in more than 250 000 members of the British public as part of the GBIT project in association with BBC Two's *Horizon* programme.⁸ The battery of tests should not be considered an IQ test in the classic sense, but instead is intended to differentiate the aspects of cognitive ability more finely. The large existing dataset also enabled us to benchmark both professions against the general population.⁹

The secondary aim of our study was to question whether public perceptions of rocket science and brain surgery are borne out in reality. Falling under the umbrella of science, technology, engineering, and mathematics (STEM) industries, neurosurgery and aerospace engineering face difficulties in maintaining their workforce and are predicted to be understaffed in coming decades.^{10 11} Considerable evidence suggests that school aged children's desire to pursue a career is influenced by their perceptions of particular professions, in turn impacting on the diversity of the workforce and the trajectory of specialties.^{12 13} School aged children perceive STEM to be "masculine" and "clever." This perception is heavily influenced by gender, class, and race, and deters females, people from lower socioeconomic groups, and people of non-white ethnicity from pursuing STEM careers.¹⁴ Perceptions and the stereotypes underlying them are derived from various sources, but school experiences and mass media are important.¹³ Questioning these stereotypes could have implications for public outreach and future recruitment.

Methods

We performed an international prospective comparative study, with participants recruited through the internet. Anyone who self-identified as an aerospace engineer or a neurosurgeon in the United Kingdom, Europe, the United States, and Canada was eligible to participate.

The roles were defined as any individual who had completed a degree relating to the relevant specialty. As specialisation occurs at the postgraduate stage, we excluded individuals who were studying for their primary degree (undergraduate science or primary medical degree).

This study was publicised via email and LinkedIn through our collaborators. The Society of British Neurological Surgeons and the Canadian Neurological Sciences Federation cascaded the invitation email to respective members. The UK Space Agency advertised the study on LinkedIn and through their partner organisations. The Royal Astronomical Society advertised the study in their June members' bulletin. The European Space Agency advertised the study via its mailing list. To ensure responses were genuine, access to the study website was restricted to listed members of these groups and the study was not publicised on social media platforms.

Data collection

Data collection took place from 2 June to 23 July 2021. The study comprised a sequence of 12 tasks from a library available on the Cognitron server (www.cognitron.co.uk). The test took about 30 minutes to complete.

The tasks were selected on the basis of previous data, which showed they can be used to measure distinct aspects of human cognition, spanning planning and reasoning, working memory, attention, and emotion processing abilities. Previous work has shown that the battery of tasks is robust to the type of device that a person uses to complete the test; sensitive to population variables of interest such as age, gender, and education level; and not so strongly correlated as to measure just one overarching ability. As a result, the raw scores on each task are not of interest; instead, the meaningful findings are obtained by comparing standardised scores between individuals or groups to showcase differences in the measures.

Before doing the test, participants completed a questionnaire comprising six questions related to specialist area, gender, age, geographical location, handedness, and level of experience (years in specialty).

Task designs and data preprocessing

The 12 tasks were prospective word memory, digit span, spatial span, block rearrange test (two dimensional spatial problem solving), four towers test (three dimensional spatial problem solving), the Tower of London test (spatial planning), two dimensional manipulation, target detection, verbal analogies, rare word definitions, emotional discrimination, and delayed recall of words (see supplementary figure 1). Each task was scored, and, except for the rare word definitions task, was based on reaction time (ie, speed of response).

Data were preprocessed in a similar fashion to previous studies using the Cognitron platform.⁹ Briefly, only those datasets in which all tasks had been completed were included for analysis. In addition, we excluded participants who we considered had lost task focus—that is, the window had been inactive (in the background) for more than two seconds. We also performed a manual check for inconsistencies in questionnaire responses and excluded these datasets. Scores for each task >8 standard deviations from the mean were winsorised to reduce the effect of spurious outliers.

Statistical analysis

Confounding variables (age, handedness, and gender) were regressed out of the raw task scores and reaction times using generalised linear modelling, leaving adjusted scores. Through factor analysis, the eigenvalues of the correlations between adjusted task scores and reaction times were used to split the scores into several domains, with each task contributing weights to the domain. Two factor analyses were conducted, one for the task scores (12 tasks) and one for the reaction times (11 tasks). The number of domains for each factor analysis was based on the Kaiser criteria

(eigenvalue >1). Using generalised linear modelling we then compared the domain scores between groups.

The comparator group comprised members of the UK general population who had completed the same set of tasks. This is a subset of the more than 250 000 participants who completed the GBIT but incorporates all eligible participants who had completed the battery of tests undertaken by the aerospace engineers and neurosurgeons. Only 18 257 were eligible because the initial battery of GBIT went through iterative amendments before settling on this final battery. The GBIT cohort was recruited through diverse sources, including the BBC Two's *Horizon* programme, the BBC, and BBC News home pages and news meta-apps. Members of the cohort were predominantly white (226 257/269 264; 84.0%), had completed secondary school (84 860/269 264; 31.5%), and had a university degree (154 656/269 264; 51.4%). The task weightings derived from this study were applied to create domain scores for the general population. Z scores for each participant were then generated using the mean and standard deviation of domain scores from the general population. To assess if the z scores from each group were different from those of the general population, we used two tailed one sample *t* tests.

All data processing, analysis, and visualisation were conducted on Matlab v2020b (Mathworks). P values <0.05 were considered significant.

Patient and public involvement

Although patients and the public were not involved in the conception, design, or execution of the study, the study was conceived as part of the research arm of Brainbook, a UK charity dedicated to science communication and public engagement in neurosurgery and the neurosciences. Members of the researchers' families reviewed the manuscript before submission.

Results

A total of 748 participants took part in the study: 600 aerospace engineers (80.2%) and 148 neurosurgeons (19.8%). As the mailing lists were under the control of their parent organisations and the size of these were not determined, it was not possible to calculate a response rate; only a small proportion (<20%) completed the survey.

The groups were matched for gender, handedness, and experience (years) in their specialty but not for age (table 1). Both groups comprised more males than females (72.8% of aerospace engineers and 71.6% of neurosurgeons). Most of the aerospace engineers were based in mainland Europe (n=459, 76.5%), whereas most of the neurosurgeons were based in the UK (n=108, 73.0%).

After data cleaning, 401 complete datasets were included in the final analysis, including 329 aerospace engineers (82.0%) and 72 neurosurgeons (18.0%). The factor analysis revealed six domains (four from the task scores and two from the reaction times), and the loading from each task suggested that these domains corresponded to memory, spatial problem solving,

semantic problem solving, mental manipulation and attention, problem solving speed, and memory recall speed (see supplementary figure 2).

When the domain scores were compared between the groups, neurosurgeons showed significantly higher scores in semantic problem solving (difference 0.33, 95% confidence interval 0.13 to 0.52, P=0.001; fig 1). Aerospace engineers showed significantly higher scores in mental manipulation and attention (−0.29, −0.48 to −0.09, P=0.004). No difference was found between the groups in domain scores for memory (−0.18, −0.40 to 0.03, P=0.09), spatial problem solving (−0.19, −0.39 to 0.01, P=0.07), problem solving speed (0.03, −0.20 to 0.25, P=0.82), and memory recall speed (0.12, −0.10 to 0.35, P=0.29).

In the final analysis, the domain scores were compared with 18 257 members of the general population who completed the same tasks as part of the GBIT (fig 2, table 2).^{8,9} Across all six domains, only two differences were significant: problem solving speed was quicker for neurosurgeons than for the general population (mean z score 0.24, 95% confidence interval 0.07 to 0.41, P=0.008) and memory recall speed was slower for neurosurgeons than for the general population (−0.19, −0.34 to −0.04, P=0.01).

Discussion

Aerospace engineers and neurosurgeons were equally matched across most domains but differ in two respects: aerospace engineers showed better mental manipulation abilities, whereas neurosurgeons were better at semantic problem solving. Compared to the general population, aerospace engineers did not show significant differences in any domains. Neurosurgeons were able to solve problems faster than the general population but showed a slower memory recall speed.

Rocket scientists versus brain surgeons

The personal characteristics of our cohorts encapsulate the known characteristics of aerospace engineering and neurosurgery: both specialties comprise a higher number of men than women.^{15–18} A skew towards younger participants aged 20 to 40 years could reflect the technical savvy of this generation, although both professions are highly technical.

The cognitive profile of aerospace engineers and neurosurgeons was broadly similar. No significant difference was found in four of the six domains (see supplementary figure 2); however, neurosurgeons showed increased semantic problem solving ability (P=0.001). This problem solving task was derived from scores for the rare word definition and verbal analogies tests. This difference might relate to setting, with the neurosurgeons mainly from the UK and the aerospace engineers mainly from mainland Europe—although English as a first language was not a major confounder in the original study.⁹ Alternatively, the exposure of neurosurgeons to Latin and Greek etymologies in medical education could have conferred an advantage in defining rare words.¹⁹ Conversely, aerospace engineers showed increased abilities in mental manipulation and

Table 1 | Personal characteristics of 748 neurosurgeons and aerospace engineers who attempted a battery of cognitive tasks. Values are numbers (percentages) unless stated otherwise

Characteristics	Aerospace engineers (n=600)	Neurosurgeons (n=148)	P value
Age (years):			
20-29	168 (28.0)	33 (22.3)	<0.001
31-40	163 (27.2)	53 (35.8)	
41-50	150 (25.0)	38 (25.7)	
51-60	90 (15.0)	13 (8.8)	
≥60	15 (2.5)	5 (3.4)	
Prefer not to say	5 (0.8)	1 (0.7)	
Gender:			
Male	437 (72.8)	106 (71.6)	0.34
Female	151 (25.2)	34 (23.0)	
Non-binary	1 (0.2)	1 (0.7)	
Prefer not to say	6 (1.0)	4 (2.7)	
Handedness:			
Right	511 (85.2)	132 (89.2)	0.44
Left	64 (10.7)	11 (7.4)	
Ambidextrous	25 (4.2)	5 (3.4)	
Experience (years in specialty):			
0-9	266 (44.3)	75 (50.7)	0.45
10-19	181 (30.2)	40 (27.0)	
20-29	112 (18.7)	20 (13.5)	
≥30	38 (6.3)	11 (7.4)	
Location:			
Great Britain and Republic of Ireland	113 (18.8)	108 (73.0)	<0.001
Mainland Europe	459 (76.5)	16 (10.8)	
Other	18 (3.0)	18 (12.2)	

Difference in distributions is compared using χ^2 tests.

attention ($P=0.004$), which are critical to engineering disciplines and actively taught, suggesting perhaps that this ability is amenable to training.²⁰

Rocket scientists and brain surgeons versus the general population

Scores across all domains for both groups were not significantly different from those of the control population except for problem solving speed, which was faster in neurosurgeons ($P=0.008$), and memory recall speed, which was slower in neurosurgeons ($P=0.01$; fig 2). No significant difference was found between aerospace engineers and the control population in any of the domains. These results suggest that, despite the stereotypes depicted by the phrases “It’s not rocket science” and “It’s not brain surgery,” all three groups showed a wide range of cognitive abilities. In the original GBIT, 90% of Britons scored above average on at least one aspect of intelligence, illustrating the importance of studying multiple domains that make up a concept of intelligence rather than a single measure.⁸

Problem solving speed describes how quickly humans process information and apply solutions to problems. The scores for this domain were derived mainly from the reaction times of the visuospatial tasks. This information processing speed has been thought to be an important measure that correlates strongly with other psychometric variables, and less susceptible to training effects and therefore an important measure of objective intelligence.²¹⁻²⁴ The difference in problem solving speed exhibited by neurosurgeons might arise from the fast paced nature of neurosurgery, which attracts those with a pre-existing flair for rapid processing, or it

could be, albeit less likely, a product of training for rapid decision making in time critical situations.

Memory recall speed was derived from immediate and delayed prospective word memory and digit span. It is not clear why neurosurgeons performed more poorly than the general population in this domain. It is not unusual for surgeons in general to memorise strings of information for short periods, but perhaps they rarely need to recall these at speed.

At a time when recruitment and retention in the National Health Service face an uncertain future, and surgical training has been severely affected by covid-19,^{25 26} it is perhaps more important than ever to consider the factors that influence career choice, both at the level of the schoolchild deciding on a career and at the level of medical trainees who have yet to specialise. The number of applications for surgery has decreased in several countries²⁷ and the perception of surgery is influential: intimidating stereotypes of surgery and of surgeons can deter medical students from pursuing a surgical career²⁷; in particular, the notion of surgery being a “masculine” pursuit.^{18 27} The under-representation of women and people from ethnic minority groups in surgical specialties might result, at least in part, from these perceptions.^{15 16}

A similar situation is evident in aerospace engineering, which encompasses the design, testing, and building of aircraft, spacecraft, missiles, and satellites.²⁸ In the United States, less than 17% of bachelor’s degrees in aerospace engineering are awarded to people from ethnic minority groups, and only 14% are awarded to women.¹⁷ Fewer adolescents are choosing to study subjects related to an engineering career, and women and people from ethnic minority groups in particular are rejecting careers in engineering at an early age, often before they reach secondary school.¹⁰ Again, stereotypes associated with engineering influence the likelihood of these minority groups pursuing engineering careers: misconceptions surrounding the perceived difficulty and skillset required for engineering affect the probability of women becoming engineers.²⁹ Gender socialisation extends to school subjects, with mathematics and physics seen as traditionally more “masculine” disciplines and the concept that men are better equipped to pursue STEM careers with an intrinsically more “systemised” brain.^{30 31} We see this reflected in the predominance of males in our cohorts. Despite these stereotypes, and the higher proportion of males, aerospace engineers and neurosurgeons vary in their cognitive aptitudes as does the general population. Our results highlight the further efforts required to widen access to these specialties to mitigate impending staff shortages and ensure a diverse workforce to drive future innovation.

Limitations of this study

Our study tested just one facet of the way in which two phrases might be applied. The phrases could be used to connote the general intelligence of practitioners in the specialties, the complexity of a task, or the background and knowledge required to attempt such a

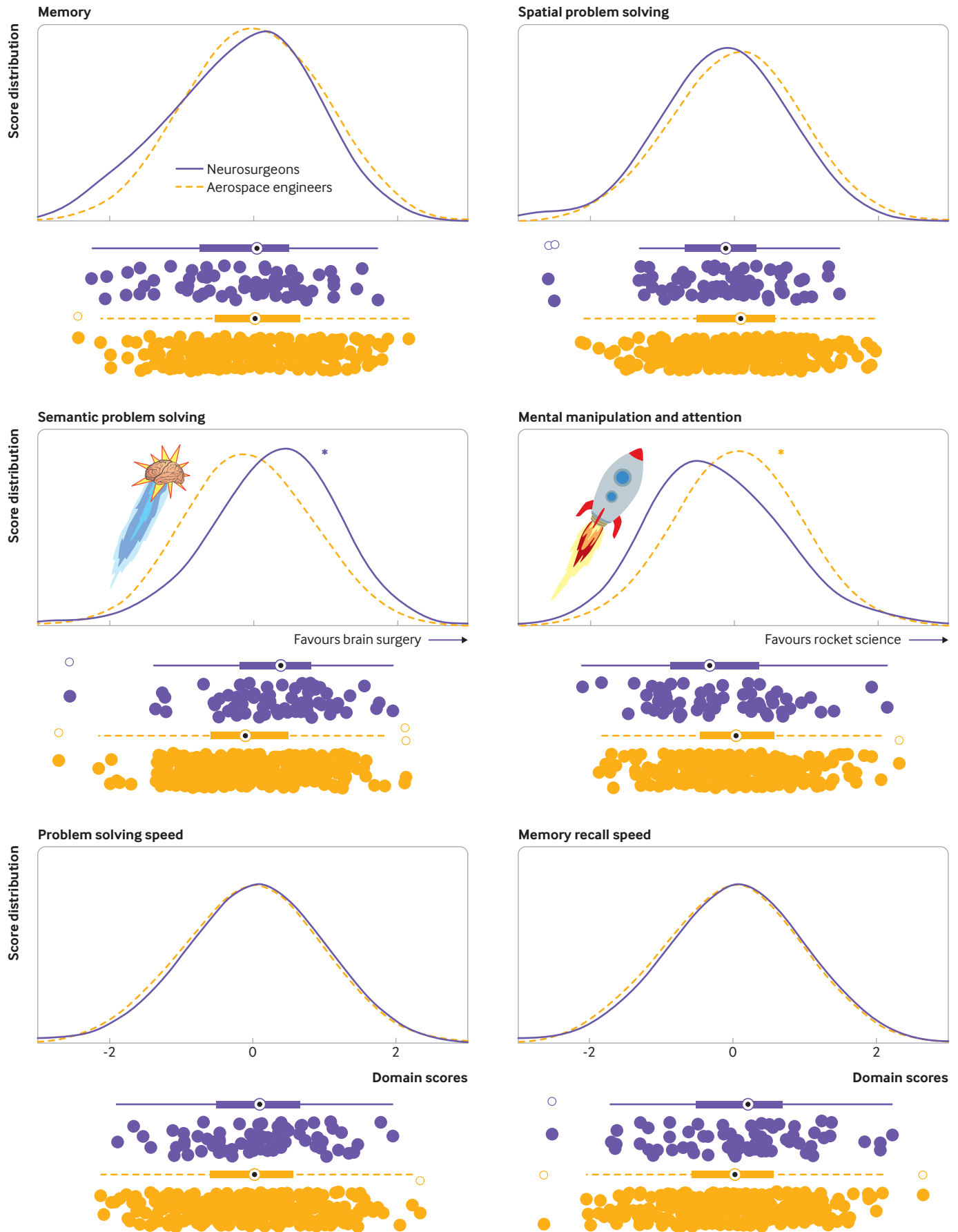


Fig 1 | Smoothed distribution estimates and scatter and density plots of domain scores. *Significant differences

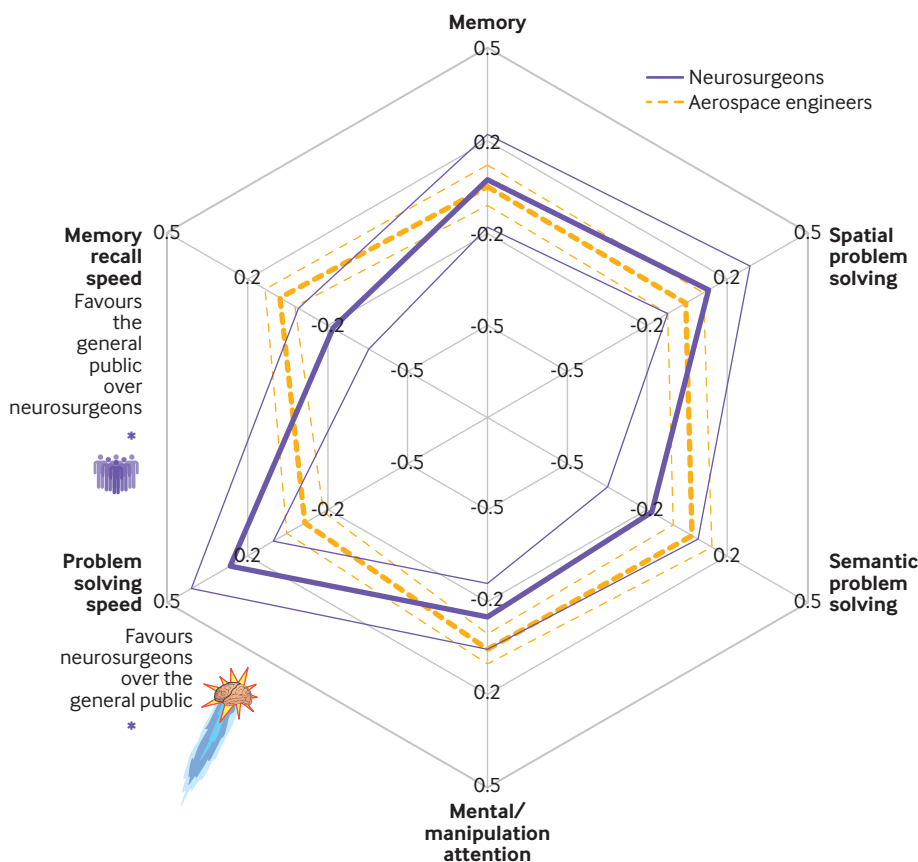


Fig 2 | Radar plot comparing domain scores of neurosurgeons and aerospace engineers with 18 257 UK participants who completed the same tasks as part of the Great British Intelligence Test. Thin lines represent 95% confidence intervals. *Significantly different compared with the general population

task. We acknowledge the limitation that we have only studied the first of these connotations but believe this approach has merit as the public perception of these specialties might at least in part be based around the apparent intelligence of its members.

This study has a few other methodological weaknesses. The study was limited in its geographical reach and therefore does not represent the global range of aerospace engineers and neurosurgeons. In addition, the populations were not balanced for geographical locations. It is also possible that the GBIT normative data might not represent true cognitive abilities of the general population as the test is based on self-selection rather than random sampling. The control group was mainly white, had completed secondary school, and had a university degree. Previous Cognitron studies have shown that the battery of tests is robust to a participant’s first language—we did not

factor the location into our statistical analyses. Although the battery of tests is robust to the device on which it is performed, it is possible that other technical factors, such as the variable efficiency of the computers in hospitals, could influence certain tests that are time limited.

Conclusions

In situations that do not require rapid problem solving, it might be more correct to use “It’s not brain surgery,” but in situations where rapid information recall is needed this phrase should be avoided. It is possible that both neurosurgeons and aerospace engineers are unnecessarily put on a pedestal and “It’s a walk in the park” or another phrase unrelated to a career might be more appropriate. It is also possible that other professions might deserve to be on that pedestal, and future work should aim to determine the most deserving group.

Table 2 | Comparisons of each domain with 18 257 UK participants who completed the same tasks as part of Cognitron’s Great British Intelligence Test

	Memory	Spatial problem solving	Semantic problem solving	Mental manipulation and attention	Problem solving speed	Memory recall speed
Space engineering						
Mean (95% CI) z score*	0.00 (-0.07 to 0.07)	-0.01 (-0.09 to 0.06)	0.02 (-0.06 to 0.10)	0.01 (-0.04 to 0.06)	-0.07 (-0.14 to 0.01)	0.03 (-0.03 to 0.09)
P value	0.98	0.71	0.63	0.73	0.09	0.31
Neurosurgery						
Mean (95% CI) z score*	0.02 (-0.14 to 0.19)	0.08 (-0.09 to 0.25)	-0.14 (-0.33 to 0.04)	-0.11 (-0.23 to 0.01)	0.24 (0.07 to 0.41)	-0.19 (-0.34 to -0.04)
P value	0.80	0.37	0.14	0.07	0.008	0.01

*Calculated from mean and standard deviation of the domain scores from 18 527 UK participants who completed the same tasks as part of Cognitron’s Great British Intelligence Test. Each group’s domain z scores were then compared with those of the general population using two tailed one sample t tests.

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Contributors: IU, KSL, AA, and AC conceived the idea, designed the study, and obtained ethical approval. PH, RL, and AH devised the Cognitron platform and programmed its use for the study. PH and AC analysed the data. IU and AC drafted the manuscript. All authors were involved in the editing of the manuscript and approved the final version before submission. AC is the guarantor. The corresponding author is the guarantor and attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted.

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Competing interests: Three of the authors are neurosurgical trainees or residents; none are aerospace engineers. All authors have completed the ICMJE uniform disclosure form at www.icmje.org/disclosure-of-interest/ and declare: support from the Royal College of Surgeons and Great Ormond Street Children's Charity; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval: This study was approved by the University College London research ethics committee (19713/001) and is supported by the Society of British Neurological Surgeons and the United Kingdom Space Agency.

Data sharing: Technical appendix, statistical code, and dataset are available from the corresponding author. The general population comparison data from the Great British Intelligence Test are not available as an open dataset.

The lead author (AC) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Dissemination to participants and related patient and public communities: Results will be disseminated primarily through the Brainbook charity. We will design infographics and a lay summary of the study, which will be disseminated through the charity's website and active social media channels. We will provide avenues for the public to ask questions to the authors (via interactive Q&A sessions on Instagram, Twitter, and Facebook). In addition, we aim to disseminate the study findings through press releases. These are with the aims of dispelling myths and increasing access to both specialities and STEM careers in general.

Provenance and peer review: Not commissioned; externally peer reviewed.

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Supplementary information: 12 tests administered as part of the Cognitron Great British Intelligence Test battery

Supplementary information: Factor analysis to condense task performance data into distinct domains