Original Research Article

Executive Functioning of College Students pursuing Sciences and Non-Sciences

Bansal Nupur M[1], Bapu Vigraanth[2]

[1]IV Semester MSc Clinical Psychology Student, Department Of Psychology, Kristu Jayanti College (Autonomous), Bengaluru, India
[2]Assistant Professor and PG Programme Coordinator, Department Of Psychology, Kristu Jayanti College (Autonomous), Bengaluru, India
Corresponding author: Bapu Vigraanth
Email – vigraanth@kristujayanti.com

ABSTRACT

Background: The widespread belief in India that science demands greater intellectual prowess than non-sciences, this study aimed to provide concrete evidence on whether a genuine cognitive difference exists between science and non-science students by focusing on set-shifting and planning abilities.
Methodology: A quantitative, ex post facto design was used to collect data from 100 college students (non-Science=50; Science= 50) from Bangalore. Screening was done using Google forms and RSPM. Berg's Card Sorting Test and Tower of London Test on The Psychology Experiment Building Language (IBM) was used to examine Set-shifting and Planning ability respectively to compare domain and gender differences.
Results: Descriptive statistics and independent sample T-test was used to check the mean differences between groups (Domains and gender) and no significant differences were found in the mean scores of Sciences and Non-science students along with Males and Females for Planning and Set-Shifting abilities, accepting all six null hypotheses.
Conclusion: These findings challenge traditional stereotypes and underscore the importance of individual characteristics and educational methodologies in shaping cognitive abilities, supporting a multidisciplinary approach to education aligned with global initiatives advocating for balanced learning outcomes.

Keywords: Planning, Set-shifting, Sciences, Non-Sciences, Tower of London, Berg's Card Sorting Test

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INTRODUCTION

Executive Functioning of College Students pursuing Sciences and Non-Sciences
STEM i.e. Science, Technology, Engineering, and Mathematics was introduced in the year 2001 by the scientific administrators at the U.S National Science Foundation (an independent agency of the U.S government that supports research) (Priyanka, n.d) [1]. The discussion of the humanities vs. STEM debate highlights the social pressures placed on students to choose STEM careers regardless of their personal preferences [2]. The focus of criticism is on STEM-focused education systems that are skewed and create unfavourable attitudes of humanities students [3-4]. This research facilitates a discussion for the benefits of humanities education in promoting critical thinking. The paper advocates for additional promotion for humanities education, curriculum improvements, and a change in parental thinking in order to support non-STEM courses. According to The Government of India, Department of Higher Education's annual report "All India Survey on Higher Education (AISHE), illustrates the increase in undergraduate enrolment trends of STEM subjects from 2010–11 to 2020–21 [5].
Planning is a complex cognitive function that involves the organization of thoughts and actions to achieve a goal over a specific time frame and Set shifting is a cognitive process involving the ability to switch between mental sets or tasks, adapting behaviour according to changing demands and based on these two executive functions, cognitive differences were compared. The existing body of literature reveals a lack of agreement

regarding the distinctions in executive functioning between students in the sciences and humanities(non-sciences). While some studies, exemplified by researchers [6-8], assert anatomical and cognitive differences, Contreras and others [9] found no such distinctions between the two distinctive educational domains. Moreover, there is a notable gap in research focused on higher education students, with most studies concentrating on secondary and higher secondary education levels. Cognitive styles differ between humanities, commerce and sciences students [10-11].

This study had a small sample size and assessed just the "cognitive style" and not a particle "cognition" per se. Similar limitations and results were found in a study where they found Set-shifting ability was positively correlated with science and math achievement, but not with humanities achievement. This study's population ie. Chinese students' results cannot be well understood in the Indian context due to differences in educational pedagogy, culture specific expectations and a lot of other factors portraying the need for a study in the Indian context [11]. Furthermore, a significant void exists in studies conducted in the Indian context, evaluating the executive functioning of humanities and science students. Planning ability, a crucial component of executive functioning, has also been neglected in the existing literature. The present study seeks to address these gaps by employing innovative methodologies, such as a computerized version of the Tower of London and Wisconsin Card Sorting Test, on a normal population. Additionally, the introduction of the Berg Card Sorting Test to assess set-shifting adds on to the literature, as prior research has predominantly focused on clinical populations. Overall, this research aims to contribute valuable insights into the executive functioning of students in different academic disciplines and cultural settings.

METHODOLOGY

Research Design

The study adopts a quantitative research design with a Quasi-experimental research design, predominantly post-test only and no control group model making it an Ex-post facto design to explore and record information pertaining to the planning and set-shifting abilities of science and non-sciences students within a given population.

Objectives

- To study if there is any significant difference in set shifting ability between college students pursuing sciences and non-sciences.
- To study if there is any significant difference in planning ability between college students pursuing sciences and non-sciences.
- To study if there is any significant difference in set shifting ability between males and females pursuing sciences.
- To study if there is any significant difference in set shifting ability between males and females pursuing non-sciences.
- To study if there is any significant difference in planning ability between males and females pursuing sciences.
- To study if there is any significant difference in planning ability between males and females pursuing non-sciences.

Hypotheses

- H01: There is no significant difference in set shifting ability between college students pursuing sciences and non-sciences.
- H02: There is no significant difference in planning ability between college students pursuing sciences and non-sciences.
- H03: There is no significant difference in set shifting ability between males and females pursuing sciences.
- H04: There is no significant difference in set shifting ability between males and females pursuing non-sciences.
- H05: There is no significant difference in planning ability between males and females pursuing sciences.
- H06: There is no significant difference in planning ability between males and females pursuing non-sciences.

Sampling

A total of 100 participants were selected for the study using Purposive sampling technique. Forms were first circulated around college students in Bangalore and based on the responses and inclusion and exclusion

criteria participants were screened. Inclusion Criteria included The age for participants should be 18-25 years old, Science domain included participants from Life Sciences, Forensic Science, Computer sciences and Non-science domain includes participants from Communication & Media, English, Business Management and Law. Participants who have had any past head injury, trauma or any mental illness, had preexisting knowledge about the tools and awareness of the objectives, had history of change in domains, professionally trained or involved in any sport or any performing arts [12], diagnosed with color blindness, not falling in the average range of Intelligence (Grade 4 or above and Grade 2 or below in RSPM) or having a background of Psychology were excluded from the study.

Ethical Consideration

The study adhered to all American Psychological Association's Ethical Principles of Psychologists and Code of Conduct particularly focusing on ethics of Section 8: Research and Publication. Institutional Approval was taken, Informed Consent to Research was also put into action, steps were taken to protect the prospective participants from adverse consequences, no deception was used, and plagiarism and duplication was avoided.

Tools Used

Screening Tools:

Google Form was used to collect basic information like socioeconomic status, history and contact information for screening purposes. Raven's Standard Progressive Matrices (RSPM) was conducted to screen participants to make the sample more standardized.

Tools Assessing Executive Functioning:

The Psychology Experiment Building Language (PEBL) was used to assess executive functioning of the clients focusing mainly on Planning (Tower of London) and Set Shifting (BCST). Tower of London is a neuropsychological test widely used to assess planning and problem-solving ability through manual and computerized versions. PEBL'S Berg Card-Sorting Test was used to assess participant's set shifting ability. [13-15].

Procedure of the study

Tests were conducted at Kristu Jayanti College, Bengaluru, in a controlled environment. Each test was carried out individually, with only one participant performing the test in a designated room. Socio-demographic details were collected through Google Forms, with the items also gathering data for inclusion and exclusion criteria. 104 Participants had filled the form initially and then Participants (N=100) were short-listed based on the inclusion and exclusion criteria.

Formal emails were sent to the participants, notifying them about their selection and providing the date and time for the assessment. Informed consent was given, accompanied by a verbal explanation of all ethics and rights. Once informed consent was signed, participants underwent a screening test to make sure they don't fall in the extreme ends for intelligence which was done using Raven's Standard Progressive matrices. (Below average or above average). Once screened, the participants were given instructions for Tower of London, PEBL followed by the participants attempting TOL on a laptop. On completion, the same was done for BCST. After the test conduction, participants were debriefed about the research and its objectives.

Statistical techniques

This research, conducted using SPSS software for analysis, primarily focused on employing descriptive and inferential statistics to analyse the data. Descriptive statistics were utilized to examine various aspects of the sample, such as the sample size, the frequency of participants in both the Sciences and Non-sciences groups, and the distribution of genders (Male and Female) within the sample, including the breakdown of gender distribution within each group (i.e., males/females in Sciences and Non-sciences).

The primary hypothesis of the study aimed to ascertain differences between the two groups and potential gender disparities in executive functioning. To test this hypothesis, inferential statistics were employed, specifically the Independent Sample T-test. This statistical method facilitated the comparison of mean scores between groups, enabling the determination of whether any significant differences existed.

RESULTS

There was a total of 100 participants (Science = 50; non-science 50). Among these participants, there were 56 females and 44 males in total. The Science domain had 20 female participants and 30 male participants. Conversely, in the non-science domains, there were 36 female participants and 14 male participants. Furthermore, the average age of all participants was calculated to be 20.38 years.

Table 1: Mean and Inferential Statistics to compare difference in Set-shifting abilities among Sciences and Non-Sciences groups.

	Groups	Mean	Std. Deviation	t
Categories Completed	**Science**	5.10	2.565	0.621
	Non-Science	4.78	2.590	
Failure to Maintain a Set	**Science**	1.92	1.338	0.000
	Non-Science	1.92	1.627	
Perseverative Errors	**Science**	23.62	12.540	-0.008
	Non-Science	23.64	12.555	

An Independent Sample T-test was conducted to compare the difference between set-shifting among science students and non-science students and there was no significant difference in scores of categories completed among the Science group (M= 5.10, SD= 2.565) and the Non-science group (M= 4.78, SD= 2.590); t(98) = 0.621, p = 0.536. There was no significant difference in scores of Failure to Maintain a Set among the Science group (M= 1.92 , SD= 1.338) and the Non-science group (M= 1.92, SD= 1.627); t(98) = 0.000, p = 1.000.There was no significant difference in scores of Perseverative Errors among the Science group (M= 23.62 , SD= 12.540) and Non-Science group (M= 23.64, SD= 12.555); t(98) = -0.008, p = 0.994.
As Set Shifting ability was assessed using Categories Completed, Failure to Maintain a Set and Perseverative Errors [16], no significant difference was found between science group and Non-Science group for all the three scores hence, we accept the first null hypothesis that "there is no significant difference in set shifting ability between college students pursuing sciences and non-sciences" (Table 1).

Table 2: Mean and Inferential Statistics to compare difference in Planning abilities among Sciences and Non-Sciences groups

	Groups	Mean	Std. Deviation	t
Errors	**Science**	4.92	2.302	0.042
	Non-Science	4.90	2.485	
Time Taken	**Science**	277.09	81.113	-0.679
	Non-Science	289.12	95.487	

An Independent Sample T-test was conducted to compare the difference and there was no significant difference in the error scores among the Science group (M= 4.92, SD= 2.302) and the Non-science group (M= 4.90, SD= 2.485); t(98) = 0.042, p = 0.967. There was no significant difference in the Time Taken among the Science group (M= 2777.09 , SD= 81.113) and Non-Science group (M= 289.12, SD= 95.487); t(98) = -0.679, p = 0.499. As Planning ability was assessed using Number of Errors made and Time Taken (Krikorian and Gay, 1994), no significant difference was found between science group and non-science group for both the scores hence, we accept the second null hypothesis (Table 2).

Table 3: Mean and Inferential Statistics to compare gender difference in Set Shifting abilities in science group

	Gender	N	Mean	Std. Deviation	t
Categories Completed	**Female**	20	4.30	2.638	-1.844
	Males	30	5.63	2.414	
Failure to Maintain a Set	**Female**	20	1.75	1.333	-0.730
	Males	30	2.03	1.351	
Perseverative Errors	**Females**	20	27.30	11.739	1.728
	Males	30	21.17	12.644	

According to the analysis, there was no significant difference in scores of categories completed among the Female group (M= 4.30, SD= 2.638) and Male group (M= 5.63, SD= 2.414); t(48) = -1.844, p = .071. There was no significant difference in scores of Failure to Maintain a Set among Females (M= 1.75 , SD= 1.333) and Males (M= 2.03, SD= 1.351); t(48) = -.730, p = 0.469. There was no significant difference in scores of

Perseverative Errors among Females (M= 27.30, SD= 11.739) and Males (M= 21.17, SD= 12.644); t(48) = 1.728, p = .090.
As Set Shifting ability was assessed using Categories Completed, Failure to Maintain a Set and Perseverative Errors [16], no significant difference was found between Females and Males for all the three scores hence, we accept the third null hypothesis (Table 3).

Table 4: Mean and Inferential Statistics to compare gender difference in Set Shifting abilities in non-science group

	Gender	N	Mean	Std. Deviation	t
Categories Completed	**Female**	36	4.69	2.550	-0.371
	Males	14	5.00	2.774	
Failure to Maintain a Set	**Female**	36	1.89	1.489	-0.215
	Males	14	2.00	2.000	
Perseverative Errors	**Females**	36	23.94	13.653	0.272
	Males	14	22.86	9.558	

According to the analysis, there was no significant difference in scores of categories completed among the Female group (M= 4.69, SD= 2.550) and Male group (M= 5.00, SD= 2.774); t(48) = -0.371, p = 0.712.
There was no significant difference in scores of Failure to Maintain a Set among Females (M= 1.89 , SD= 1.489) and Males (M= 2.00, SD= 2.000); t(48) = -0.215, p = 0.831.There was no significant difference in scores of Perseverative Errors among Females (M= 23.94 , SD= 13.653) and Males (M= 22.86, SD= 9.558); t(48) = 0.272, p = 0.787. As Set Shifting ability was assessed using Categories Completed, Failure to Maintain a Set and Perseverative Errors [16], no significant difference was found between Females and Males for all the three scores hence, we accept the fourth null hypothesis (Table 4).
According to the analysis (Table 5), there was no significant difference in the error scores of the Female group (M= 5.60, SD= 2.583) and Male group (M= 4.47, SD= 2.013); t(48) = 1.740, p = 0.088. There was no significant difference in Time Taken among Females (M= 270.20, SD= 71.019) and Males (M= 281.69, SD= 88.078); t(48) = -0.487, p = 0.628. Planning ability was assessed using Number of Errors and Time taken [9], no significant difference was found between Females and Males for both the scores hence, we accept the fifth null hypothesis.

Table 5: Mean and Inferential Statistics to compare difference in Planning abilities among Females and Males in Science group

	Groups	N	Mean	Std. Deviation	t
Errors	**Female**	20	5.60	2.583	1.740
	Male	30	4.47	2.013	
Time Taken	**Female**	20	270.20	71.019	-0.487
	Male	30	281.69	88.078	

Table 6: Mean and Inferential Statistics to compare difference in Planning abilities among Females and Males in Non-Science group

	Groups	N	Mean	Std. Deviation	t
Errors	**Female**	36	5.06	2.449	0.706
	Male	14	4.50	2.624	
Time Taken	**Female**	36	293.23	92.141	0.485
	Male	14	278.54	106.499	

According to the analysis, there was no significant difference in the error scores Female group (M= 5.06, SD= 2.449) and Male group (M= 4.50, SD= 2.624); t(48) = 0.706, p = 0.483. There was no significant difference in Time Taken among Females (M= 293.23, SD= 92.141) and Males (M= 278.54, SD= 106.499); t(48) = 0.485, p = 0.630. Planning ability was assessed using Number of Errors and Time taken [17], no

significant difference was found between Females and Males for both the scores hence, we accept the sixth null hypothesis (Table 6).

DISCUSSION

There were six null hypotheses of this research, and all hypotheses were accepted, and the study found no significant differences in planning and set-shifting abilities in college students pursuing sciences and non-sciences, nor any significant differences in set-shifting and planning were found between females and males pursuing sciences or non-sciences. As there is no significant difference in planning and Set-Shifting ability between college students pursuing Sciences and Non-Sciences. These findings are intriguing when viewed in the context of existing research, particularly the study conducted by Li and others [11]. The current study's discrepancy with a study [11] regarding the relationship between learning and academic achievement, prompting an examination of educational practices. In India, educational strategies are evolving, with institutions like the UGC advocating for an interdisciplinary approach that emphasizes a blend of subjects and skills. This trend aligns with global initiatives such as those endorsed by the ACBSP, which prioritize comprehensive educational excellence. Both approaches underscore the importance of a balanced education over specialization. This study contributes to our understanding of how these contemporary educational methodologies impact learning outcomes and academic success [18-19].

All four null hypotheses regarding gender differences in planning and set-shifting abilities across science and non-science disciplines were also accepted which contradicts a study finding [8]. The current study's findings challenge traditional stereotypes about cognitive abilities and gender roles in academia. Historically, there has been a tendency to associate certain cognitive skills, such as systemizing, with males and others, such as empathizing, with females. However, in the modern era, these stereotypes have been broken, as evidenced by the increasing number of females pursuing science and males studying non-science subjects. This societal shift towards breaking gender stereotypes in academic pursuits may contribute to the absence of gender differences in cognitive abilities observed in this study. Even graduate attributes, the findings suggest that cognitive abilities related to planning and set shifting are not inherently tied to gender but rather are influenced by individual characteristics and preferences therefore, in the modern education system these attributes facilitate a multidisciplinary approach [19]. Grissom and Reyes (2019) found an absence of significant gender differences in cognitive abilities [20].

Similarly, researchers [11] found that gender differences in cognitive ability have been steadily decreasing across birth cohorts in China, like trends observed in the United States. The study's findings indicate that this trend towards gender equality in cognitive skills supports the absence of significant gender differences in planning and set-shifting abilities, regardless of whether individuals are in science or non-science disciplines [21].

The study's future implications may include promoting a more holistic and multidimensional educational strategy that prioritizes the development of executive functioning abilities across all subject areas. Incorporating graduate qualities in both schools and colleges may be another implication as executive functioning not only helps individuals with their academia and career performance but also is a great moderator for daily living skills and survival skills.

Few possible limitations of the study can be small sample size, limited geographical area of data collection, lack of consideration of individual differences and understanding the difference between only 2 categories i.e.. Sciences and non-sciences.

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