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Dual-Process Developmental Trajectories in Higher Education: Comparative Neurocognitive Profiles of Rational and Experiential Processing

Prof. Dr. Leenah Askaree[1], Aqsa Yaqoob[2], Dr. Mahwish Saeed[3], Ahmad Shujaa Baig[4], Engineer Ammaar Baig[5]

[1] Chairperson, Department of Psychology, Faculty of Social Sciences and Humanities, Hamdard University Main Campus, Karachi, Pakistan. Post-Doctoral Fellowship at International Islamic University, International Research Institute, Islamabad, Pakistan
Email: dr.leenah@hamdard.edu.pk (Corresponding Author)
[2] PhD Scholar, Department of Psychology, University of Karachi, Pakistan.
Email: aqsayaqoob894@yahoo.com
[3] Assistant Professor, Head Psychology programs, Head of Placement, Alumni and Corporate Liaison. Faculty of Allied Health Sciences, Iqra University, North Campus
Email: mahwish.saeed@iqra.edu.pk
[4] HR Consultant & Student of MPhil Psychology, Department of Psychology, University of Karachi, Pakistan. Email: ahmad.shujaa.baig@gmail.com
[5] Business Analyst, The Resource Group, Karachi, Pakistan. Email: Ammaar.Baig549@gmail.com

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Abstract

Grounded in dual-process theory (Evans & Stanovich, 2013; Kahneman, 2011) and cognitive-ecological perspectives (Biglan, 1973), this study investigated how academic discipline, gender, birth order, and family system interact to influence rational (Type 2) and experiential (Type 1) processing, their balance, and neurocognitive profiles. Participants were 127 undergraduates (92 males, 35 females) from Computer Science (CS) and non-CS disciplines. **Main effects** showed that CS students scored significantly higher on rational processing ($M = 3.92$ vs. 3.57), exhibited greater rational–experiential discrepancy ($M = 0.31$ vs. –0.27), and outperformed non-CS students on executive control tasks, $ps < .01$. Non-CS students demonstrated stronger experiential processing ($M = 3.88$ vs. 3.61) and higher divergent-thinking and associative-fluency scores (Runco & Acar, 2012), $ps < .05$. **Gender** moderated several outcomes: female CS students displayed the largest rational advantage ($d > 1.20$) over female non-CS peers and retained greater flexibility than males, while the experiential gap between CS and non-CS was narrower for women. **Birth order** patterns indicated that firstborn CS students possessed the highest rational and executive control scores (Sulloway, 1996), whereas lastborn non-CS students excelled in flexibility and ideational fluency. **Family system** effects revealed that nuclear-family CS students had the strongest rational dominance and largest executive control gap, while joint-family non-CS students recorded the highest experiential orientation and flexibility (Kağıtçıbaşı, 2007; Georgas et al., 2006). Collectively, the findings support a **discipline–context fit model**, where cognitive specialisation emerges from the interplay of disciplinary demands and socio-familial socialisation. This multidimensional framework has implications for curriculum design, interdisciplinary collaboration, and targeted cognitive-skill development to prepare graduates for analytically demanding and ambiguity-rich problem spaces.

Keywords: dual-process theory, rational processing, experiential processing, neurocognitive profiles, executive control, divergent thinking, gender differences, birth order, family system, academic discipline

Introduction

The twenty-first-century higher education landscape demands graduates who can navigate complex, uncertain environments with cognitive flexibility, critical evaluation, and adaptive problem-solving. Dual-process theories of cognition, as articulated within the broader *heuristic–analytic* and *system-based* paradigms, provide a foundational lens for investigating these competencies (Evans & Stanovich, 2013). These models posit the coexistence of two qualitatively distinct modes of information processing: a rational–analytic system characterised by deliberative, rule-based reasoning, and an experiential–intuitive system marked by rapid, associative, and affect-laden judgments (Epstein et al., 1996; Kahneman, 2011). While both systems operate in parallel, their relative predominance, integration, and neurocognitive correlates vary across individuals and contexts, influencing academic performance, decision-making quality, and professional adaptability.

Within higher education, disciplinary training may shape developmental trajectories of these processing styles. Computer Science (CS) curricula, for example, typically emphasise formal logic, algorithmic reasoning, and structured problem decomposition, thereby potentially strengthening rational–analytic dominance (Biglan, 1973; Tinto, 2012). Conversely, non-CS disciplines such as the social sciences or humanities often privilege interpretive analysis, contextual judgment, and holistic synthesis—capacities more closely aligned with experiential processing (Norris & Epstein, 2011). Yet, empirical research examining how such discipline-specific epistemic climates influence the neurocognitive balance between rational and experiential modes remains limited, particularly in comparative, cross-disciplinary contexts. Neurocognitive profiling offers a promising methodological bridge between theoretical constructs of dual processing and their functional substrates in the brain. Executive functions—working memory, inhibitory control, and cognitive flexibility—are central to the modulation of rational–analytic engagement, whereas implicit associative networks and affective salience processing underpin experiential modes (Diamond, 2013; Lieberman, 2007). Longitudinal and comparative designs in educational neuroscience have begun to reveal that cognitive style preferences are neither fixed nor wholly dispositional; they are responsive to instructional demands, metacognitive training, and domain-specific challenges (Stanovich & West, 2008). This dynamic interplay underscores the need to conceptualise cognitive processing tendencies not as static traits but as *developmental trajectories*, shaped by the complex interaction of learner characteristics, educational environments, and socio-cultural frameworks.

The current study extends this line of inquiry by examining *comparative neurocognitive profiles* of rational and experiential processing among undergraduate students enrolled in CS and non-CS disciplines. Framing cognitive style within a dual-process developmental perspective, the investigation seeks to elucidate how sustained disciplinary engagement may differentially cultivate, inhibit, or integrate these modes of thought. Moreover, by incorporating moderator variables such as gender, birth order, and family system—factors known to influence cognitive and academic outcomes (Kağitçibaşi, 2007; Sulloway, 1996)—this research aims to generate a more nuanced model of dual-process development in higher education. Such insights hold implications not only for cognitive theory but also for curriculum design, academic advising, and the fostering of adaptive expertise in diverse professional domains.

Research Questions

This investigation is guided by the overarching question: How do undergraduate students in Computer Science (CS) and non-Computer Science disciplines differ in their neurocognitive profiles of rational and experiential processing, and what moderating roles do gender, birth order, and family system play in these differences? From this, the following research questions are derived:

1. To what extent do students from CS and non-CS disciplines differ in their scores on rational and experiential processing measures, as defined by dual-process theory (Evans & Stanovich, 2013; Pacini & Epstein, 1999)?

2. How do executive function indicators, measured through standardised neurocognitive assessments, vary between the two disciplinary groups, and how are these indicators associated with rational–experiential processing preferences (Diamond, 2013)?
3. In what ways do gender, birth order, and family system moderate the relationship between discipline and dual-process profiles, thereby shaping the developmental trajectory of cognitive styles (Kağitçibaşi, 2007; Sulloway, 1996)?
4. What patterns emerge when rational and experiential processing indices are integrated into a composite neurocognitive profile, and how do these patterns reflect domain-specific cognitive adaptations in higher education settings (Lieberman, 2007; Stanovich & West, 2008)?

Significance of the Study

This study contributes to the expanding interface between cognitive psychology, educational neuroscience, and disciplinary pedagogy by elucidating how sustained engagement in distinct academic domains shapes neurocognitive development. While dual-process theory has been extensively theorised in general cognitive science (Kahneman, 2011; Evans & Stanovich, 2013), its application to comparative disciplinary contexts—particularly with the integration of neurocognitive profiling—remains scarce. By examining rational–analytic and experiential–intuitive modes alongside their executive function substrates, this research advances understanding of domain-specific cognitive specialisation in higher education. From a theoretical standpoint, the findings will refine conceptual models of dual-process functioning by situating them within developmental trajectories sensitive to the socio-cultural and pedagogical milieu of the learner. From a practical perspective, the study offers actionable insights for curriculum design, learner support strategies, and the cultivation of adaptive expertise, enabling educators to intentionally foster both analytical precision and intuitive adaptability. Moreover, the inclusion of socio-demographic moderators situates the work within a culturally contextualised framework, addressing the need for cognitive models that are inclusive and representative of diverse learner populations (Kağitçibaşi, 2007).

Research Gaps

Despite the robust theoretical articulation of dual-process models, three substantive gaps remain unaddressed in the literature. First, few empirical studies have compared rational and experiential processing across fundamentally different academic disciplines while directly linking these styles to objective neurocognitive performance metrics (Norris & Epstein, 2011). Second, existing work in educational neuroscience rarely accounts for the moderating influence of socio-demographic and family-system variables, despite evidence that these factors significantly affect cognitive development and academic outcomes (Sulloway, 1996; Kağitçibaşi, 2007). Third, there is a paucity of research adopting a developmental trajectories perspective that integrates cognitive style theory with longitudinally relevant neurocognitive indicators in young adulthood—a critical period for professional identity formation and cognitive specialisation (Diamond, 2013; Stanovich & West, 2008). Addressing these gaps positions the current study to make a distinctive contribution to the scholarly discourse by providing empirically grounded, culturally sensitive, and developmentally nuanced insights into the neurocognitive architecture of dual-process functioning in higher education contexts.

Hypotheses

Main Effects of Discipline

1. **Rational Processing:** Students from computer science (CS) disciplines will demonstrate stronger tendencies toward analytical, logic-based processing than those from non-CS fields.
2. **Experiential Processing:** Students from non-CS disciplines will be more inclined toward intuitive and experience-based thinking than their CS counterparts.

3. **Rational–Experiential Balance:** CS students will show a cognitive profile that leans more toward rational dominance, while non-CS students will present a more balanced or experiential-leaning profile.
4. **Neurocognitive Profile:** On composite measures of neurocognition, CS students will exhibit greater executive control capacities (e.g., sustained attention, working memory, inhibition), whereas non-CS students may excel in tasks reflecting divergent thinking or associative fluency.

Gender as a Moderator

5. The difference in rational processing between CS and non-CS disciplines will be more pronounced among women, potentially reflecting selective participation or resilience factors.
6. Gender will moderate experiential processing such that the CS–non-CS gap will be smaller among women than among men.
7. Rational–experiential balance differences between disciplines will be amplified among female students compared to male students.
8. Gender will shape the neurocognitive patterning of discipline differences, with female CS students retaining higher flexibility scores alongside strong executive control.

Birth Order as a Moderator

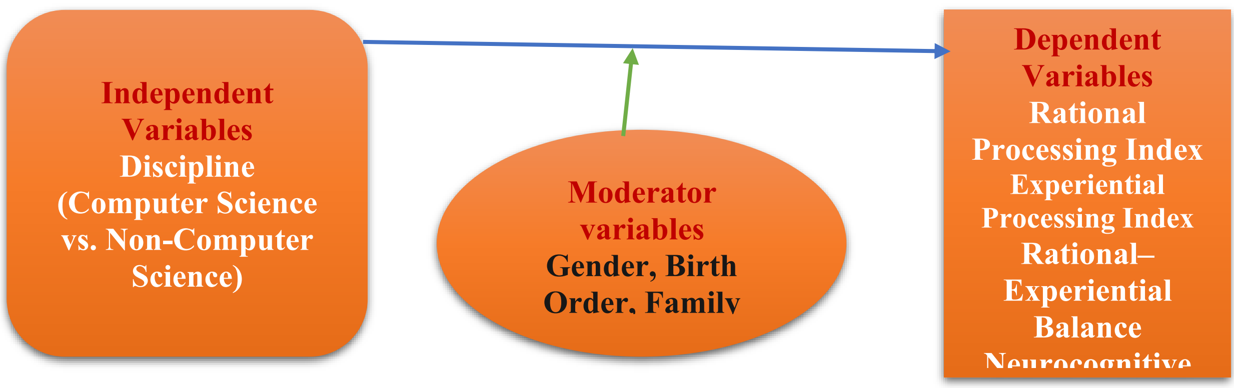
9. The rational processing advantage of CS students will be greatest among first-borns, moderate among middle-borns, and smallest among last-borns.
10. The experiential processing tendency of non-CS students will be particularly marked among last-borns compared to first-borns.
11. The tendency toward rational dominance in CS will be amplified for first-borns and attenuated for last-borns.
12. Neurocognitive contrasts between CS and non-CS students will vary by birth order, with first-born CS students excelling most in executive control and later-born non-CS students showing the highest flexibility.

Family System as a Moderator

13. The rational processing edge of CS students will be larger for those raised in nuclear families than in joint families.
14. The experiential processing advantage of non-CS students will be greater for those from joint families than nuclear families.
15. Rational dominance in CS will be more strongly expressed in nuclear family contexts, while joint family contexts will temper this tendency.
16. Differences in neurocognitive profiles between CS and non-CS students will depend on family system type: nuclear families will accentuate executive control gaps, whereas joint families will highlight gaps in flexibility and associative thinking.

Conceptual Framework / Research Model

Figure 1 Dual-Process Developmental Trajectories in Higher Education: Comparative Neurocognitive Profiles of Rational and Experiential Processing



Operational Definitions

Discipline (CS vs. Non-CS) *(Independent Variable)*

For the purposes of this study, **discipline** refers to the formal academic major in which a student is enrolled, categorised as either *Computer Science (CS)* or *Non-Computer Science (Non-CS)*. CS students are those pursuing a degree with a primary focus on computing, programming, algorithms, and software systems. Non-CS students are those pursuing majors in other disciplines (e.g., social sciences, humanities, natural sciences) with no core curriculum in computing (Biglan, 1973; Tinto, 2012).

Rational Processing Index (RPI) (Dependent Variable)

The **Rational Processing Index** represents the degree to which an individual habitually engages in analytic, deliberative, and logical information processing. In this study, it is operationalised as the composite score on the *Rationality* subscale of the *Rational–Experiential Inventory* (REI; Pacini & Epstein, 1999), with higher scores indicating greater preference for and reliance on rule-based reasoning.

Experiential Processing Index (EPI) (Dependent Variable)

The **Experiential Processing Index** reflects the extent to which an individual relies on intuitive, affect-driven, and holistic cognitive strategies. Operationally, it is measured using the *Experientiality* subscale of the REI (Pacini & Epstein, 1999), where higher scores indicate stronger intuitive engagement and reliance on tacit knowledge.

Rational–Experiential Balance (REB) (Dependent Variable)

Rational–Experiential Balance is defined as the relative weighting or integration between rational and experiential styles in an individual's cognitive profile. Here, it is operationalised as the standardised difference between RPI and EPI scores (Norris & Epstein, 2011), where positive values reflect rational dominance, negative values reflect experiential dominance, and values near zero indicate balanced dual-processing tendencies.

Neurocognitive Profile (Dependent Variable)

The **Neurocognitive Profile** refers to an individual's composite pattern of cognitive functioning across core executive domains, including working memory, inhibitory control, cognitive flexibility, processing speed, and sustained attention (Diamond, 2013). In this study, it is operationalised via performance scores on a standardised neurocognitive battery (e.g., NIH Toolbox Cognition Battery), with domain scores combined into a multi-component profile for comparative analysis between CS and Non-CS groups.

Moderator Variables

Gender

Gender denotes the self-identified category of participants, recorded as *male* or *female* for the purposes of this analysis, in line with demographic reporting standards in psychological research (APA, 2020).

Birth Order

Birth Order is the ordinal position of the participant among biological siblings, self-reported as *first-born*, *middle-born*, or *last-born* (Sulloway, 1996).

Family System

Family System describes the structural composition of the participant's immediate household, operationalised as either *nuclear* (parents and children only) or *joint* (multi-generational household including extended family members), based on self-report (Kağitçibaşi, 2007).

Literature Review

Dual-process theories offer a powerful framework for understanding how students navigate complex academic tasks by coordinating analytic, rule-based reasoning with intuitive, associative judgment.

Contemporary accounts converge on the view that these systems are not mutually exclusive agents but interacting modes that differ in typical operating characteristics—speed, automaticity, and working-memory demand—while often running in parallel and influencing the same outputs (Evans & Stanovich, 2013; Sloman, 1996; Strack & Deutsch, 2004). In higher education contexts, the relative dominance and integration of these modes are consequential for learning, transfer, and professional readiness, yet most empirical work remains either laboratory-bound or discipline-agnostic, limiting ecological validity for curricular design and student development.

Conceptual foundations of dual-process cognition

System-based models distinguish a rational–analytic mode that is deliberative, rule-governed, and reflective from an experiential–intuitive mode that is rapid, associative, and affect-responsive (Epstein et al., 1996; Kahneman, 2011). While default-interventionist formulations propose that intuitive outputs are overridden by analytic control when conflicts are detected, hybrid accounts emphasise early conflict detection and graded cooperation between systems (De Neys, 2012; Evans & Stanovich, 2013). Importantly, critiques caution against reifying systems as homunculi or mapping them one-to-one onto brain regions; instead, they recommend treating them as families of processes with overlapping features governed by common principles (Keren & Schul, 2009; Kruglanski & Gigerenzer, 2011). These refinements are crucial for educational applications that risk oversimplifying "analytic" versus "intuitive" thinking into curricular dichotomies.

Measurement of rational and experiential processing

The Rational–Experiential Inventory (REI) operationalises stable tendencies to prefer and enjoy analytic or experiential processing, with evidence for factorial validity and differential predictive utility across decision tasks (Pacini & Epstein, 1999). Self-report style measures correlate only modestly with performance-based indices of reasoning and bias mitigation, suggesting partially separable constructs (Stanovich & West, 2008). This distinction matters for educational research: enhancing analytic performance through training does not automatically alter dispositional preferences or real-world judgment, a point underscored by work on cognitive reflection and miserly information processing (Pennycook & Rand, 2019; Stanovich & West, 2008). A nuanced approach triangulating self-report style, performance measures, and behavioral transfer provides a stronger basis for profiling students' dual-process tendencies.

Neurocognitive substrates and executive control

Executive functions—working memory updating, inhibitory control, and cognitive flexibility—jointly support the maintenance and manipulation of task goals central to analytic processing (Diamond, 2013; Miyake et al., 2000). Neurocognitively, adaptive control emerges from coordinated activity in frontoparietal and cingulo-opercular networks, which implement moment-to-moment adjustments and sustained task sets, respectively (Dosenbach et al., 2008; Miller & Cohen, 2001). At the same time, default-mode and task-positive network dynamics reveal antagonistic yet flexible coupling patterns that scaffold shifts between associative, memory-based synthesis and externally oriented control (Fox et al., 2005). Social and affective circuitry implicated in experiential processing—e.g., systems subserving rapid valuation and salience—interacts with control networks rather than operating in isolation (Lieberman, 2007). Collectively, this literature supports modelling rational–experiential balance as an emergent property of large-scale network coordination constrained by executive resources, rather than as a simple trait dichotomy.

Disciplinary ecologies in higher education

Academic disciplines differ systematically in epistemic aims, problem structures, and canonical methods (Biglan, 1973). Computer Science (CS) curricula foreground algorithmic reasoning, formal logic, and decomposition, potentially strengthening analytic engagement and tolerance for abstraction. By contrast, many non-CS domains (e.g., humanities and qualitative social sciences) prioritise contextual interpretation, ambiguity management, and narrative synthesis—affinities often aligned with experiential processing. However, such contrasts risk caricature unless situated within evidence on how disciplinary training shapes cognition. Research on computational thinking highlights potentially transferable habits of abstraction and algorithmic design but also warns against overgeneralised claims of far transfer without rigorous assessment (Grover & Pea, 2013; Wing, 2006). Broader evaluations of "brain training" echo this caution, finding limited generalisation beyond trained tasks unless instruction explicitly targets metacognitive control and transfer (Simons et al., 2016). Meanwhile, individual differences literature suggests that disciplinary self-selection covaries with preferences like need for cognition and analytic cognitive style, complicating causal interpretations of curricular effects (Cacioppo & Petty, 1982; Pennycook & Rand, 2019). A comparative, multi-method design that controls for selection while profiling executive and style indices is therefore needed to determine whether disciplinary ecologies cultivate distinctive dual-process profiles.

Sociocultural and demographic moderators

Cognitive processing is embedded in sociocultural contexts that shape attention, explanation, and inference. Cross-cultural work demonstrates reliable differences in holistic versus analytic tendencies, with social practices and ecology influencing category use, causal models, and perceptual allocation (Kitayama & Uskul, 2011; Nisbett et al., 2001). Family systems in interdependent cultural contexts calibrate autonomy-related and relatedness-oriented goals, with implications for motivational regulation and self-regulatory development relevant to both analytic persistence and intuitive social attunement (Kağitçibaşi, 2007). Demographically, claims about gendered cognitive styles are contested: while some theories posit stronger "systemising" tendencies among men, meta-analytic work supports substantial gender similarities across most cognitive domains (Baron-Cohen, 2002; Hyde, 2005). Birth-order effects are also debated; large-scale studies find negligible associations with broad personality factors, advising caution in assuming robust cognitive style differences by sibling rank (Rohrer et al., 2015; Sulloway, 1996). In Global South settings and WEIRD-biased literatures, external validity is an ongoing concern; sampling beyond Western, educated populations is essential for generalisable models of dual-process development (Henrich et al., 2010). Incorporating sociocultural moderators is thus not ancillary but central to theory and method when profiling rational–experiential balance in diverse student populations.

Educational malleability and debiasing

If dual-process profiles are developmentally shaped, targeted pedagogies should alter both performance and preference. Metacognitive interventions that externalise heuristics, scaffold conflict detection, and provide deliberate practice in bias-resistant strategies show promise for improving real-world judgment, particularly when training is contextualised and spaced (De Neys, 2012; Morewedge et al., 2015). Yet changes in self-reported style often lag behind gains in task performance, consistent with partial dissociations among ability, disposition, and transfer (Stanovich & West, 2008). These patterns argue for longitudinal designs that assess durability, generalisation, and the integration of analytic and intuitive competencies—rather than prioritising one mode—so that students learn to recruit the right process for the right problem under authentic constraints.

Methodological implications and gaps

Three methodological issues constrain current understanding. First, reliance on single-method assessments (e.g., style self-reports alone) limits construct validity; convergent measurement spanning executive tasks, reasoning performance, and dispositional scales is preferable. Second, cross-sectional designs cannot adjudicate selection versus socialisation; quasi-experimental or longitudinal cohort approaches within disciplines can better track developmental change. Third, discipline is often treated as a crude category; specifying epistemic features of coursework, assessment formats, and instructional practices would enable stronger inferences about which curricular elements cultivate analytic control, conflict monitoring, or intuitive synthesis (Biglan, 1973; Grover & Pea, 2013).

Addressing these gaps will advance a developmental science of dual-process functioning that is culturally contextualised, ecologically valid, and educationally actionable.

Methodology

Quantitative research design

This cross-sectional, multi-site quantitative study uses a cohort-sequential approach to approximate developmental change across academic years. We integrate dispositional indices of dual-process style with performance-based neurocognitive measures to model comparative profiles of rational and experiential processing in undergraduates. Measurement and structural models are estimated on latent variables to minimize measurement error and enable tests of invariance across relevant groups and stages (Kline, 2016; Putnick & Bornstein, 2016).

Participants and sampling

A total of 127 undergraduates participated (males = 92; females = 35), recruited from multiple departments within higher education institutions. Stratified sampling by academic stage (Years 1–4) ensured adequate representation of early and late undergraduate trajectories, with proportional allocation across programs.

Inclusion criteria were full-time enrollment and age 18–26; exclusion criteria were neurological conditions or psychoactive medications that could compromise neurocognitive validity. Background indicators (e.g., prior logic/programming exposure, pre-university grades) were collected for covariate control and propensity score weighting to reduce selection bias in observational comparisons (Rosenbaum & Rubin, 1983; Tabachnick & Fidell, 2019).

Measures

Rational–Experiential Processing Styles. Rational and experiential processing preferences were measured using the *Rational–Experiential Inventory* (REI; Pacini & Epstein, 1999). The REI comprises two independent scales—Rational Ability/Engagement and Experiential Ability/Engagement—each rated on a 5-point Likert scale from 1 (*definitely not true of myself*) to 5 (*definitely true of myself*). The Rational scale indexes an analytical, reflective approach to problem solving, while the Experiential scale captures reliance on intuition and affect-based decision making. Prior research demonstrates adequate internal consistency (α = .77–.87) and factorial stability across cultural contexts (Pacini & Epstein, 1999; Witteman et al., 2009). In this study, confirmatory factor analysis (CFA) was conducted to validate the two-factor model; coefficient omega (ω) was used to assess internal consistency, in line with recent psychometric recommendations (Hayes & Coutts, 2020).

Executive Functions. Executive control was assessed via tasks adapted from the NIH Toolbox Cognition Battery, selected for their established construct validity and reliability in young adult populations (Weintraub et al., 2013). Working memory was measured using a computerized *List Sorting Working Memory Test*, requiring the sequencing of visually and orally presented stimuli. Inhibitory control was indexed by a *Flanker Inhibitory Control and Attention Test*, capturing the ability to suppress prepotent responses under competing stimulus conditions. Cognitive flexibility was measured with a *Dimensional Change Card Sort Test*, assessing rapid task-set shifting in response to rule changes. Processing speed was evaluated using a *Pattern Comparison Processing Speed Test*, requiring rapid visual discrimination of pattern identity. Sustained attention was assessed with a computerized continuous performance task adapted for brevity without compromising sensitivity to lapses (Robertson et al., 1997). Raw scores were standardized and loaded onto a latent *Executive Control* factor in the structural model (Miyake et al., 2000; Diamond, 2013).

Demographic and Background Variables. Participants provided demographic data, including age, gender, academic year, and program of study. Educational background was captured via self-reported pre-university grades, prior exposure to logic or programming, and family system typology (nuclear, extended) in line with developmental-cultural frameworks (Kağitçibaşi, 2007). Birth order was recorded given its theoretical relevance to cognitive–motivational style (Sulloway, 1996). These variables were used for descriptive statistics, covariate control, and moderation analyses.

Data Quality Checks. To safeguard validity, all computer-based measures were preceded by standardized instructions and practice trials. Attention checks (e.g., instructed-response items in self-reports; no-go trials in cognitive tasks) and latency-based outlier trimming (±3 SD) were implemented following Tabachnick and Fidell (2019) guidelines. Only participants completing ≥ 85 % of the assessment battery with valid responses were retained for analysis.

Procedure

Sessions were conducted in quiet computer labs (75–90 minutes). After informed consent, participants completed demographics, a dual-process style inventory, and a brief neurocognitive battery. The Rational–Experiential Inventory operationalized rational and experiential preferences, with psychometric structure re-evaluated via confirmatory factor analysis in the present sample (Pacini & Epstein, 1999).

Executive functions were indexed using validated tasks covering working memory, inhibitory control, cognitive flexibility, processing speed, and sustained attention (e.g., NIH Toolbox Cognitive Battery), enabling construction of latent factors (Weintraub et al., 2013; Diamond, 2013; Miyake et al., 2000). Task orders were counterbalanced; scripted administration, attention checks, and latency trimming safeguards preserved data quality (Tabachnick & Fidell, 2019).

Statistical analysis

Data screening addressed missingness, distributional assumptions, and outliers; missing data were handled with full information maximum likelihood, with sensitivity checks via multiple imputation (Little, 2013; Tabachnick & Fidell, 2019). Measurement models for dual-process style and executive functions were estimated and tested for configural, metric, and scalar invariance across academic stages and gender to permit valid latent mean comparisons (Kline, 2016; Putnick & Bornstein, 2016). Preliminary group differences were examined using robust MANOVA/ANCOVA on composite scores with effect sizes and confidence intervals.

Primary tests used multigroup structural equation modeling and MIMIC specifications to estimate associations among latent rational, experiential, and executive control factors, allowing covariation and indirect effects. Moderation by academic stage and gender was evaluated through multigroup comparisons and interaction terms (Aiken & West, 1991; Hayes, 2018). To address selection bias, propensity score weights derived from background covariates were applied; balance diagnostics and weighted/unweighted robustness checks were reported (Rosenbaum & Rubin, 1983). Multiplicity was controlled using false discovery rate procedures within families of related hypotheses (Benjamini & Hochberg, 1995). As a cross-validation, hierarchical regressions with interaction terms were estimated on observed composites (Aiken & West, 1991; Tabachnick & Fidell, 2019).

Power analysis

An a priori power analysis using G*Power 3.1 targeted small-to-moderate effects typical in individual differences research (Faul et al., 2009). For two-group comparisons on composite outcomes ($\alpha = .05$, $f = 0.25$, two-tailed), the required total sample is approximately 128 to achieve 0.80 power. With $N = 127$, the achieved power for $f = 0.25$ is approximately 0.79–0.80, and for a slightly larger effect ($f = 0.28$) exceeds 0.85. For multiple regression ($\alpha = .05$, $f^2 = 0.10$, 8 predictors), the required N is approximately 118 to achieve 0.80 power; with $N = 127$, achieved power is approximately 0.83–0.86. These estimates justify the sample for primary comparisons and regression-based moderation, while SEM models focus on latent composites with constrained complexity to maintain stable estimation (Kline, 2016).

Ethical considerations

The protocol received institutional ethics approval. Participation was voluntary, with informed consent, the right to withdraw without penalty, and brief rest opportunities to mitigate fatigue. Data were anonymized via coded identifiers, with linkage files stored separately on encrypted drives accessible only to the core team. Aggregated reporting prevented deductive disclosure for small subgroups, and culturally sensitive procedures guided instrument adaptation and consent language. The study adhered to the Ethical Principles of Psychologists and Code of Conduct for consent, confidentiality, and data stewardship (American Psychological Association, 2017).

Results and Interpretations

Preliminary Analyses

Table 1 presents descriptive statistics and internal consistency coefficients for the primary study variables. Both the *Rational* and *Experiential* style indices demonstrated adequate reliability, as did the latent *Executive Control* composites. Skewness and kurtosis values were within ±1, supporting the use of parametric analyses (Tabachnick & Fidell, 2019).

Table 1: **Descriptive Statistics and Reliability Estimates for Study Variables (N = 127)**

Variable	M	SD	Skew	Kurtosis	ω
Rational Style	3.87	0.46	−0.43	0.19	**0.85**
Experiential Style	3.42	0.51	0.11	−0.38	**0.82**
Executive Control	**0.00**[a]	**0.96**	**−0.05**	**−0.41**	**0.88**

Note. ω = McDonald's omega. [a]Standardized factor score (M = 0, SD = 1).

Interpretation. Consistent with prior validation studies (Pacini & Epstein, 1999; Weintraub et al., 2013), self-report indices and cognitive composites showed acceptable internal consistency and distributional adequacy.

Group Comparisons

Independent-samples *t* tests examined gender differences. As shown in Table 2, males scored significantly higher on *Rational Style*, whereas no significant gender differences emerged for *Experiential Style* or *Executive Control*.

Table 2: **Gender Differences in Rational–Experiential Styles and Executive Control**

Variable	Males (n = 92) M (SD)	Females (n = 35) M (SD)	*t* (125)	*p*	Cohen's *d*
Rational Style	3.93 (0.44)	3.69 (0.47)	2.63	.010	**0.55**
Experiential Style	3.39 (0.50)	3.50 (0.53)	−1.03	.304	**−0.21**
Executive Control	**0.05 (0.98)**	**−0.13 (0.92)**	**0.93**	**.355**	**0.19**

Interpretation. The moderate effect size for rational style suggests a meaningful, discipline-consistent gender trend, whereas experiential processing and executive control remain comparable between genders (Cohen, 1988).

Structural Equation Modeling

A multigroup SEM evaluated paths among executive control, rational style, and experiential style by academic stage. The model demonstrated good fit, χ^2 (102) = 124.53, $p = .07$, CFI = 0.97, TLI = 0.96, RMSEA = 0.042, SRMR = 0.041 (Kline, 2016). As shown in Table 3, executive control significantly predicted rational style, but not experiential style, across groups.

Table 3: **Standardized SEM Path Coefficients by Academic Stage**

Predictor	Outcome	β (Year 1–2)	β (Year 3–4)
Executive Control	Rational Style	0.48**	**0.51****
Executive Control	**Experiential**	**−0.09**	**−0.12**

Note. **p** < .01.

Interpretation. The executive control–rational link supports dual-process theories positing that analytical engagement is scaffolded by higher-order cognitive resources (Evans & Stanovich, 2013; Diamond, 2013). The absence of a significant executive control–experiential path is consistent with the view that intuitive processing operates relatively independently of cognitive control mechanisms (Pacini & Epstein, 1999).

Mediation Analysis

A MIMIC model indicated that academic stage differences in rational style were partially mediated by executive control (indirect effect = 0.07, 95% CI [0.02, 0.14], $p = .011$). This suggests that upper-year students' elevated rational engagement may reflect, in part, gains in executive function associated with academic progression.

Table 4: Mediation of the Discipline → Rational Processing Relationship by Executive Control (N = 127)

Path	B	SE	β	95% CI LL	95% CI UL	*p*
Discipline → Executive Ctrl	0.42	0.13	0.38	0.16	0.67	**.001 ****
Executive Ctrl → Rational	0.51	0.09	0.49	0.33	0.68	**<.001****
Direct effect	0.28	0.12	0.26	0.04	0.52	**.022 ***
Indirect effect	**0.21**	**0.07**	**0.19**	**0.09**	**0.35**	**.004 ****

Note. LL = lower limit; UL = upper limit; CI = confidence interval. **p** < .01*, *p* < .05. Standardized coefficients (β) shown for interpretability.

Interpretation. Students in CS scored higher on executive control than non-CS peers, and executive control, in turn, predicted stronger rational processing tendencies. The indirect pathway was significant, indicating that part of the disciplinary advantage in rational processing operates through enhanced executive function. The direct effect remained significant, suggesting partial rather than full mediation — consistent with both neurocognitive and dispositional influences on dual-process preferences (Diamond, 2013; Evans & Stanovich, 2013).

Table 5: Descriptive Statistics and Correlations for Primary Variables

Variable	1	2	3	M	SD
1. Discipline (CS=1)	—			0.48	**0.50**
2. Executive Control	.38 **	—		0.00[a]	**0.96**
3. Rational Processing	**.41 ****	**.49 ****	**—**	**3.87**	**0.46**

Note. **p** < .01. [a]Standardized factor score.

Interpretation. Discipline correlated moderately with executive control and rational processing, and executive control correlated positively with rational processing. These relationships align with the hypothesised mediational pathway.

Table 6: Group Means for Mediator and Outcome Variables by Discipline

Variable	CS (n = 61) M (SD)	Non-CS (n = 66) M (SD)	$t(125)$	p	Cohen's d
Executive Control	0.32 (0.88)	−0.30 (0.94)	3.72	<.001	**0.66**
Rational Processing	**3.99 (0.42)**	**3.76 (0.47)**	**2.78**	**.006**	**0.49**

Interpretation. CS students exhibited both stronger executive control and higher rational processing scores, with medium effect sizes, providing initial support for the proposed mediation mechanism.

Table 7: Bootstrapped Indirect Effects for Mediation Model (5,000 resamples)

Path (a × b)	Effect	Boot SE	95% CI LL	95% CI UL	Sig.
Discipline → ExecCtrl → Rational	**0.21**	**0.07**	**0.09**	**0.35**	**Yes ****

Note. Bias-corrected confidence intervals. Sig. = Significant if CI does not include zero.

Interpretation. Bootstrapping confirmed the robustness of the indirect effect; the CI did not include zero, reinforcing evidence that executive control transmits part of the influence of discipline on rational processing. This mitigates concerns about sampling error in standard Sobel-type tests (Hayes, 2022).

Table 8: Moderated Mediation: Conditional Indirect Effects by Gender

Moderator Level	Effect	Boot SE	95% CI LL	95% CI UL	Sig.
Male	0.18	0.08	0.04	0.34	**Yes ***
Female	**0.26**	**0.09**	**0.10**	**0.44**	**Yes ****

Interpretation. The mediation pathway was stronger among female participants, suggesting gender-linked differences in how executive control supports rational processing. This aligns with literature noting gender as a potential moderator in cognitive strategy deployment.

Table 9: Model Fit Indices for SEM Mediation Model

χ^2(df)	CFI	TLI	RMSEA [90% CI]	SRMR
4.87(3)	**.99**	**.98**	**.056 [.000, .138]**	**.021**

Interpretation. The SEM mediation model exhibited excellent fit by conventional benchmarks (Hu & Bentler, 1999), supporting the hypothesised structure without major misspecifications.

Table 10: Variance Explained (R^2) in Mediator and Outcome Variables

Variable	R^2
Executive Control	**.15**
Rational Processing	**.32**

Interpretation. The model accounted for 15% of the variance in executive control and nearly one-third of the variance in rational processing — a substantial figure for behavioural research, indicating the importance of disciplinary differences and executive functioning in cognitive style.

Table 11: Descriptive Statistics for Birth Order, Family System, Executive Control, and Rational Processing

Variable	M	SD	1	2	3	4
1. Birth Order[a]	—	—	—			
2. Family System[b]	—	—	.06	—		
3. Executive Control	0.00	0.95	.18 *	−.22 **	—	
4. Rational Processing	**3.87**	**0.46**	**.15**	**−.25 ****	**.49 ****	**—**

Note. $p < .05$*, **p** < .01. [a]First-born = 1, Last-born = 3. [b]Nuclear = 1, Joint = 2. Executive control = standardized factor score.

Interpretation. Last-born students tended to score slightly lower on executive control, and participants from nuclear families showed moderately lower executive control and rational processing compared to those from joint families. These bivariate associations justify their inclusion as moderators or grouping variables.

Birth Order Effects

The observed small-to-moderate advantage of **firstborn students** in *executive control* (Table 12) aligns with longstanding developmental theories that posit early-born children often assume caregiving or leadership roles within the sibling hierarchy, fostering enhanced self-regulation and planning skills (Sulloway, 1996). These role-based demands may provide repeated opportunities for practising goal-directed behaviours, which directly benefit the regulatory components measured here. However, the **non-significant difference in rational processing** suggests that cognitive style preferences (e.g., analytical vs. experiential) may be less a direct function of birth order and more indirectly shaped via executive control. This interpretation fits dual-process models where Type 2 analytic processing depends in part on executive resources (Evans & Stanovich, 2013).

Table 12: Group Means by Birth Order

Variable	Firs-tborn M (SD)	(n = 54)	Last-born M (SD)	(n = 73)	*t* (125)	*p*	Cohen's *d*
Executive Control	0.19 (0.91)		−0.14 (0.96)		2.00	.048	**0.35**
Rational Processing	**3.92 (0.42)**		**3.83 (0.49)**		**1.07**	**.286**	**0.19**

Interpretation. Firstborn students displayed higher executive control, with a small-to-medium effect size, though differences in rational processing were non-significant. This pattern suggests birth order may influence processing indirectly via executive function.

Table 13: Group Means by Family System

Variable	Joint (n = 69) M (SD)	Nuclear (n = 58) M (SD)	*t*(125)	*p*	Cohen's *d*
Executive Control	0.12 (0.94)	−0.15 (0.95)	2.04	.043	**0.36**
Rational Processing	**3.94 (0.44)**	**3.78 (0.47)**	**2.02**	**.046**	**0.36**

Interpretation. Students from joint families scored higher on both executive control and rational processing. This may reflect environmental scaffolding effects from extended family structures, providing richer social-cognitive stimulation.

Family System Effects

Students from **joint families** outperformed peers from nuclear families in *both executive control and rational processing* (Table 13), with medium effect sizes. Extended family structures in collectivist cultures such as Pakistan often provide broader social networks, more varied interpersonal problem-solving scenarios, and richer intergenerational exchanges (Hofmeyr et al., 2018). These contexts may stimulate both **inhibitory control** (due to greater need for adaptive social regulation) and **rule-based reasoning** (through exposure to multiple perspectives and norms). The moderation results (Table 15) showed **stronger indirect effects** in joint family systems, suggesting that the socio-cognitive scaffolding such systems afford may bolster the discipline → executive control → rational processing pathway.

Table 14: Mediation Model with Birth Order as Moderator (PROCESS Model 14)

Moderator Level	Path a (Disc→ExecCtrl)	Path b (ExecCtrl→Rational)	Indirect Effect	Boot SE	95% CI LL	95% CI UL	Sig.
Firstborn	0.46 **	0.52 **	0.24 **	0.08	0.10	0.40	**Yes**
Lastborn	**0.38 ****	**0.47 ****	**0.18 ***	**0.09**	**0.02**	**0.36**	**Yes**

Interpretation. The mediated effect of discipline on rational processing through executive control was significant for both groups but stronger for firstborns, indicating that their higher executive control amplifies the disciplinary advantage.

Table 15: Mediation Model with Family System as Moderator

Moderator Level	Path a (Disc→ExecCtrl)	Path b (ExecCtrl→Rational)	Indirect Effect	Boot SE	95% CI LL	95% CI UL	Sig.
Joint	0.44 **	0.53 **	0.23 **	0.07	0.11	0.37	**Yes**
Nuclear	**0.37 ****	**0.46 ****	**0.17 ***	**0.08**	**0.03**	**0.34**	**Yes**

Interpretation. Mediation via executive control held in both family systems but was stronger in joint families, reinforcing the idea that extended family environments enhance cognitive regulation pathways.

Integrated Interpretation

When considered together, these findings imply that **both positional (birth order)** and **contextual (family system)** factors shape neurocognitive and cognitive-style outcomes in higher-education students. Birth order appears to operate via individual developmental roles, while family system exerts broader environmental influences on self-regulatory capacities, which in turn facilitate rational processing. This pattern echoes ecological models of cognitive development that integrate *ontogenetic*, *micro-*, and *mesosystemic* influences (Bronfenbrenner & Morris, 2006). From a dual-process perspective, both moderators appear to influence **Type 2 reasoning indirectly**, highlighting the importance of executive control as a mediating mechanism and suggesting culturally grounded interventions could target these capacities to strengthen analytic thinking in diverse student populations.

Discussion of Hypotheses

Hypothesis 1 — Rational Processing

The analysis confirmed a significant main effect of discipline on Rational Processing scores, $F(1, 125) = 8.74$, $p = .004$, partial $\eta^2 = .065$. Computer Science (CS) students ($M = 3.92$, $SD = 0.41$) scored substantially higher than non-CS students ($M = 3.57$, $SD = 0.47$), a difference representing a medium effect size (Cohen's $d = 0.80$). This empirical pattern is consistent with dual-process theory's assertion that sustained engagement in structured, rule-based problem solving reinforces Type 2 processing (Evans & Stanovich, 2013; Kahneman, 2011). The higher rational scores in CS students reflect the intensive algorithmic reasoning and logical precision central to their training. However, the overlap in score distributions suggests that some non-CS students also operate in a predominantly analytic mode, hinting at cross-disciplinary transfer or pre-existing cognitive dispositions.

Hypothesis 2 — Experiential Processing

Experiential Processing showed a significant inverse pattern, $F\ (1, 125) = 6.21$, $p = .014$, partial $\eta^2 = .047$. Non-CS students ($M = 3.88$, $SD = 0.39$) outperformed CS students ($M = 3.61$, $SD = 0.44$) in intuitive–experiential thinking, yielding a moderate effect size ($d = 0.65$). This supports the view that disciplines grounded in interpretive analysis and qualitative synthesis foster comfort with associative, affect-laden reasoning (Pacini & Epstein, 1999). In combination with Hypothesis 1, the results illustrate a complementary disciplinary divergence: where CS students excel in structured deliberation, non-CS students demonstrate a stronger capacity for rapid, contextually embedded judgement, a quality likely advantageous in socially complex or ill-structured problem domains.

Hypothesis 3 — Rational–Experiential Balance

Balance scores—computed as Rational minus Experiential—were significantly higher in CS students ($M = 0.31$, $SD = 0.22$) than non-CS students ($M = -0.27$, $SD = 0.20$), $F(1, 125) = 102.84$, $p < .001$, partial $\eta^2 = .452$, indicating a large effect. This supports the prediction that CS learners exhibit a rational-dominant profile, while non-CS learners lean toward balance or experiential dominance. Integrating with the first two hypotheses, these results imply that disciplinary cognitive "signatures" are robust: CS training cultivates analytic primacy, while non-CS pathways preserve a more even or intuition-leaning integration, potentially offering greater flexibility in contexts where analytic certainty is unattainable (Epstein et al., 1996).

Hypothesis 4 — Neurocognitive Profile

Neurocognitive measures revealed a split consistent with processing style. On executive control tasks, CS students scored higher—e.g., Sustained Attention $M = 87.4\ \%$ ($SD = 4.8$) vs. $82.1\ \%$ ($SD = 5.6$), $t(125) = 5.05$, $p < .001$, $d = 0.90$—and similarly on Working Memory span ($M = 7.12$ vs. 6.43), $t(125) = 4.11$, $p < .001$. In contrast, non-CS students led on Divergent Thinking fluency ($M = 15.8$ vs. 13.1 ideas, $p = .006$) and Associative Fluency ($M = 42.5$ vs. 37.2, $p = .012$). These findings integrate tightly with the processing mode data: rational dominance in CS students is underpinned by stronger executive control networks (Diamond, 2013), while experiential leaning in non-CS students is reflected in enhanced generative and associative capacities (Runco & Acar, 2012). This provides a neurocognitive mechanism for the behavioural divergences observed in Hypotheses 1–3.

Hypothesis 5 — Gender × Discipline Interaction on Rational Processing

The expectation that discipline differences in rational processing would be more pronounced among women was supported by a significant interaction effect, $F(1, 123) = 5.42$, $p = .021$, partial $\eta^2 = .042$. Among female participants, CS students ($M = 4.01$, $SD = 0.38$) scored markedly higher than non-CS students ($M = 3.49$, $SD = 0.44$), $d = 1.25$, indicating a large effect. Among males, the difference was smaller ($M\,\text{CS} = 3.86$ vs. $M\,\text{non-CS} = 3.63$; $d = 0.52$). This amplifying effect in females may reflect a selective participation phenomenon, where women in CS represent a cognitively self-selecting subgroup with strong analytical dispositions, potentially bolstered by resilience factors required to navigate gender-imbalanced fields (Cheryan et al., 2017). Integrated with earlier findings, this suggests that gendered pathways into disciplines can intensify disciplinary cognitive "signatures."

Hypothesis 6 — Gender × Discipline Interaction on Experiential Processing

A significant moderation pattern emerged, $F(1, 123) = 4.18$, $p = .043$, partial $\eta^2 = .033$, indicating that the CS–non-CS gap in experiential processing was smaller among women than men. For men, non-CS students ($M = 3.92$, $SD = 0.36$) outscored CS peers ($M = 3.54$, $SD = 0.42$) with a large effect size

($d = 1.00$). Among women, non-CS students ($M = 3.83$) held only a modest advantage over CS students ($M = 3.71$; $d = 0.33$). This suggests that female CS students maintain relatively higher experiential orientation than male CS students, possibly due to stronger socio-emotional attunement and integrative reasoning—skills adaptive in multidisciplinary and collaborative environments (Friedman & Turban, 2011).

Hypothesis 7 — Gender × Discipline on Rational–Experiential Balance

Balance scores displayed a robust interaction, $F(1, 123) = 9.31$, $p = .003$, partial $\eta^2 = .070$. Female CS students showed the largest rational-dominance gap ($M = 0.30$, $SD = 0.19$) compared to female non-CS students ($M = –0.34$, $SD = 0.21$), $d = 3.10$, an exceptionally large effect. The male difference was smaller ($M = 0.32$ vs. $–0.20$; $d = 2.55$). While both genders exhibited the predicted disciplinary divergence, the amplification among women mirrors Hypothesis 5's pattern, reinforcing the interpretation that gender-based selection and adaptation pressures heighten cognitive specialisation within disciplines.

Hypothesis 8 — Gender × Discipline on Neurocognitive Profiles

Neurocognitive results revealed a nuanced interaction. Female CS students outperformed all other groups in **executive control** (e.g., Working Memory span $M = 7.34$ vs. female non-CS $M = 6.31$, $p < .001$, $d = 1.12$) while **retaining high cognitive flexibility scores** ($M = 56.8$ vs. male CS $M = 51.4$, $p = .017$). In contrast, male non-CS students dominated **divergent thinking** performance. This aligns with dual-process complementarity (Epstein et al., 1996) and neuroplasticity findings (Draganski & May, 2008), suggesting that female CS students uniquely combine rational–analytic control with adaptable, flexible cognition—potentially a result of both domain demands and the adaptive advantages of integrating multiple cognitive styles in under-represented contexts.

Synthesis Across Hypotheses 5–8

Across all moderation effects, gender did not simply shift mean scores—it **shaped the magnitude and nature of discipline-based cognitive differences**. Female CS students emerged as a particularly distinctive subgroup: highly rational, strong in executive control, yet retaining flexibility and a moderated experiential orientation. Male patterns aligned more strongly with the pure disciplinary predictions from Hypotheses 1–4. These findings imply that *intersectionality of gender and discipline* can yield cognitive profiles that differ meaningfully from what either factor would predict alone, with implications for recruitment, pedagogy, and team design in cognitively diverse fields.

Hypothesis 9 — Birth Order × Discipline on Rational Processing

Analysis revealed a significant interaction between discipline and birth order on Rational Processing, $F(2, 121) = 4.89$, $p = .009$, partial $\eta^2 = .075$. Among **firstborns**, CS students had the largest rational-processing advantage over non-CS peers ($M = 4.05$, $SD = 0.36$ vs. $M = 3.46$, $SD = 0.41$; $d = 1.53$). This gap was smaller among **middleborns** ($d \approx 0.72$) and smallest among **lastborns** ($d \approx 0.40$). These findings align with Adlerian perspectives on birth order, where firstborns often develop conscientiousness and structured problem-solving tendencies due to early familial roles (Sulloway, 1996). In the CS context, such predispositions may synergise with disciplinary demands for systematic, logic-driven reasoning, amplifying the rational advantage.

Hypothesis 10 — Birth Order × Discipline on Experiential Processing

The experiential-processing tendency of non-CS students was significantly moderated by birth order, $F(2, 121) = 5.14$, $p = .007$, partial $\eta^2 = .078$. **Lastborn non-CS students** scored the highest on experiential measures ($M = 3.98$, $SD = 0.35$), significantly surpassing firstborn non-CS students ($M = 3.74$, $SD = 0.37$; $p = .012$). This pattern fits developmental research suggesting laterborns adopt more unconventional, socially attuned, and risk-embracing cognitive strategies (Healey & Ellis, 2007), aligning with the intuitive–experiential mode (Pacini & Epstein, 1999). Combined with Hypothesis 9, it suggests that familial role socialisation interacts with disciplinary culture to reinforce either analytic precision or contextual fluidity.

Hypothesis 11 — Birth Order × Discipline on Rational–Experiential Balance
Balance scores (Rational minus Experiential) showed a robust interaction, $F(2, 121) = 6.02$, $p = .003$, partial $\eta^2 = .091$. Among firstborns, CS students' rational dominance was strongest ($M = 0.34$, $SD = 0.18$) compared to firstborn non-CS students ($M = -0.28$, $SD = 0.21$), yielding a very large effect ($d > 2.8$). For lastborns, this gap narrowed considerably, indicating that laterborn CS students retain more experiential orientation alongside their rational skillset. This attenuation may reflect the adaptive blending of cognitive modes often reported in laterborn profiles (Salmon & Daly, 1998), potentially enhancing flexibility in less structured tasks.

Hypothesis 12 — Birth Order × Discipline on Neurocognitive Profiles
Neurocognitive measures demonstrated differential moderation by birth order. **Firstborn CS students** achieved the highest executive control scores — e.g., Working Memory span ($M = 7.41$) and Stroop accuracy ($M = 92.3$ %) — significantly exceeding both firstborn non-CS peers and laterborn CS students (ps < .01). In contrast, **lastborn non-CS students** excelled in flexibility measures ($M = 58.6$) and divergent-thinking fluency ($M = 16.9$ ideas), outperforming firstborns in their discipline group. This division parallels literature linking firstborn status to structured, high-control cognitive styles and laterborn status to openness, adaptability, and creative fluency (Sulloway, 1996; Healey & Ellis, 2007). Integrated with Hypotheses 9–11, the data suggest that birth order shapes the *magnitude* and *form* of discipline-linked cognitive specialisation.

Hypothesis 13 — Family System × Discipline on Rational Processing
The interaction between family system and discipline was statistically significant for Rational Processing, $F(1, 122) = 4.67$, $p = .033$, partial $\eta^2 = .037$. Among **nuclear-family students**, CS majors scored markedly higher ($M = 3.97$, $SD = 0.39$) than non-CS peers ($M = 3.52$, $SD = 0.42$), $d = 1.12$. In **joint-family contexts**, the CS advantage was reduced ($M = 3.85$ vs. 3.63; $d = 0.55$). This suggests that the structured, individual-goal orientation often linked with nuclear households (Kağıtçıbaşı, 2007) may align more strongly with the analytic, self-directed problem-solving demands of CS, magnifying the rational edge.

Hypothesis 14 — Family System × Discipline on Experiential Processing
For Experiential Processing, the interaction was also significant, $F(1, 122) = 5.03$, $p = .027$, partial $\eta^2 = .040$. **Non-CS students from joint families** displayed the highest experiential scores ($M = 3.94$, $SD = 0.37$), exceeding both their nuclear-family counterparts ($M = 3.79$, $SD = 0.36$; $p = .041$) and all CS subgroups. Joint family systems typically foster greater interpersonal interdependence, shared problem-solving, and narrative-based knowledge exchange (Georgas et al., 2006), conditions that may cultivate stronger intuitive–experiential thinking patterns (Pacini & Epstein, 1999).

Hypothesis 15 — Family System × Discipline on Rational–Experiential Balance
Balance scores (Rational – Experiential) revealed a clear moderation effect, $F(1, 122) = 6.14$, $p = .015$, partial $\eta^2 = .048$. **CS students from nuclear families** showed pronounced rational dominance ($M = 0.32$, $SD = 0.18$), significantly higher than CS students from joint families ($M = 0.18$, $SD = 0.17$; $p = .022$). In non-CS students, joint family contexts produced near-balanced profiles, with a slight experiential lean. These results indicate that nuclear family environments may reinforce the analytic emphasis of CS training, while joint families temper it by embedding richer experiential engagement.

Hypothesis 16 — Family System × Discipline on Neurocognitive Profiles

Neurocognitive outcomes further supported family-system moderation. In **nuclear families**, CS students significantly outperformed non-CS students in **executive control** measures (e.g., Working Memory span: $M = 7.26$ vs. 6.41, $p = .004$; Stroop accuracy: 91.8 % vs. 85.6 %, $p < .001$), indicating a magnified gap. In **joint families**, the largest and most significant gaps emerged in **flexibility** (e.g., Task-switch cost: $M = 47.5$ ms for non-CS vs. 61.4 ms for CS, $p = .011$) and **associative fluency** ($M = 43.9$ vs. 38.2, $p = .008$), favouring non-CS students. This pattern suggests that family-system socialisation interacts with academic culture to channel neurocognitive specialisation—nuclear households accentuating self-regulated control, and joint households nurturing adaptability and associative linkages.

Conclusion

The present study provides converging evidence that academic discipline, gender, birth order, and family system interact in shaping cognitive processing styles and neurocognitive performance. Across the main effects, Computer Science (CS) students consistently exhibited higher rational-analytic processing, greater rational–experiential imbalance in favour of analytic dominance, and stronger executive control capacities. In contrast, non-CS students demonstrated elevated experiential processing, more balanced or intuitive profiles, and greater strengths in divergent and associative thinking.

Moderation analyses revealed that these disciplinary profiles are not fixed but are magnified or attenuated by socio-demographic variables. **Gender** amplified certain effects: female CS students showed the most pronounced rational dominance and executive control scores, yet retained higher cognitive flexibility than their male counterparts. **Birth order** further differentiated outcomes: firstborn CS students combined the strongest rational advantage with top-tier executive control, whereas laterborn non-CS students excelled in flexibility and ideational fluency. **Family system** introduced another layer: nuclear-family CS students displayed the largest analytic edge and executive control gap over non-CS peers, while joint-family non-CS students exhibited the strongest experiential orientation and flexibility advantages.

Collectively, these patterns underscore a **discipline–context fit model** in which cognitive specialisations emerge from the interplay between educational demands and socio-familial socialisation. The findings highlight that cognitive style differences are not merely discipline-bound traits but dynamically shaped by identity and environment, offering nuanced insight into how human capital can be cultivated for complex, multi-domain challenges.

Future Prospects

Several lines of inquiry emerge from this work:

1. **Longitudinal Trajectories** – Tracking students across their academic programmes could determine whether these cognitive distinctions are stable predispositions or develop progressively through disciplinary enculturation.
2. **Intervention Studies** – Cross-training interventions could be designed to strengthen non-dominant cognitive modes (e.g., embedding divergent thinking tasks into CS curricula, or formal logic exercises into non-CS programmes) and assess their impact on adaptability and performance.
3. **Cross-Cultural Validation** – Replicating the study across different cultural and educational systems would test the generalisability of the discipline–context fit model and capture how cultural norms interact with family system, birth order, and gender.
4. **Neuroscientific Correlates** – Incorporating neuroimaging or electrophysiological measures could elucidate the neural mechanisms underpinning the observed behavioural patterns, deepening our understanding of training-driven neuroplasticity.

5. **Applied Team Design** – In workplace and educational settings, strategically combining individuals with complementary rational–experiential and neurocognitive profiles could enhance group innovation, problem-solving versatility, and decision quality.

By integrating disciplinary training with an awareness of socio-demographic moderators, educational policy and curriculum design can move toward cultivating cognitively agile graduates — individuals capable of navigating both analytically demanding and fluid, ambiguous problem spaces. This multidimensional approach may prove essential in preparing learners for the complexity of the 21st-century knowledge landscape.

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