UNIVERSITY OF FRIBOURG, SWIZTERLAND
UNIVERSITY EDUCATION AND DIGITAL SKILLS DEPARTMENT

PROFESSIONAL PROJECT: CRITICAL ISSUES AND LIMITATIONS IN COGNITIVE SCIENCES RESEARCH.

Final work for the Certificate in Higher Education and Educational Technology
Under the direction of dr. Dorothée Ayer

Stefano IOANNUCCI
Department of Psychology, Faculty of Humanities, University of Fribourg
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I declare on my honour that my final work is my own work, composed without any unauthorized outside assistance.

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Setting the project in a professional context

In recent years, cognitive science and neuroscience research have encountered considerable scrutiny regarding the rigor and reproducibility of their findings. This scrutiny is part of a larger "replication crisis" that has swept across the social and biomedical sciences, revealing foundational issues in study design, statistical methods, and scientific publishing practices (Munafò et al., 2017). For students pursuing studies in cognitive science, neuroscience and related disciplines, a deep awareness and understanding of these challenges is crucial—not only for their ability to produce credible and impactful research but also to critically engage with existing literature.

The ongoing replication crisis has highlighted widespread problems, such as insufficient statistical power, questionable research practices and publication biases, which have collectively undermined the reliability of many published findings in psychology and neuroscience (Open Science Collaboration, 2015). This crisis has far-reaching implications for the field, calling into question the validity of established theories (that are often taught to students) and the strength of the evidence base guiding both scientific advancement and real-world applications. As the next generation of researchers and practitioners, students must be equipped with the analytical skills and methodological rigor necessary to navigate this complex landscape and contribute to the development of more robust, reproducible, and ethically sound scientific practices. Addressing these system challenges has become a priority for the broader cognitive science community. A growing movement toward open science, mass collaboration projects, and enhanced transparency aims to mitigate issues like publication bias and inadequate statistical power (Nosek et al., 2018). Therefore, this project proposes a specialized course titled **"Critical Issues and Limitations in Cognitive Sciences Research"**, which targets advanced undergraduate or graduate students in cognitive science, neuroscience, or related disciplines. The course aligns with both the educational needs of students and the professional demands of the field by fostering analytical and methodological competencies directly relevant to the challenges facing cognitive science research today. It is part of a growing ongoing effort within the field, as attested by the flourishing of interest and formative material around the topic.

Within the professional context, this course responds to a pressing need to prepare students with the critical thinking skills and methodological expertise required to engage meaningfully with published research in their domain of study. As students transition into academic or industry roles, the ability to identify potential weaknesses in research designs, interpret data with nuance, be aware of the limitations in scientific publishing, and propose innovative solutions will be increasingly essential. Through an in-depth examination of these contemporary challenges, this course aims to equip learners with a comprehensive toolkit to navigate such complexities, cultivating the development of independent thinkers who can contribute to the advancement of the field with rigor and integrity.

This learning project also adopts a socially constructivist, flipped-classroom approach to its material. A socially constructivist model emphasizes collaborative learning and knowledge co-construction, a concept based on Vygotsky's (1978) theory of the "zone of proximal development," where students expand their understanding through guided interactions. In this setting, knowledge is not merely transmitted from instructor to student; rather, it is constructed as students analyze and critique research independently. The flipped-classroom model further complements this approach by shifting autonomous learning outside of the classroom, making in-class time a space for active, participatory learning (Bergmann & Sams, 2012). In doing so, this project envisions to provide students with a dynamic environment that encourages debate, inquiry, and critical reflection.

Project objectives

The primary objective of this course is to promote students' ability to critically evaluate cognitive science and neuroscience research, recognizing both methodological limitations and potential biases in study design. The course is structured to enhance analytical and evaluative skills through progressive exposure to real-world examples of both well-conducted and flawed studies. Therefore, the course aims to equip students with the necessary competences to identify weaknesses in research practices and to propose feasible improvements, committing to the development of independent thinkers able to navigate specialized literature. Specifically, the course seeks to develop students who can:

- **Critically evaluate cognitive science research by identifying methodological limitations and biases.**
- **Apply rigorous analytical approaches to research evaluation.**
- **Contribute to improving research practices through evidence-based critique.**
- **Engage collaboratively in the scientific discourse.**
- **Demonstrate ethical awareness in research practice.**

Description of context

For this pedagogical project, the chosen instructional approach consists in the “block course” model. In the context of higher education, the block course—an intensive, short-term program condensed into several consecutive days—has proven to be highly effective for teaching specialized subjects. This format aligns closely with constructivist pedagogical theory, which emphasizes active, student-centered learning over passive reception of knowledge (Bruner, 1961; Vygotsky, 1978). The block course model facilitates a learning environment that is immersive and focused, allowing students to dedicate their cognitive resources fully to the subject matter without the distractions and competing deadlines often associated with traditional semester-long courses (Tinto, 2007). By limiting the scope to a single topic at a time, the block format helps to level the playing field and provides all learners with the opportunity to engage deeply with the material. Embedded within the block course approach is the concept of "assessment for learning" (Black & Wiliam, 1998), which aligns closely with social constructivist classrooms where knowledge is co-constructed through social interaction and dialogue. In this model, assessments are not merely final evaluations, but rather integrated into the flow of classroom activities, providing students with immediate, constructive feedback that reinforces their understanding and addresses knowledge gaps in real-time (Sadler, 1989). This formative assessment strategy, combined with the intensive nature of the block format, facilitates a dynamic learning experience where students and educators collaborate to build and refine their comprehension of the subject matter.

Despite these advantages, the block model does present challenges due to its intensity. For both students and instructors, the model requires robust planning and a flexible mindset to accommodate the increased pace (Davies, 2006). Educators need to abandon traditional structures in favor of methods that support active learning and resilience under condensed schedules. According to research on cognitive load theory, the design of such courses should carefully consider pacing, allowing room for reflection to ensure sustained engagement and avoid burnout (Scott, 2003), multimedia content or innovative student-engaging practices are also highly beneficial in this context.

The instructor’s role within the block model also shifts significantly. Rather than delivering continuous content in a lecture-based format, the instructor acts as a facilitator, guiding students through group work, presentations, debates, and analysis activities that allow for self-directed knowledge construction. In essence, this model incorporates aspects of a flipped classroom, where students prepare with foundational knowledge and then actively apply and interrogate concepts in the classroom. This promotes a deeper understanding of the subject matter and fosters ownership of learning, as students themselves engage in critical thinking and knowledge application (Mazur, 2009). Immersing students in a focused, collaborative environment that emphasizes active engagement, the block course model aligns with the principles of social constructivism and self-regulated learning. This pedagogical approach is particularly well-suited for tackling specialized and complex topics, as the one in this proposal.

Needs analysis

Effective educational design in cognitive sciences must begin with a thorough understanding of learners' needs, particularly given the field's evolving methodological challenges and increasing analytical complexity. This analysis examines several key dimensions that inform the course's pedagogical approach and content structure.

In contemporary cognitive science and neuroscience, students face increasingly sophisticated methodological and analytical demands. Beyond fundamental research skills, they require advanced statistical literacy to navigate complex research designs and critical evaluation abilities to assess scientific literature meaningfully (Button et al., 2013; Munafò et al., 2017). These competencies are not merely academic requirements but translate directly to professional demands in both research and industry settings. The field's rapid evolution necessitates that students develop adaptable analytical skills and a deep understanding of methodological rigor that will serve them throughout their careers.

The replication crisis in cognitive science has revealed systemic challenges that directly impact how we train future researchers. Specific issues such as chronically low statistical power in neuroimaging studies (typically below 30%; Button et al., 2013, Poldrack et al., 2017), pervasive publication bias favoring positive results (Ioannidis, 2005), and inconsistent analysis pipelines in fMRI research (Botvinik-Nezer et al., 2020) exemplify the field's methodological challenges. Recent high-profile failures to replicate influential studies, such as ego-depletion research (Hagger et al., 2016) and social priming effects (Doyen et al., 2012), underscore the importance of methodological rigor. These challenges demand that students develop practical skills in preregistration, power analysis, and reproducible workflows (Nosek et al., 2018). Understanding these issues is not merely theoretical; it shapes how future researchers will design, conduct, and evaluate studies.

The diverse academic backgrounds of students in cognitive science necessitate an integrated approach to methodology training. While statistical methods and research design principles may be universal, their application varies across subdisciplines. This diversity presents both a challenge and an opportunity: course content must be accessible to students from various backgrounds while leveraging their different perspectives to enrich collective understanding, following principles of inclusive pedagogy (Hockings, 2010). Case studies drawn from multiple subdisciplines and collaborative work groups mixing different specializations can facilitate this integration, an approach supported by research in interdisciplinary education (Repko & Szostak, 2020).

Students enter cognitive science programs with varying levels of (and interest in) statistical sophistication and research experience, a heterogeneity that demands careful pedagogical consideration (Biggs & Tang, 2011). Some may have extensive programming experience but limited exposure to experimental design, while others may have strong theoretical foundations but need support with quantitative methods. This diversity requires a flexible pedagogical approach that can accommodate different learning styles and prior knowledge levels, aligned with theories of differentiated instruction (Tomlinson, 2014). Interactive workshops, hands-on analysis sessions, and peer learning opportunities provide multiple pathways to master course material, following established principles of active learning (Prince, 2004). Individual consultation opportunities and supplementary materials ensure that students can access appropriate support regardless of their starting point.

The complexity of research methodology education demands a comprehensive assessment approach that goes beyond traditional evaluation methods (Black & Wiliam, 2009). Continuous monitoring of skill development, regular verification of understanding, and practical application assessment are essential. This necessitates multiple feedback channels, including immediate in-class responses, peer review sessions, and detailed written evaluations. The assessment structure must balance the need for rigorous evaluation with opportunities for learning from mistakes and iterative improvement, following principles of formative assessment (Sadler, 1989).

The above-outlined needs analysis has directly shaped the course design, informing the adoption of a block format that allows deep engagement with complex topics, the integration of varied assessment methods, and the incorporation of real-world applications. The emphasis on collaborative learning and continuous feedback reflects the field's professional realities, where research quality depends on rigorous peer review and methodological transparency.

Roles

In a block course designed around social constructivist principles, the educator's role transcends traditional instructional paradigms. As mentioned, rather than functioning as a mere transmitter of knowledge, the instructor becomes a facilitator of learning experiences, a guide in knowledge construction, and a moderator of critical discussions (King, 1993). This transformation fits well with contemporary understanding of effective science education, where instructors create environments conducive to discovery and critical thinking rather than simply delivering content (Hmelo-Silver & Barrows, 2006).

The instructor's responsibilities in this context can be understood through three primary dimensions:

First, as a learning architect, the instructor designs and scaffolds experiences that progressively develop students' analytical capabilities. This involves carefully structuring paper analyses, moderating group discussions, and creating opportunities for peer feedback that align with students' zones of proximal development (Vygotsky, 1978). For example, when introducing paper critique sessions, the instructor first models the analysis process, then guides students through collaborative evaluation, before finally supporting independent analytical work.

Second, as a feedback facilitator, the instructor integrates assessment seamlessly into the learning process. This role manifests through real-time guidance during research analyses, structured feedback during presentations, and facilitation of peer review sessions. Following the principles of formative assessment (Black & Wiliam, 2009), feedback becomes a tool for learning rather than merely evaluation, helping students refine their understanding of methodological rigor and research critique.

Third, as a metacognitive guide, the instructor helps students reflect on their learning process and development as critical thinkers. This involves promoting self-assessment, encouraging reflection, and fostering awareness of how methodological understanding evolves through practice (Schön, 1987).

Within this constructivist framework, students transition from passive recipients to active architects of their understanding. This shift emphasizes three key roles:

First, as critical analysts, students engage directly with research literature, developing and applying analytical frameworks to evaluate methodological rigor. This role requires students to move beyond surface-level reading to deep analysis, questioning assumptions, and identifying methodological strengths and weaknesses (Ennis, 2018).

Second, as collaborative learners, students participate in knowledge construction through group work, peer feedback, and collective problem-solving. This collaboration extends beyond simple group tasks to include negotiating meanings, challenging perspectives, and synthesizing diverse viewpoints. Following principles of cooperative learning (Johnson & Johnson, 2009), students learn not only from course materials but also from peers' insights and experiences.

Third, as reflective practitioners, students regularly examine their own learning process and evolving understanding of science production. This metacognitive practice helps develop self-regulated learning skills essential for ongoing professional development (Zimmerman, 2002).

The effectiveness of this pedagogical approach relies on the dynamic interaction between instructor and student roles. When an instructor models critical analysis of a research paper, students actively engage by questioning assumptions and proposing alternative interpretations. Similarly, during group discussions, the instructor's role shifts between facilitator and observer, allowing students to take ownership of their learning while providing guidance when needed.This carefully orchestrated interaction creates what Lave and Wenger (1991) describe as a "community of practice," where learning occurs through legitimate peripheral participation in authentic research analysis activities. As students become more proficient, the instructor gradually reduces scaffolding, promoting greater autonomy in analytical thinking and methodological critique.

Pedagogical scenario:

1. **Contents**

The course "Critical Issues and Limitations in Cognitive Sciences Research" provides a structured exploration of methodological challenges and solutions in contemporary cognitive science. The content is organized into four interconnected thematic axes, each containing theoretical foundations, real-world examples, practical applications and current debates. This content structure enables progressive skill development while maintaining clear connections between theoretical understanding and practical application. The sequence allows students to build from fundamental concepts to advanced applications, with each block reinforcing and expanding upon previous learning. These thematic axes are:

Axe I: Foundations of Scientific Publishing and Research Evaluation

- Evolution of scientific publishing practices
  - Historical development of peer review
  - Current publication models and their implications
  - Impact factors and citation metrics
- Contemporary challenges in academic publishing
  - "Publish or perish" culture and its consequences
  - Authorship issues (contribution assessment, author ordering)
  - Editorial biases and journal policies
  - Predatory publishing and quality control
- Critical reading of scientific papers
  - Structure and evaluation of research articles
  - Identifying methodological strengths and weaknesses
  - Assessment of statistical reporting
  - Recognition of potential biases

Axe II: Methodological Issues in Cognitive Science

- Statistical foundations and common problems
  - Power analyses and sample size determination
  - Multiple comparisons and error rates
  - Effect size estimation and interpretation
  - Bayesian vs. frequentist approaches
- Research design challenges

- Control group selection and matching
- Randomization procedures
- Blinding methods
- Confound identification and control

▪ Measurement and instrumentation

- Reliability and validity considerations
- Standardization of procedures
- Calibration and quality control
- Data preprocessing decisions

Axe III: Specific Challenges in Neuroscience Research

▪ Neuroimaging methodology

- fMRI design considerations
- Statistical power in neuroimaging
- Multiple testing in whole-brain analyses
- Reproducibility of imaging findings

▪ Data analysis pipelines

- Preprocessing decisions and their impact
- Analysis software comparisons
- Parameter selection and justification
- Results validation methods

▪ Common pitfalls and limitations

- Reverse inference problems
- Individual differences and variability
- Technical artifacts and their control

Axe IV: Solutions and Future Directions

▪ Open science practices

- Preregistration protocols
- Registered reports
- Data sharing platforms and standards
- Code sharing and documentation

▪ Collaborative research approaches

- Multi-lab collaborations (e.g., ManyLabs)
- Replication initiatives
- Large-scale data collection efforts
- Standardization projects

▪ Quality improvement strategies

- Reporting guidelines and checklists
- Validation procedures
- Peer review innovations
- Alternative metrics and impact measures

2. **Learning Objectives**:

By the end of this course, students will ideally have acquired knowledge to:

- **Identify and understand common limitations and biases in research**. Through a structured analysis of primary literature, students will learn to recognize frequently occurring issues, such as insufficient sample sizes, statistical errors and publication biases. They will demonstrate this ability through in-class discussions that will encourage the assimilation of key notions. These skills align with the "Remembering" and "Understanding" levels of Bloom's Taxonomy (Bloom, 1956), and Fink's "Foundational Knowledge" level (Fink, 2013), providing a foundation for deeper analysis.
- **Analyze and critique published cognitive science and neuroscience studies for statistical errors and methodological soundness**. Students will dissect example research studies to identify specific methodological flaws (or merits), which will then presented in small groups. Evaluation will be based on their ability to provide detailed, evidence-based critiques that highlight the strengths and weaknesses of the research. This hands-on approach promotes "Analyzing" and "Evaluating" skills within Bloom's Taxonomy (Bloom, 1956), which are essential for producing informed, independent critiques of research. It also aligns with Fink's "Application" level (Fink, 2013).
- **Evaluate the effectiveness of mass collaboration and open science initiatives in addressing the replication crisis and other scientific challenges.** By debating research proposals that incorporate open science principles with their peers, students will engage in the "Evaluating" level of Bloom's Taxonomy (Bloom, 1956). This objective also reflects the "Learning How to Learn" dimension of Fink's Taxonomy (Fink, 2013), as students practice constructing knowledge collaboratively and iteratively.
- **Reflect on their own learning process by discussing their changing perspectives on scientific research rigor and integrity, developing an ethical awareness of the implications of reproducibility issues in cognitive science and neuroscience.** This

aligns with the “Integration” and “Human Dimension” levels of Fink’s Taxonomy (Fink, 2013).

3. Evaluation Method

Given the short course length, the evaluation will focus on both the analysis of research papers and student presentations.

A. Individual Component (50%)

- Paper Analysis 1: Well-conducted study (25%)

- Paper Analysis 2: Flawed study (25%)

These will be carried out with a standardized tool (Annex I) and evaluated on 3 different dimensions (Annex II), being:

Key issue/merit identification: Accurately identifies and describes the main methodological strengths or weaknesses of the study, providing a clear rationale for why these are important.

Methodological analysis: Demonstrates understanding of the study’s research design, objectives and procedures. Critically evaluates the appropriateness and rigor of the methodology.

Statistical understanding: Correctly interprets and critiques the statistical analyses used in the study. Identifies potential statistical errors or limitations, providing arguments with references to course material.

B. Group Component (40%)

- Group presentations

Evaluated on 5 different dimensions (Annex III), being:

Content analysis: Ability to understand methodological details and provide details.

Critical thinking: Sophisticated analysis of strengths/weaknesses and proposal of solutions/alternatives.

Evidence & support: Claims consistently supported with specific evidenc and use of course concepts.

Organization & clarity: Structure, flow, and respect of time constraints.

Group coordination: Transitions and participation between members.

C. Participation Component (10%)

- Shows up in class and actively participates in proposed activities.

4. Teaching Strategies

To ensure that students are actively engaged and can develop critical thinking skills, the course will blend lectures with hands-on learning and peer collaboration:

- **Interactive lectures:**
  Each day will start with a lecture covering a specific. These lectures will be interactive, encouraging questions and discussions.
- **Case studies:**
  Real-world examples of both well-conducted and poorly-conducted studies will be examined in class. These case studies will highlight issues such as sampling bias or inadequate controls and serve as the foundation for the group discussions.
- **Paper analysis tool (Annex I):**
  A guided tool for analyzing scientific papers will be provided to students to help them systematically evaluate research.
- **Group work:**
  Students will be split into small groups to present their paper analysis conclusions. Students will randomly be assigned to the groups (different ones per group activity). This fosters collaboration and exposes them to multiple perspectives.
- **Critical discussions:**
  After the paper analysis, students will engage in critical group discussions comparing their findings and highlighting areas of consensus and divergence.

5. Course Outline

Day 1: The Scientific Publishing Process and Common Statistical Errors

- **Hour 1: Introduction to the Course**
  - Overview of course objectives, format, and expectations.
  - Brief discussion: Why critical analysis is important in cognitive science research?
  - Video introduction to the replication crisis (15-20 minutes).
- **Hour 2: Problems in the Scientific Publishing Process**
  - Topics covered:
    - "Publish or perish" mentality.
    - Peer review issues and inflation in publishing.
    - Impact factors and metrics.
    - Editorial biases and predatory publishing.

    - Discussion on real-world examples of these issues (with video).
- **Hour 3: Introduction to Common Statistical Errors**
    - Present the paper "Ten Most Common Statistical Errors" (lecture format).
    - Interactive quiz (e.g., using Kahoot) to test understanding of statistical errors.
- **Hour 4: Paper Analysis (Part 1)**
    - Students analyze a well-conducted neuroscience paper, in a guided analysis using the "How to Read a Scientific Paper" tool.

Day 2: Methodological Issues in Cognitive Science

- **Hour 1: Student Presentations (Part 1)**
    - Groups present their analyses of the well-conducted paper from Day 1.
    - Discuss similarities and differences in their findings.
- **Hour 2: The Replication Crisis in Cognitive Science**
    - Lecture and discussion on replication crisis and meta-analysis.
    - Case study of a failed replication in cognitive science.
    - Students work in small groups to analyze the study, identify its weaknesses, and suggest improvements.
- **Hour 3: Sampling Issues and Multi-Study Investigations**
    - Lecture on common problems with control groups, statistical power, sample sizes and multi-study setups.
    - Discussion on how these issues affect the robustness of scientific conclusions.
- **Hour 4: Interactive Workshop**
    - The class is divided into two groups: one supports the idea that the replication crisis is the biggest issue in cognitive science, while the other argues against it.
    - Students debate both sides, debating evidence and arguments for their stance.

Day 3: Problems in Neuroscience

- **Hour 1: Introduction to Neuroscience-Specific Problems**
    - Topics covered:
        - Limited statistical power in neuroimaging.
        - Inverse inference.
        - Disjointed analysis pipelines in neuroscience.
        - Specific risks of instrumentation (e.g., MRI, EEG).
- **Hour 2: Case Study on Flawed Neuroimaging Research**
    - Presentation of a neuroscience case where flawed instrumentation led to incorrect conclusions.
    - Group work: Identify the flaws and suggest improvements.
- **Hour 3: Paper Analysis (Part 2)**

    - Students analyze a poorly conducted neuroscience paper, always employing the "How to Read a Scientific Paper" tool for critical analysis.
- **Hour 4: Interactive Case Debate on Neuroscience Methods**
    - Students are presented two short neuroscience studies (real or hypothetical) that take different methodological approaches. One might use a small sample with in-depth neuroimaging, while the other employs a larger sample with simplified imaging protocols.
    - The class is divided into two groups: each defend one study's methodology. Argue why their study's approach may be more effective or valid, focusing on factors like statistical power, inference reliability, and practical limitations.

Day 4: Solutions and Future Directions

- **Hour 1: Student Presentations (Part 2)**
    - Groups present their analyses of the flawed paper from Day 3.
    - Discuss similarities and differences in their findings.
- **Hour 2: Open Science Practices and Mass Collaboration**
    - Lecture on mass collaboration projects and open science initiatives (e.g., ManyLabs, OpenNeuro).
    - Discuss preregistration, Registered Reports, and collaborative data sharing.
- **Hour 3: Workshop – Designing a Research Proposal**
    - Small groups work on designing a basic neuroscience research project incorporating open science principles (e.g., preregistration).
- **Hour 4: Final Group Presentation and Discussion**
    - Groups present their research proposals.
    - Wrap-up: Summarize key takeaways from the course.
    - Final Q&A session to address remaining questions & feedback.

Multimedia usage

The integration of multimedia and interactive tools in this block course is grounded in established pedagogical theories and evidence-based instructional design principles. Following Cognitive Load Theory (Sweller, 1988), the course's multimedia strategy carefully manages information processing demands, particularly important in concentrated learning formats where cognitive overload poses a significant risk. This theoretically-grounded approach specifically addresses the challenges inherent in block course formats. The employment of video resources and other digital interacting elements is thus beneficial to decrease the burden of frontal, sustained, lectures on students attending a block course, while stimulating their motivation to engage with the course's materials.

The digital learning environment, implemented through Moodle, reflects principles of Self-Regulated Learning Theory (Zimmerman, 2002) and the Community of Inquiry framework (Garrison et al., 2000). This platform enables students to regulate their learning autonomously while participating in a structured academic community. The asynchronous nature of the platform supports what Anderson (2003) terms "deep and meaningful learning," allowing students to engage with material at their optimal cognitive processing pace. This approach aligns with Vygotsky's (1978) social constructivist principles, where knowledge building occurs through both individual exploration and social interaction within a supportive digital environment. All of the course's material and references will be made available on this platform, for the students to freely engage with.

Interactive assessment tools, particularly Kahoot, are implemented based on Active Learning Theory (Bonwell & Eison, 1991) and Game-Based Learning Theory (Prensky, 2001). These theoretical frameworks emphasize the importance of engaged participation and immediate feedback in the learning process.

Discussion & conclusion of the implementation section

The implementation design for "Critical Issues and Limitations in Cognitive Sciences Research" reflects careful consideration of both pedagogical principles and practical constraints. The block course format, though effortful, offers unique advantages for teaching complex methodological concepts. Students immersed in this focused study of research practices can engage deeply with critical issues in cognitive science research methodology.

The course structure addresses several key challenges in methodology education. The progressive organization of content—from publishing practices through to innovative solutions—allows students to develop a comprehensive understanding of research quality issues. The integration of theoretical knowledge with practical analysis activities supports the development of applicable skills. Additionally, the emphasis on collaborative learning and peer feedback creates an environment where students learn from diverse perspectives, particularly valuable given their varied academic backgrounds.

The implementation plan includes several innovative elements that warrant discussion. The paper analysis tool provides systematic guidance for critical evaluation, while interactive debates encourage deeper engagement with methodological controversies. Multimedia resources help manage cognitive load during intensive sessions and spark debates, and the varied assessment methods ensure comprehensive evaluation of learning outcomes.

Implementation challenges include the intensive nature of the schedule and varying levels of statistical knowledge among students. The course addresses these through careful pacing, supplementary materials, and individual consultation opportunities. The block format itself helps mitigate these concerns as students can focus entirely on skill development without competing course demands.

The course design represents a balanced approach to methodology education, grounded in pedagogical theory while remaining practical and student-centered. This implementation aims to develop students' critical faculties while preparing them for critical thinking and methodological challenges they may face ahead in their careers. It is my intention to gather and use the insights gained from student feedback and peer review to continuously refine and update your course content, activities, and assessment methods, committing to responsive, evidence-based teaching practices that adapt to the evolving needs of the students and the field of cognitive science.

Subjective reflections on acquired competences

This pedagogical project emerged from the intersection of two significant aspects of my academic journey: my growing awareness of methodological challenges in cognitive science research and my development as an educator through the Did@cTIC program. The course design reflects both my experiences as a PhD student encountering the replication crisis and my evolving understanding of effective pedagogical practices.

The Did@cTIC program provided essential theoretical foundations and practical tools that directly shaped this course design.

Module A's emphasis on structured pedagogical planning influenced how learning objectives align with course activities. The module's focus on student perspectives helped develop a course structure responsive to diverse learning needs and prior knowledge levels. This influence manifests particularly in the carefully scaffolded progression from fundamental concepts to complex methodological issues.

Module B's insights into assessment methods significantly impacted the evaluation structure. The principles of coherence, pertinence, and quality in assessment design guided the development of both formative and summative evaluation methods. Professor Coen's "index of uncertainty" concept particularly influenced the inclusion of regular feedback mechanisms throughout the block course format. These assessment strategies aim to support student learning while maintaining rigorous standards.

Module C proved especially valuable as it enabled me to formalize my reflections on scientific research practices. The module's emphasis on broader societal implications of research helped frame the course's focus on research integrity and methodological rigor. This perspective influenced the inclusion of ethical considerations and professional responsibility in the course content.

The application of Did@cTIC principles to this specific subject matter presented unique challenges and opportunities. The block course format required careful consideration of principles learned in Module A, leading to the strategic integration of multimedia elements and interactive learning activities. The emphasis on collaborative learning reflects both social constructivist theories from the program and the reality of modern scientific practice.

While I anticipate challenges in its implementation, the foundational knowledge gained through the Did@cTIC program provides a robust framework for addressing these challenges thoughtfully and systematically. Looking ahead, I recognize that this course will require continuous refinement based on student feedback and emerging developments in both cognitive science and pedagogical theory. In my limited experience teaching, students have been generally eager to share their opinion on the teaching material and style. To this end, I plan to hand out a feedback sheet on the final day of the course. This will provide students with an outlet to provide their thoughts on the pacing and nature of course content, as well as the suitability of learning activities. The skills and perspectives gained through the Did@cTIC program will prove invaluable in this ongoing process of course development and adaptation.

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Axe III: Specific Challenges in Neuroscience Research

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Axe IV: Solutions and Future Directions

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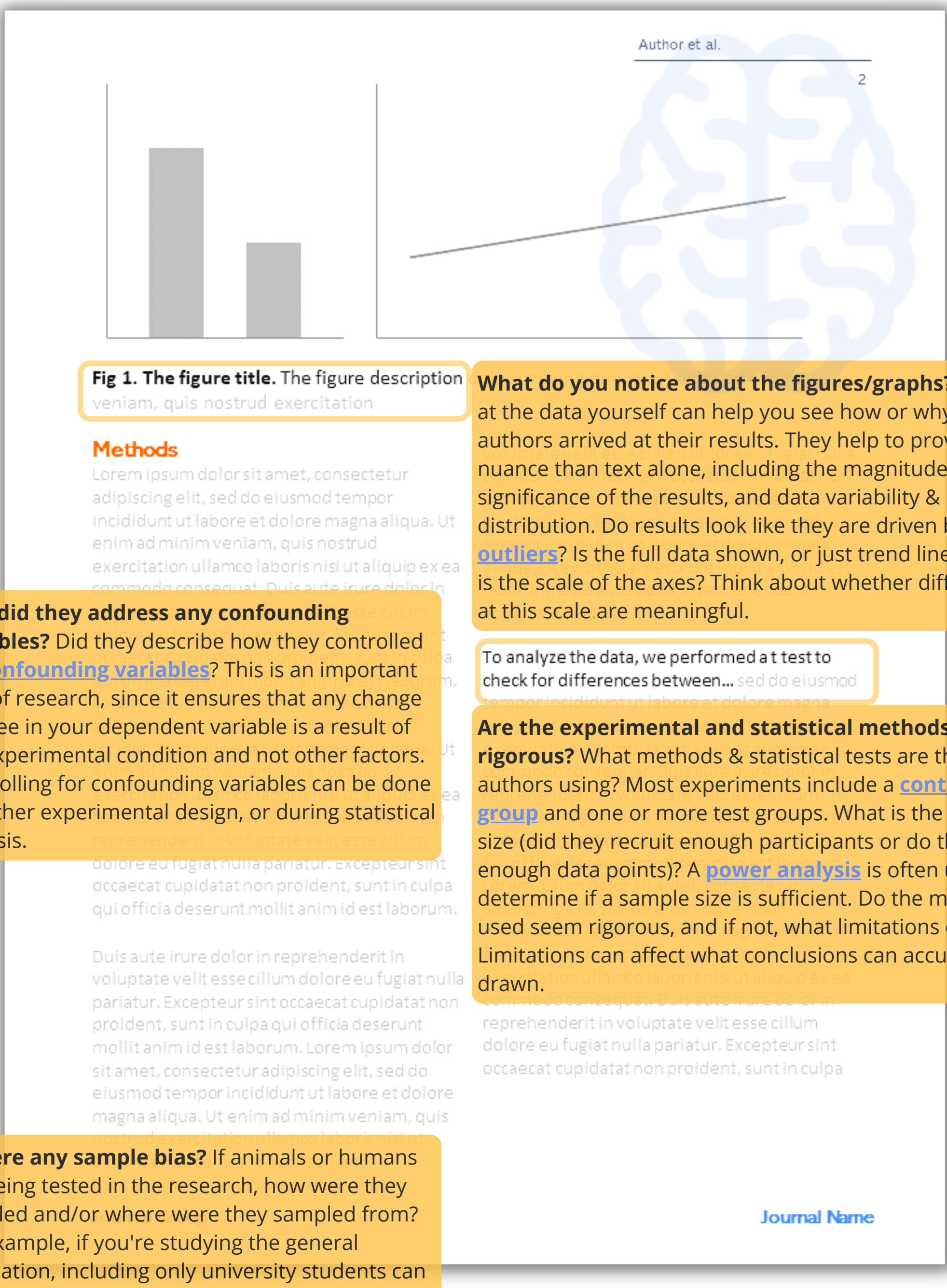
ANNEX I

This tool guides the systematic evaluation of scientific papers. It provides a structured approach for examining key aspects of research articles, from initial context assessment through to detailed methodological analysis. The tool consists of two parts: a visual guide highlighting critical elements to consider and a worksheet template for carrying out the analysis. Begin with the visual guide to familiarize yourself with key evaluation points. Then use the worksheet to systematically document your analysis of the paper under review.

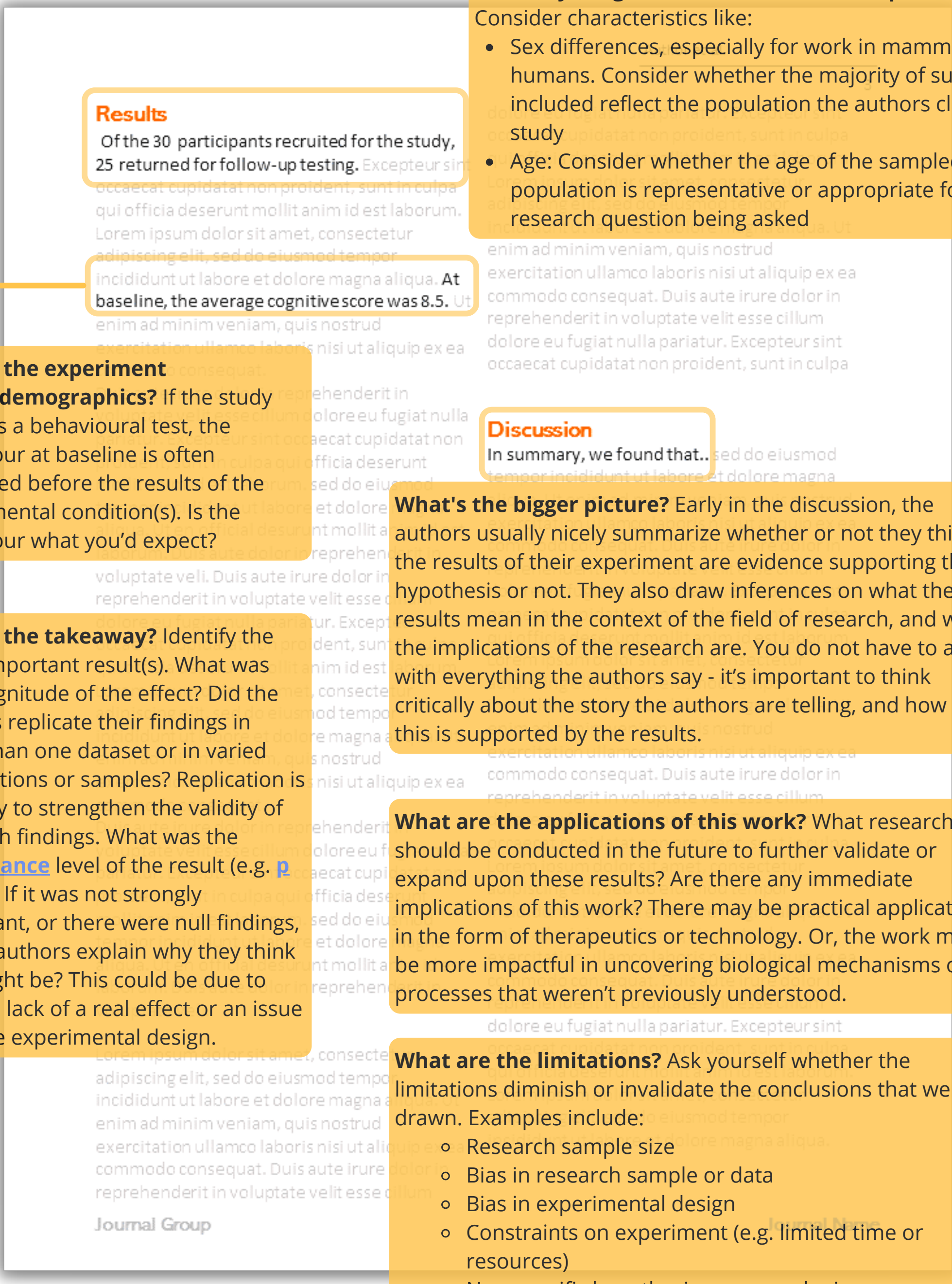


What do you notice about the figures/graphs? Looking at the data yourself can help you see how or why the authors arrived at their results. They help to provide more nuance than text alone, including the magnitude and significance of the results, and data variability & distribution. Do results look like they are driven by outliers? Is the full data shown, or just trend lines? What is the scale of the axes? Think about whether differences at this scale are meaningful.

How did they address any confounding variables? Did they describe how they controlled for confounding variables? This is an important part of research, since it ensures that any change you see in your dependent variable is a result of the experimental condition and not other factors. Controlling for confounding variables can be done via either experimental design, or during statistical analysis.

Are the experimental and statistical methods rigorous? What methods & statistical tests are the authors using? Most experiments include a control group and one or more test groups. What is the sample size (did they recruit enough participants or do they have enough data points)? A power analysis is often used to determine if a sample size is sufficient. Do the methods used seem rigorous, and if not, what limitations exist? Limitations can affect what conclusions can accurately be drawn.

Is there any sample bias? If animals or humans are being tested in the research, how were they sampled and/or where were they sampled from? For example, if you're studying the general population, including only university students can introduce sampling bias. This can limit the generalizability of the results.



Does anything stand out about the sample? Consider characteristics like:

- Sex differences, especially for work in mammals and humans. Consider whether the majority of subjects included reflect the population the authors claim to study
- Age: Consider whether the age of the sampled population is representative or appropriate for the research question being asked

What's the experiment basics/demographics? If the study includes a behavioural test, the behaviour at baseline is often described before the results of the experimental condition(s). Is the behaviour what you'd expect?

What's the takeaway? Identify the most important result(s). What was the magnitude of the effect? Did the authors replicate their findings in more than one dataset or in varied populations or samples? Replication is one way to strengthen the validity of research findings. What was the significance level of the result (e.g. p value)? If it was not strongly significant, or there were null findings, do the authors explain why they think this might be? This could be due to either a lack of a real effect or an issue with the experimental design.

What's the bigger picture? Early in the discussion, the authors usually nicely summarize whether or not they think the results of their experiment are evidence supporting their hypothesis or not. They also draw inferences on what these results mean in the context of the field of research, and what the implications of the research are. You do not have to agree with everything the authors say - it's important to think critically about the story the authors are telling, and how well this is supported by the results.

What are the applications of this work? What research should be conducted in the future to further validate or expand upon these results? Are there any immediate implications of this work? There may be practical applications, in the form of therapeutics or technology. Or, the work may be more impactful in uncovering biological mechanisms or processes that weren't previously understood.

What are the limitations? Ask yourself whether the limitations diminish or invalidate the conclusions that were drawn. Examples include:

- Research sample size
- Bias in research sample or data
- Bias in experimental design
- Constraints on experiment (e.g. limited time or resources)
- Non-specific hypothesis or research aims
- Lack of context-setting (previous research)
- Lack of controls for confounding variables

How to Read a Scientific Paper Worksheet

by BrainPost

What's the context?

Include the top 3 points that provide context around why the work is important

1. ______________________________
____
2. ______________________________
____
3. ______________________________
____

What's the hypothesis?

Include the prediction or proposed claims the authors are investigating

____
____
____
____

What are the independent (IV) and dependent variables (DV)?

IV: ______________________________
____
DV: ______________________________
____

What's the experimental method or test?

Include a brief overview of the experimental methods or tests being used

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MY COMMENTS:

____
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What's the sample?

Describe the sample and any notable characteristics

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____

What are the key results?

Include the top key results/findings that the paper outlines

1. ____________________

2. ____________________

3. ____________________

4. ____________________

5. ____________________

What are the limitations?

Were there any limitations in terms of the experimental design or sampling?

What are the inferences?

What conclusions do the authors make based on these results?

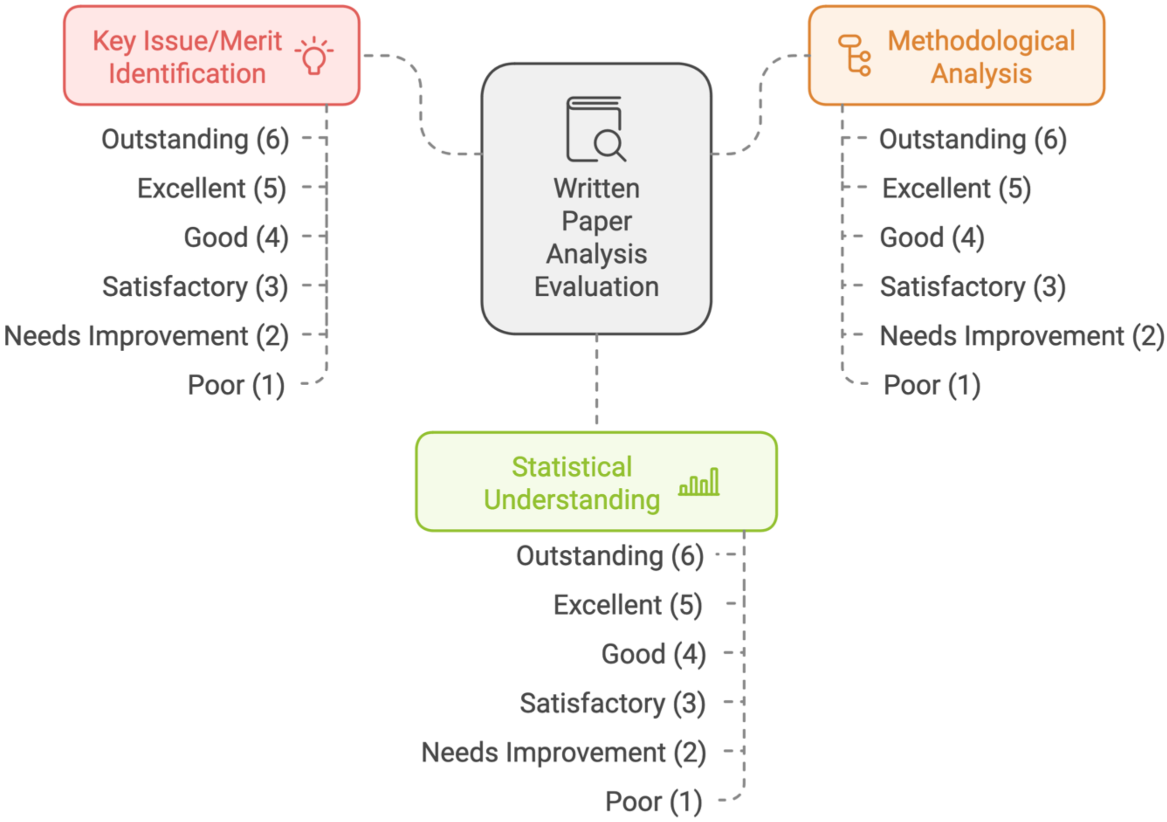
NOTES:

E.g. How do you interpret these results?

ANNEX II

This rubric guides the evaluation of written paper analyses across three key dimensions: Key Issue/Merit Identification, Methodological Analysis, and Statistical Understanding. Each dimension is rated on a 6-point scale:

- Outstanding (6): Demonstrates exceptional analytical depth; identifies subtle issues; provides innovative insights
- Excellent (5): Shows thorough analysis; identifies all major issues; provides strong evidence
- Good (4): Demonstrates clear understanding; identifies most key issues; supports main points
- Satisfactory (3): Shows basic understanding; identifies obvious issues; provides adequate support
- Needs Improvement (2): Misses significant issues; shows incomplete understanding
- Poor (1): Fails to identify major issues; shows fundamental misunderstandings



ANNEX III

This rubric enables systematic evaluation of group presentations across five key dimensions: Content Analysis, Critical Thinking, Evidence & Support, Organization & Clarity, and Group Coordination. Each dimension is rated on a 6-point scale:

- Outstanding (6): Demonstrates exceptional mastery; surpasses expectations; shows original insight.
- Excellent (5): Shows comprehensive understanding; meets all requirements at high level.
- Good (4): Demonstrates solid competency; meets most requirements effectively.
- Satisfactory (3): Meets basic requirements; shows adequate understanding.
- Needs Improvement (2): Partially meets requirements; shows significant gaps.
- Poor (1): Falls significantly short of requirements; shows major deficiencies.