AI-Assisted Psychological Research

From Experiment Design to Manuscript Composition

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The AI Revolution is Here

🚀 The Pace of Change

- AI capabilities increase exponentially
- 2023: ChatGPT changes the game
- 2024: Multi-modal models, coding agents, research assistants
- 2025: **AI agents that can complete entire research workflows**

⚠️ Critical Principle

Embrace AI, but **HUMAN MUST STAY IN THE LOOP**!

Why Human-in-the-Loop Matters

✅ AI Excels At

- **Speed**: Process data in seconds
- **Consistency**: No fatigue or bias
- **Scale**: Handle massive datasets
- **Repetition**: Automate tedious tasks
- **Pattern recognition**: Find hidden insights

⚠️ AI Needs Human For

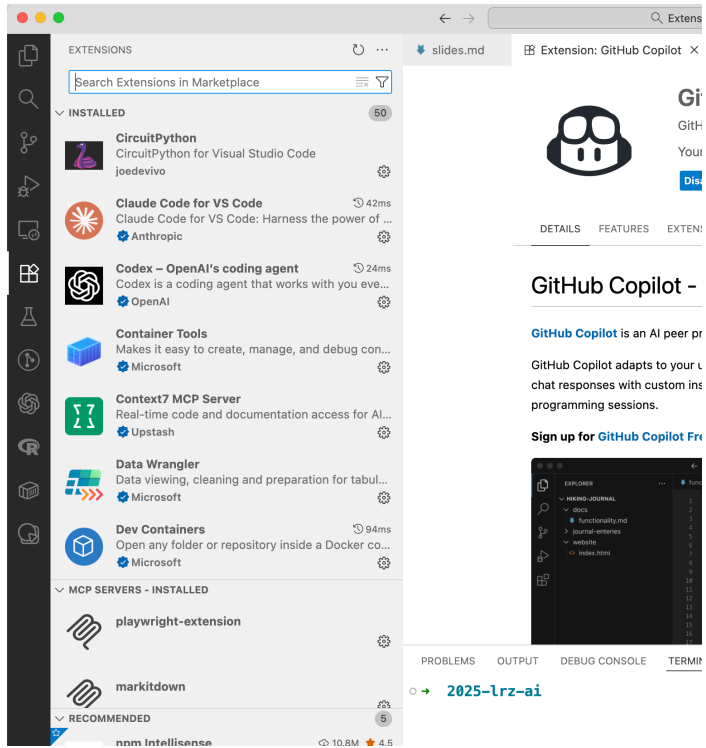
- **Critical thinking**: Evaluate validity
- **Domain expertise**: Interpret results
- **Ethical judgment**: Research integrity
- **Creativity**: Novel hypotheses
- **Quality control**: Verify every output

AI as your research assistant, not replacement

Required Software Stack

Code Editors with AI Integration

1. **VS Code** or **Positron** - Free, most popular
   - Download: code.visualstudio.com
   - Download: positron.posit.co
2. Extensions: GitHub Copilot, Claude Code, Cursor integration



AI Coding Assistants

Claude Code (Anthropic)

- CLI tool for terminal
- Best for research workflows
- Strong reasoning capabilities
- Install: `npm install -g @anthropic-ai/claude-code`

GitHub Copilot (Microsoft/OpenAI)

- Inline code suggestions / agents
- **FREE for university staff/students!** 🎓
- Apply: education.github.com
- Best for: Autocomplete, boilerplate

Gemini CLI (Google)

- Google's AI in terminal
- Strong multimodal capabilities
- Install: `npm install -g @google/gemini-cli`

OpenAI Codex

- Via API or ChatGPT Plus
- Code Interpreter for analysis
- Install: `npm install -g @openai/codex`

💡 **Pro Tip:** GitHub Copilot is FREE for university members - apply with your LMU email!

Today's Demonstration

A Full Research Workflow with a recent published Study

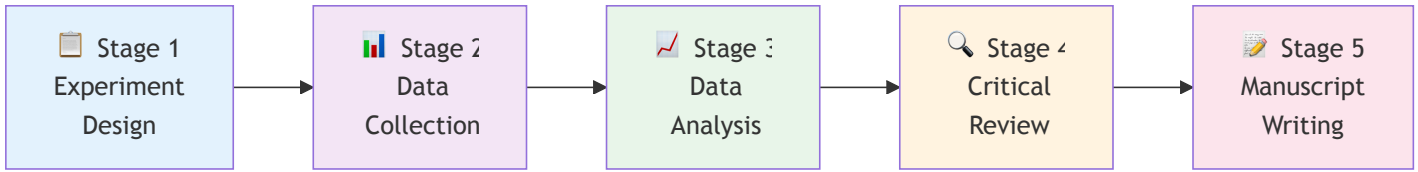
Study: Bocheva & Rahnev (2025)

- No particularly reason to select this, simply came across this paper recently
- This demonstration is to show proof of concept of AI-assisted research workflow
- The Study:
  - 1000 trials per participant
  - Hand alternates unpredictably trial-by-trial
  - Measure: How confidence on trial *t* depends on trial *t*−1

Our Goal: Complete entire research workflow using AI agents

Key Point: We'll pretend we're developing this study from scratch, but use real data for speed

The 5-Stage Workflow



Let's look into each stage! 🚀

Stage 1: Experiment Design

Task: Build PsychoPy Experiment

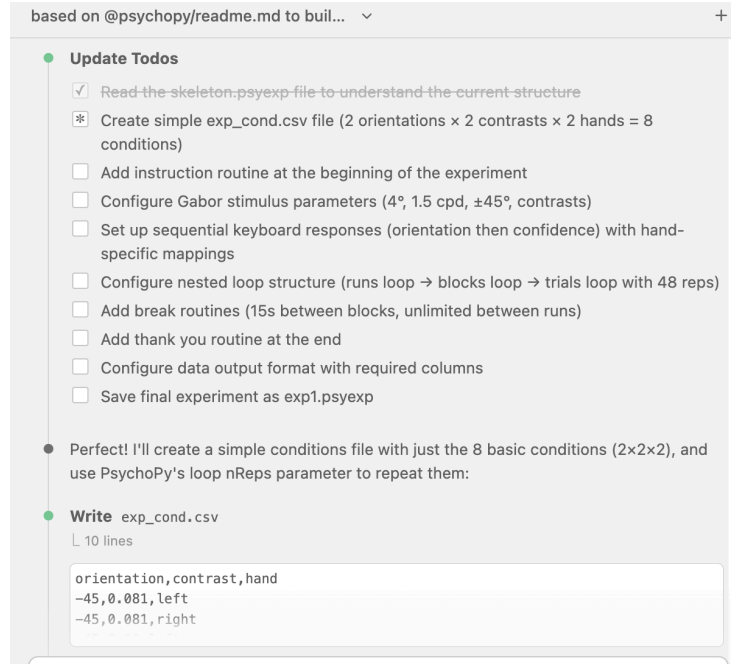
Input:

- Experiment specifications (Markdown)
- Skeleton template (.psyexp XML file)

AI Agent Task:

- Modify XML structure (not Python!)
- Configure Gabor stimulus (4°, 1.5 cpd, ±45°)
- Set timing (500ms fixation, 200ms stimulus)
- Implement hand-specific key mappings
- Create trial structure (1000 trials, blocks)

Output: Runnable .psyexp file + conditions.csv



PsychoPy Builder Interface

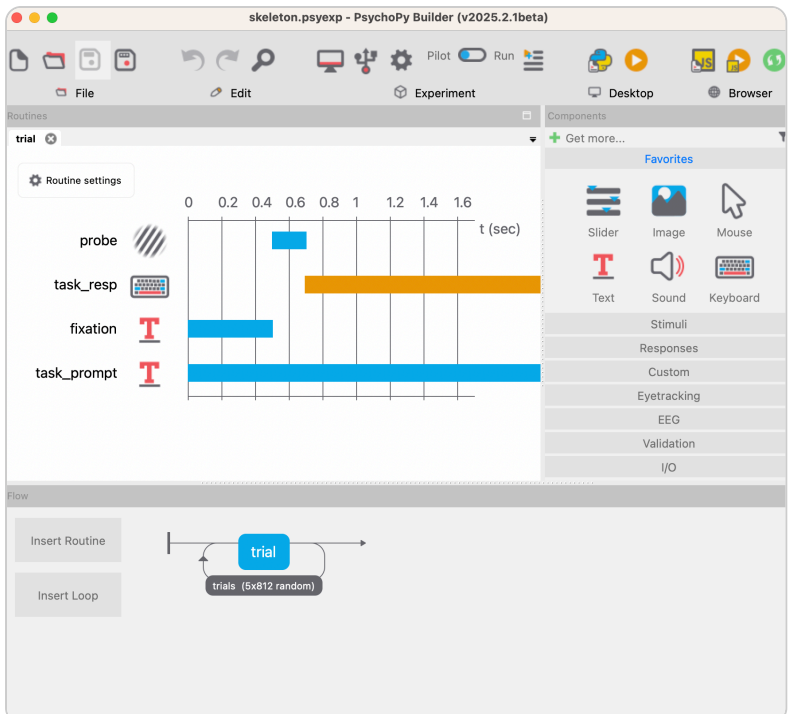
Stage 1: Hands-On Demo

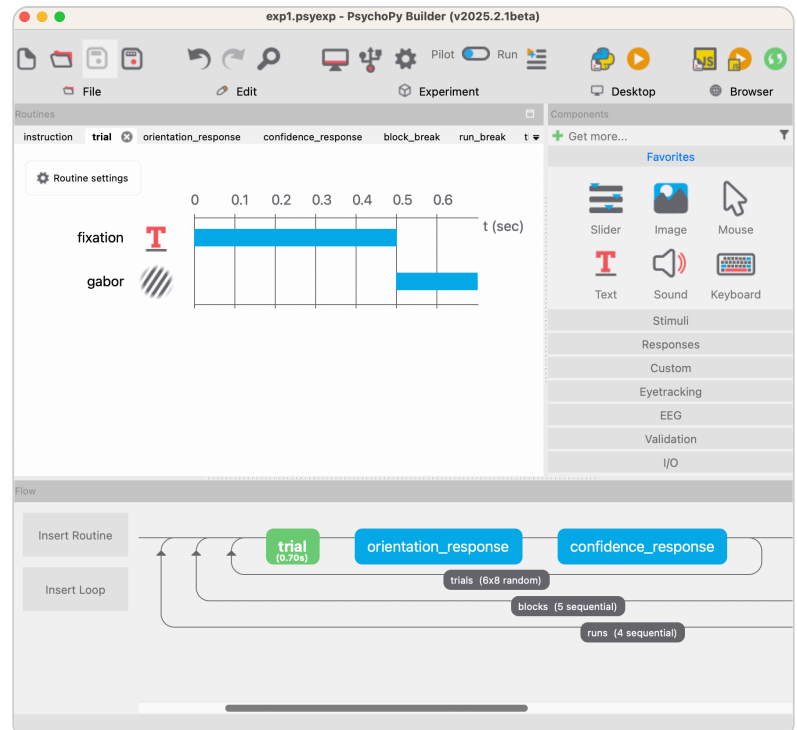
```
# Navigate to experiment folder
cd psychopy/

# Open specifications
cat readme.md

# Let AI agent modify the skeleton
"based on @psychopy/readme.md to build Stage 1 Experiment, save as study.psyexp"
```

🎯 **Watch for:**

- ✅ Read the skeleton.psyexp file to understand the current structure
- ✅ Create simple exp_cond.csv file (2 orientations × 2 contrasts × 2 hands = 8 conditions)
- ✅ Add instruction routine at the beginning of the experiment
- ✅ ...

From Sketch to Experiment (fully automated)





Stage 2: Data Collection

- Data from Published Study

Typical Workflow: Run experiment → collect data → wait for participants

Today: We use existing data from published study (pretend it's fresh!)

Data Format (CSV with 9 columns):

```
Subject,Stimulus,Response,Confidence,Correct,Contrast,Side,RT_Decision,RT_Confidence
1,1,2,1,0,2,1,1.04410273199028,0.265720397001132
1,2,1,1,0,1,2,1.54540622899367,0.225159565001377
1,1,1,2,1,1,1,1.63487691100454,0.471257911005523
...
```

Stage 3: Data Analysis

1. **Data cleaning**
    - Exclude low-quality participants
    - Remove outlier trials (RT > 3s)
2. **Serial dependence regression**
    - Confidence(t) ~ Confidence(t-1)
    - Choice(t) ~ Choice(t-1)
    - Separate: Repeat-hand vs. Switch-hand
3. **Statistical tests**
    - One-sample t-tests (slopes vs. 0)
    - Paired t-tests (repeat vs. switch)
    - Effect sizes (Cohen's d)

Outputs

- Publication-quality figures
    - Boxplots with individual data
    - Error bars (SEM)
    - Colorblind-friendly palette
- Statistical reporting
    - APA format
    - Full regression tables
- Reproducible code
    - Python (pandas, scipy, seaborn)
    - R/Quarto alternative

Stage 3: Hands-On Demo

Watch AI Analyze 42,000+ Trials

```
# AI agent prompt
"""
Analyze serial dependence from study/Raw_Data/

1. Load exp1.csv and exp2.csv
2. Apply exclusion criteria:
   - Remove subjects using single confidence >90% trials
   - Remove trials with RT > 3s
3. For each subject, fit linear regression:
   - Confidence(t) = b0 + b1*Confidence(t-1) + error
   - Separately for repeat-hand and switch-hand trials
4. Extract slopes (b1) and run paired t-tests
5. Generate Figure 1: Boxplot with connecting lines
6. Report statistics in APA format
"""
```

⏱️ **Time saved:** Manual analysis ~2-3 days → AI completes in ~10 minutes

Stage 4: Critical Review

AI as Research Reviewer

Problem: First-pass analysis often has issues

- Statistical errors
- Suboptimal visualizations
- Missing checks
- Code quality issues

Solution: AI agent reviews its own work!

```
# Generate professional review
claude-code "Review the analysis in analysis_v1.py.
Create REVIEW.md with:
- Statistical correctness check
- Visualization quality assessment
- Code quality evaluation
- Specific improvement suggestions (categorized by severity)"
```

Review is a critical step

Review → Improve → Iterate

Example Review Output (REVIEW.md)

```
## Critical Issues
- [ ] Exclusion criteria applied before/after lagging? (Check order)
- [ ] Convert python script to R/Quarto for publication readiness

## Important Improvements
- [ ] Figures: change bar plots to boxplots, combine experiments into panels
- [ ] add descriptive statistics table (accuracy, mean confidence, RT)
- [ ] Code: Modularize into functions for reusability

## Minor Suggestions
- [ ] Figure resolution: Increase to 300 DPI for publication
- [ ] Color palette: Use colorblind-friendly scheme
```

Human Role: Review REVIEW.md → Approve/reject suggestions → AI implements v2

Note: Here I **purposely** asked for conversion from python to R/Quarto to demonstrate flexibility

Stage 4: Hands-On Demo

Iterative Improvement Workflow

Step 1: AI generates REVIEW.md

```
claude-code "Review analysis_v1.py and figures_v1/,
create detailed REVIEW.md"
```

Step 2: Human reviews and adds decisions

```
## Critical Issues
- [x] APPROVED: Fix Cohen's d calculation ✓
- [ ] REJECTED: Exclusion order is correct, no change needed
```

Step 3: AI implements approved changes

```
claude-code "Implement approved improvements from REVIEW.md,
save as analysis_v2.py and figures_v2/, create CHANGELOG.md"
```

Why This Matters: Version Control

Traditional Workflow

```
analysis.py (overwritten)
figures/ (replaced)

❌ Lost: Original version
❌ Lost: Decision rationale
❌ Hard to track: What changed?
```

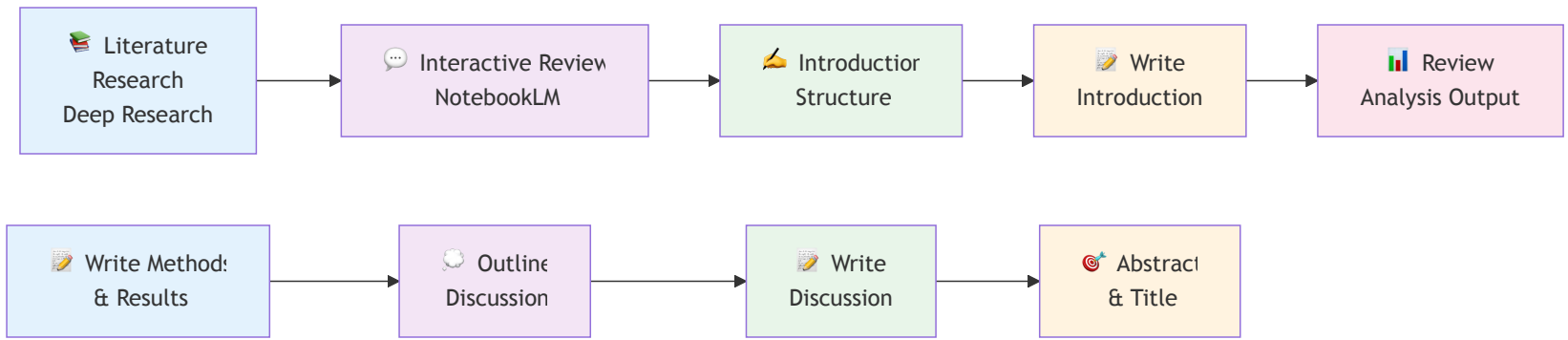
AI-Assisted Workflow

```
analysis_v1.py (preserved)
analysis_v2.py (improved)
REVIEW.md (decisions documented)
CHANGELOG.md (changes logged)
figures_v1/ (original)
figures_v2/ (improved)

✅ Full history
✅ Transparent decisions
✅ Reproducible evolution
```

💡 **Pro Tip:** Use **git** to manage versions and track changes effectively.
Computational reproducibility meets transparent research!

Stage 5: Manuscript Writing

A Multi-Step Human-AI Collaboration



Each step involves **human guidance** + **AI execution**

Step 1: Deep Research

- Finding the Right Context

Tools: Gemini, Perplexity AI, Google NotebookLM

Researcher Task:

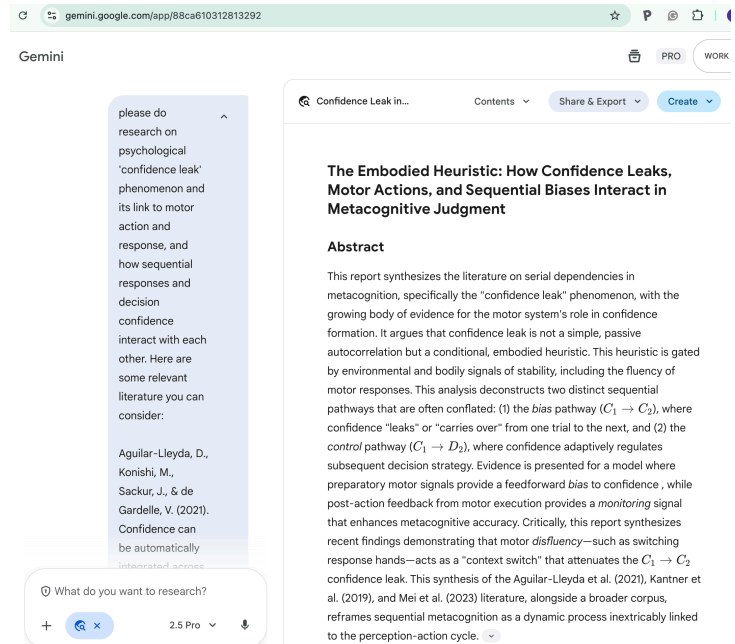
- Define research question, hypotheses
- Identify key search terms
- Evaluate relevance of results or reports

AI Task:

- Search academic databases (usually automated)
- Summarize recent findings and synthesize topics you asked.

Interaction:

- Through NotebookLM chat interface to refine understanding
- Generate ideas from multiple papers with chat interface
- Output: Structured notes (notes.md) for intro drafting



Step 2: Interactive Literature Review

- Google NotebookLM in Action

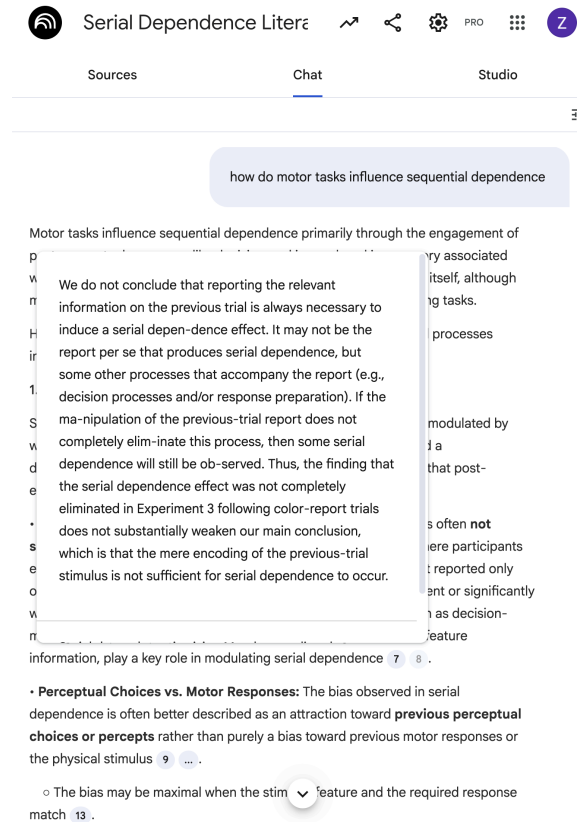
Upload: dozens papers (PDFs, <50 free!, Pro: 250 sources) to NotebookLM

Interact via Chat:

- "What are the main theories about serial dependence?"
- "Compare methods across studies"
- "What gaps exist in current research?"
- "Synthesize findings on confidence ratings"

NotebookLM generates:

- Comparative summaries
- Key quotes with citations
- Connections between papers
- Research gaps and opportunities



Step 2: Example NotebookLM Interaction

Your Questions to NotebookLM

👤 "how do motor tasks influence sequential dependence?"

👤 "How does confidence relate to decision carryover effects?"

👤 "Compare the methods used to measure serial dependence across the uploaded papers"

NotebookLM Synthesizes

🤖 Based on 15 papers:

"Here is a comprehensive breakdown of how motor tasks and
1. Role of Task Relevance and Post-Encoding Processes
...
• Encoding is Insufficient: Merely encoding the previous s

...

• Perceptual Choices vs. Motor Responses: The bias observe
"

💡 **Key Point:** NotebookLM helps you **synthesize across papers**, not just read them individually

Step 3: Introduction Structure

From Notes to Outline

Human Task

1. **Review** NotebookLM synthesis
2. **Identify** key themes:
   - Serial dependence theory
   - Confidence in decisions
   - Motor-cognitive interactions
   - Research gap
3. **Draft outline**:
   - Paragraph 1: Intro to serial dependence
   - Paragraph 2: Confidence mechanisms
   - Paragraph 3: Motor influences on cognition
   - Paragraph 4: Current study aims

AI Agent Prompt (agents.md line 800-)

```
- **Input**: Literature reviews in `study/literature/`.
- **Task**: Write a 1500-word introduction with the follow
    1. Start with a broad overview of confidence leak, us
    2. Provide a brief review of confidence leak literatu
    3. Identify the research gap: the missing link betwee
    4. Describe how this study addresses the gap (experim
- **Style**: Avoid obvious AI-generated phrases (e.g., "de
```

Output: Draft introduction (1000-1200 words)

Example Introduction Excerpt

Imagine a drone operator guiding a small craft through fog that keeps shifting in thickness. The operator decides that a faint glimmer ahead is a safe corridor and responds with full confidence. Moments later a new patch of turbulence appears, yet the operator still reports high certainty because the previous judgment felt so sure. This tendency to let earlier confidence seep into new decisions is the confidence leak phenomenon, and it persists even when each perceptual event is objectively independent. That leak can help when the world stays stable, but it can also misguide observers when conditions change rapidly, as every aviation instructor learns while training pilots to track instruments instead of gut feelings.

Researchers have now documented confidence leak across perceptual, cognitive, and memory paradigms (Rahnev et al., 2015; Kantner et al., 2019; Mei et al., 2023)…

💡 **Key Point:** Strong researcher guidance ensures AI-generated text is coherent, relevant. Meticulously eliminate any AI hallucinations (particularly in citations and literature).

Step 4: Methods & Results Writing

From Analysis Code to Narrative

Human Review Process

1. **Review** Quarto markdown output (analysis_v2.qmd)
   - Check figures for clarity
   - Verify statistical reporting
   - Identify key findings
2. **Annotate** the output file

```
# Key finding 1: Strong repeat-hand effect
# EMPHASIZE: This is 3x larger than switch-hand!
# Compare to Urai et al. (2019) who found no hand effect

# Key finding 2: Confidence carryover
# EMPHASIZE: Persists even with random stimuli
# Novel contribution to literature
```

3. **Prompt AI** with annotated findings

Step 4: Writing Methods & Results

```
# Methods Section
"Read:
- Experiment file (study.psyexp)
- Analysis script (analysis_v2.py)

Write Methods section covering:
- Participants (N, demographics, recruitment)
- Apparatus (display, stimulus properties)
- Procedure (trial structure, timing, responses)
- Exclusion criteria (from analysis script)

Style: Active voice, procedural narrative, APA format"
```

```
# Results Section
"Read:
- Analysis output (analysis_v2.qmd) with my annotations
- Figures (figures_v2/)

Write Results as flowing narrative:
- Lead with PHENOMENA, not statistics
- EMPHASIZE points I highlighted in annotations
- Integrate statistics naturally (not parenthetical dumps)
- Reference figures at key moments
- Use active verbs: 'strengthened', 'revealed', 'drove'
- Compare to previous literature where noted

Style: Story-driven, APA format statistics"
```

Step 4: Example - Stats-Driven vs. Story-Driven

❌ Stats-Driven (Bad)

"We found a significant main effect of hand condition, $F(1,41) = 67.8$, $p < .001$.

Post-hoc tests revealed that repeat-hand trials (M = 0.35, SD = 0.18) differed from switch-hand trials (M = 0.12, SD = 0.15), $t(41) = 8.23$, $p < .001$, Cohen's $d = 1.27$.

There was also a significant effect of experiment, $F(1,92) = 4.56$, $p = .035$."

- ❌ Statistics buried the story
- ❌ Passive voice ("was found")
- ❌ Hard to follow the narrative

✅ Story-Driven (Good)

"Repeating the same hand **nearly tripled** confidence carryover compared to switching hands (β = 0.35 vs. 0.12), $t(41) = 8.23$, $p < .001$, $d = 1.27$.

This dramatic strengthening **revealed a tight coupling** between motor actions and metacognitive judgments: confidence on trial t tracked the previous trial's confidence more strongly when the same hand responded, **even though stimuli were randomized** independently across trials (Figure 2)."

- ✅ Story leads ("tripled", "revealed")
- ✅ Active voice and strong verbs
- ✅ Statistics support the narrative

Step 5: Discussion Structure

- Outline Before Writing

Human Outlines Discussion

```
## Discussion Outline

1. **Summary of findings**
   - Confidence serial dependence
   - Hand-specific modulation (3x effect)

2. **Theoretical implications**
   - Motor-metacognitive coupling
   - Challenge to purely perceptual models
   - Link to embodied cognition

3. **Comparison to literature**
   - Consistent with: Fischer & Whitney (2014)
   - Extends: Urai et al. (2019) - no hand effect
   - Novel: First to show motor modulation of confidence c

4. **Limitations & future directions**
   - Hand use not manipulated independently

5. **Conclusion**
   - Broad significance for metacognition research
```

AI Agent Prompt

```
-  "Recap the findings and provide an intellectual
  discussion that connects the current results with previo
    literature. Highlight the study's contributions."
-   **Length**: ~1000 words.
-   **Output**: `study/manuscript/discussion.md`

Style: "Emphasize active voice and clear, engaging prose.
  Avoid overused AI phrases like 'shed light on' or simila
  Avoid empty sentences such as 'these findings have impor
  implications'. Similar style guidelines as for the Intro

active voice, smooth transitions,
APA citations throughout"
```

Output: Draft discussion (1500-2000 words)

Step 6: Abstract & Title

- The Final Touch

Abstract Generation

```
"Read complete draft manuscript (intro, methods, results, discussion).

Write structured abstract (250 words max):
- Background (1-2 sentences)
- Methods (2-3 sentences: design, N, analysis)
- Results (3-4 sentences: key findings with statistics)
- Conclusions (1-2 sentences: significance)

Style: Concise, self-contained, APA format"
```

Title Generation

```
"Based on abstract and key findings, suggest 5 title options:
- Informative (convey main finding)
- Concise (12-15 words)
- Engaging (but not clickbait)

- Include key terms: serial dependence, confidence, motor actions

Format: Ranked by impact, with brief rationale for each"
```

Example Output (Results)

> *Confidence ratings revealed systematic carryover from one trial to the next, and this carryover strengthened dramatically when participants used the same hand across consecutive trials (Figure 1). In Experiment 1, repeat-hand sequences produced robust positive serial dependence (β = 0.35, SD = 0.18), significantly above zero, t(41) = 12.65, p < .001, d = 1.95. This large effect indicated that confidence on trial t tracked confidence on trial t−1 even after controlling for stimulus properties, which randomized independently across trials...*

What AI Did Well

✅ **Narrative flow**: "revealed... strengthened dramatically..."

✅ **Integrated statistics**: Numbers support story, not vice versa

✅ **Precise APA format**: $t(41)$, $p < .001$, $d = 1.95$

✅ **Interpretation**: "even after controlling for..."

✅ **Figure references**: Natural integration

Stage 5: Time Investment Summary

Writing Step	Human	AI	Manual (old)
Literature search	2h	10m	4-6h
Paper synthesis (NotebookLM)	3h	inst.	2-3d
Introduction (outline + draft)	1.5h	10m	2-3d
Methods (annotate + draft)	1h	8m	1-2d
Results (annotate + draft)	2h	12m	2-14d
Discussion (outline + draft)	2.5h	15m	3-4d
Abstract & Title	15m	5m	2-3h
Total	**~12h**	**~60m**	**4-6w**

Key insight: Human does the **thinking** (outlining, annotating, reviewing),
AI does the **writing** (drafting, formatting, integrating)

Complete Workflow Summary

Stage	Task	AI Time	Human Time	Manual Time
1. Experiment	Build PsychoPy	5 min	10 min review	2-3 hours
2. Data Collection	(Simulated)	—	—	2-4 weeks
3. Analysis	Process 42K trials	10 min	30 min review	2-3 days
4. Review	Generate REVIEW.md	5 min	1 hour decisions	N/A (new!)
4b. Iterate	Implement v2	8 min	20 min verify	1-2 days
5a. Literature	Search & synthesis	10 min	5 hours (NotebookLM)	1 week
5b. Introduction	Draft section	10 min	1.5 hours outline/review	2-3 days
5c. Methods/Results	Draft sections	20 min	2 hours annotate/review	1 week
5d. Discussion	Draft section	15 min	2.5 hours outline/review	3-4 days
5e. Abstract/Title	Generate final pieces	5 min	15 min review	2-3 hours

Total AI time: ~90 minutes | Human oversight: ~15 hours
Time saved: 5-6 weeks of focused work 🚀

What Changed in Research?

Old Paradigm ⏳

- ❌ Weeks on experiment coding
- ❌ Days debugging analysis scripts
- ❌ Hours formatting references
- ❌ Repetitive data wrangling
- ❌ Manual plot adjustments

Result:

- Exhausted researchers
- Less time for thinking
- Slower publication cycle

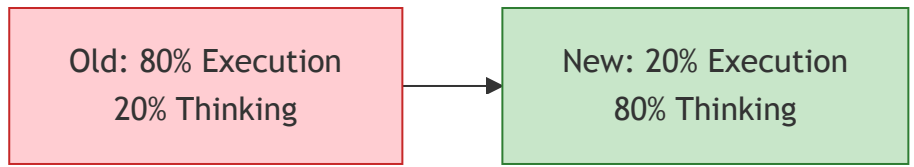
New Paradigm ✨

- ✅ Minutes for implementation
- ✅ AI handles repetitive tasks
- ✅ Humans review & decide
- ✅ More iterations possible
- ✅ Better final quality

Result:

- Energized researchers
- **Focus on critical thinking**
- **Explore novel ideas**
- Faster, better science

The Research Focus Shift



Where to Invest Your Energy

1. **Critical evaluation** of AI outputs (always verify!)
2. **Novel hypothesis generation** (AI can't do this yet)
3. **Research design decisions** (ethics, validity, innovation)
4. **Deep domain expertise** (interpret results correctly)
5. **Unexplored research questions** (where true discovery lies)

Practical Tips for Getting Started

1️⃣ Start Small

- Don’t automate your entire workflow on day 1
- Begin with **one repetitive task** (e.g., data cleaning)
- Build confidence in AI outputs through verification

2️⃣ Always Verify

- Spot-check AI code (run on subset of data)
- Compare AI results to manual calculations
- Use AI as **first draft**, not final product

3️⃣ Iterate Fearlessly

- AI makes mistakes → perfect opportunity to learn!
- Use review cycles (v1 → review → v2)
- Keep version history for transparency

Practical Tips (continued)

4️⃣ Domain Expertise Still Rules

- AI knows syntax, **you know psychology**
- Catch scientific errors AI misses
- Guide AI with precise prompts (use terminology!)

5️⃣ Combine Multiple Tools

- GitHub Copilot for autocomplete
- Claude Code, Gemini CLI for complex tasks
- ChatGPT for brainstorming and writing
- **Use strengths of each**

6️⃣ Document Everything

- Prompts used → methods transparency
- Review decisions → audit trail
- Version history → reproducibility

Ethical Considerations

Important Reminders

- **Data Privacy**
  - Don’t upload sensitive participant data to commercial AI services
  - Use local/on-premise solutions when handling PII
- **Academic Integrity**
  - Disclose AI use in methods section
  - AI assists, humans decide and take responsibility
  - All scientific claims must be verifiable
- **Authorship**
  - AI is a tool, not a co-author (per most journals)
  - Credit human contributors appropriately
- **Bias & Validity**
  - AI can perpetuate biases in training data
  - Always critically evaluate outputs
  - Use domain expertise to catch errors

The Future of Research

🎯 **Less time** on repetitive tasks

🧠 **More time** for critical thinking

🔬 **Explore** uncharted research territories

🚀 **Accelerate** the pace of discovery

💡 **Focus** on what humans do best: **asking the right questions**

Happy Vibe Coding! 🎉✨

Thank You!

Resources

📂 **Demo Project**: github.com/strongway/agents-in-research

🎓 **GitHub Student Pack**: education.github.com

📧 **Contact**: shi@lmu.de

Keep exploring, keep questioning, keep coding! 🚀