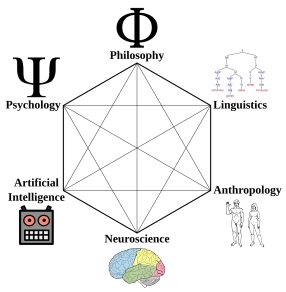
COGS 4901 | Honours Seminar in Cognitive Science

Full Year 2024–5 / York University

Website: https://eclass.yorku.ca/course/view.php?id=118745



Meetings
time: Wed 11:30am–2:30pm
location: Ross s421

Prof. Kevin Lande
e-mail: lande@yorku.ca
office: Ross S443

Course Description This capstone seminar for students in their final year of the COGS Honours BA program aims to deepen students' understanding of important issues in cognitive science and the interdisciplinary methods that are used to address them. We will approach this end in two ways. First, as a class we will discuss a range of readings that address important and controversial issues in contemporary cognitive science. These discussions will be integrated with this year's Cognitive Science Speaker Series, which features prominent cognitive scientists from around the world. We will attend these talks as well as meet separately with the speaker for an exclusive group discussion. Second, over the course of the year each student will pursue an original research project, focusing on a specific debate of his or her own choosing. This project will culminate in a substantial, original, interdisciplinary research paper that attempts to make progress on the debate. The projects are expected to engage with relevant literature and make empirically informed arguments (though students are not expected to conduct original experimental research). At the end of each semester, our classroom will transform into a mini-conference, where students present their work to the rest of the class. [Syllabus is subject to change.]

Goals • Understand major contemporary debates within cognitive science. • Understand main methodologies and approaches of cognitive science. • Critically evaluate literature from two or more cognitive science disciplines. • Develop and present original work that contributes to current debates in cognitive science.

Assignments	*Due*	*%*
Weekly Engagements		20%
• Attendance & Participation	W 11:30–2:30	
• 5 reflections *per term*	W, M 9am	
+ 2 follow-ups *per reflection*		
Research Paper		
① Proposal	Oct 4	3%
② Outline	Nov 8	7%
③ First Submission (3.5–4k wds)	Dec 20	25%
④ Revision Plan	Feb 14	5%
⑤ Final Submission (4–5k wds)	Apr 18	30%
Presentations		
• Fall Presentation (10–12 min)	Nov 20 / Nov 27	5%
• Winter Presentation (15 min)	Mar 26 / Apr 7	5%

Readings

Readings will be available on the course website.
Please read all designated materials (≈ 50 pgs / week) before the meeting for which they have been assigned.

Late Policy

• 10 grace days total for the entire year can be used for any assignments related to the research paper. Once grace days are exhausted, 1/2 letter grade is deducted for each day late.
• Late reflections & follow-ups will not be accepted.
• Missed presentations cannot be made up.
• Each research paper assignment is mandatory. An assignment will not be graded unless all prior assignments in the sequence have been completed.

Accommodations This course adheres to principles of "universal design for learning." Flexibility in deadlines is built into the course through grace days. Learning and assignments are scaffolded and students have multiple means for class participation and review. Where the course design does not already accommodate your needs, we will work together with Student Accessibility Services to find a fair solution.

Class Format We will meet in-person (except when circumstances require going remote). Students should be prepared to participate in class discussions, presentations, in-class learning activities, and occasional group work.

Attendance of the Cognitive Science Speaker Series is mandatory and part of the class. The first hour will be dedicated to a group discussion with the guest speaker. The second and third hours will consist of a public talk and Q&A, open to all members of the York Cognitive Science Community.

Academic Integrity Academic dishonesty, including plagiarism and/or submission of text generated by AI tools, will be prosecuted. All work must either reflect the student's own ideas or fully cite the source of others' ideas. Penalties include, but are not limited to, failure of the assignment and/or failure of the course. Familiarize yourself with York's policy regarding academic integrity and consult the Academic Integrity Checklist prior to submitting work.

Tentative Schedule

FALL TERM

Sep 4 Introduction to the course

- Núñez et al., "What happened to cognitive science?" (2019)
- Orwell, "Politics and the English language" (1946)

Sep 11 Bridging brain and behavior to understand action

- Schall, "On building a bridge between brain and behavior" (2004)
- Hanes & Schall, "Neural control of voluntary movement initiation" (1996)

Sep 18 Talk: Jeff Schall (York)

- Schall, "Accumulators, neurons, and response time" (2019)

Sep 25 Memory

- TBD

Oct 2 Talk: Donna Addis (UofT)

Proposal Due Oct 4

Oct 9 Death, representation, and memory

- Monsó, "How to tell if animals understand death" (2022)
- Egan, "A deflationary account of mental representation" (2020)
  RECOMMENDED: Egan, "The moon illusion" (1998)
- TBD

Oct 16 | READING WEEK | No Class

Oct 23 TBD

Oct 30 Talk: Susana Monsó (UNED)

- Monsó & Osuna-Mascaró, "Death is common, so is understanding it: the concept of death in other species" (2021)

Nov 6 Talk: Frances Egan (Rutgers)

Nov 13 Talk: Shayna Rosenbaum (York)

Outline Due Nov 8

Nov 20 & Nov 27 Presentations

Dec 6 Optional talk: Wayne Wu (Carnegie Mellon)

Initial Submission Due Dec 20

WINTER TERM

Jan 8 Collective knowledge in animal groups
Jan 15 Talk: Dora Biro (Rochester)
Jan 22 TBD
Jan 29 Talk: Clark Barrett (UCLA)
Feb 5 TBD
Feb 12 Talk: Eleonore Neufeld (U. Mass)

Revision Plan Due Feb 14

Feb. 19 | READING WEEK | No class

Feb 26 TBD

Mar 5 Talk: Daphna Heller (UofT)

Mar 12 Writing & Presentation Workshop

Mar 19 Individual Meetings

Mar 26 & Apr 2 Presentations

Final Submission Due Apr 18

Assignment Details

Final letter grades will be calculated according to York University's standard grading scale:

A+	A	B+	B	C+	C	D+	D	E	F
90–100	80–89	75–79	70–74	65–69	60–64	55–59	50–54	40–49	0–39
Exceptional	Excellent	Very	Good	Competent	Fairly Competent	Passing	Marginally Passing	Marginally Failing	Failing

1 Participation, Reflections & Follow-ups (20%)

Participation Attendance and active participation in meetings and talks will be graded. As a *seminar*, this class is centered around student discussion. In addition to engaging in class-wide discussions, students are expected to participate in occasional in-class exercises, group work, and may be called upon to present elements of the week's readings.

Reflections (5 per term) By 9am the morning of a class meeting, post a "reflection" on eClass. (No reflections or follow-ups are due Week 1 or during the presentation days.)

Reflections are open-ended, though they must substantively engage with the material for that week. They should be around 250 words in length. If you do more than 5 per term, we will count only the highest ten grades toward your total. For a reflection, you might do any of the following:

(1) Reconstruct the argument in one of the readings,
(2) Voice an objection to something claimed in one of the readings,
(3) Tease out an interesting implication of something the authors say,
(4) Draw a connection to or highlight a tension with another reading,
(5) Highlight something in the text that you found unclear and suggest what you think it might mean.

Reflections for talk days When we have a guest speaker, your reflection takes the form of a direct question that you are prepared to ask of the speaker.

Goal Reflections give you practice in writing and critical reading. They help us to organize our lessons. And they keep you engaged and prepared for the weekly meetings.

Follow-ups (2 per reflection) By 9am Mon., post two comments on the prior week's reflections.

(1) **One comment must be on a peer's reflection post.**
You can develop a point that you found interesting, pose a question, politely consider a potential objection, or respond to how the guest speaker answered (or might have answered) your peer's question.
(2) **One comment must be on your original reflection post.**
Your comment might follow up on your initial reflection or respond to a follow-up comment on your own reflection, posted by one of your peers. Where applicable, you might discuss how satisfied you were with the guest speaker's answer to the question posed in your reflection.

Goal Your initial reflection shows your thinking prior to meeting with the group. Follow-ups let you revisit yours and your peers' initial reflections in light of what we have learned from discussion.

Grading Reflections and follow-ups will be graded CREDIT (substantive engagement) or NO CREDIT. A comment that says "I found X interesting" without any real substance will receive no credit.

Late Policy Since these posts are integral to seminar meetings, late submissions will not be accepted.

2 Research Project (70%)

General Description Many of the topics in cognitive science are controversial, with cognitive scientists themselves disagreeing about what the evidence shows. In order to better understand the nature of such debates and the methods that are used to address them, you will be required to develop a substantial research paper (ultimately 4,000 to 5,000 words) that explores a specific debate and attempts to contribute to the conversation. The paper must be more than a literature review: it must advance an argument for a particular thesis, consider objections to the argument, and examine implications of the thesis. The thesis of the paper should be clearly stated in the introduction and defended in the body of the paper. You need not conduct any novel empirical research.

Assignment Sequence The paper will be developed through a mandatory sequence of assignments. An assignment will not be graded unless all prior assignments in the sequence have been completed.

General late policy Throughout the year, students have a total of 10 grace days to submit any of written assignments involved in the research project. Once these grace days are exhausted, if you still anticipate being late you should contact your instructor well in advance to explain your situation.

If you have used up your grace days, assignments with letter-grades will be penalized 1/2 of a letter for every day late. For every day that a CREDIT/NO CREDIT assignment (research proposal, outline, or revision plan) is late, the next letter-grade assignment in the sequence will be penalized by 1/2 of a letter.

Tip: For advice on writing and citation, visit: https://spark.library.yorku.ca

2.1 Proposal (3%)

Description Your research proposal will define and motivate the question that you intend to address in your research paper. You should select a narrow, manageable topic. The proposal should demonstrate the significance and feasibility of the topic. It must contain:

(1) **Question (≈ 50–100 words):** A clear statement of the question you will be seeking to address and your anticipated thesis, as well as any key terms involved in the question or thesis.

(2) **Motivation (≈ 100-300 words):** Motivate the question. Why does the question matter? What are the implications (for other theoretical debates, for practical applications, etc.) of answering it one way or another? Why is it controversial?

(3) **Bibliography (4 sources):** A preliminary bibliography containing at least four citations relevant to your research question. Here and throughout the course, please use APA reference style (see https://libguides.williams.edu/citing/apa or here).

   (a) **Two** of these citations must be **annotated** with 4–6 sentences explaining the core thesis and relevance of the cited paper to your topic.

   (b) At least **one** of these citations must be a **review** article that covers a wide range of literature.

   (c) At least **two** of these citations must be **experimental papers** that support contrasting views on the topic.

Grading The proposal will be graded CREDIT/NO CREDIT. A proposal might receive NO CREDIT if it does not meet the format requirements or if the proposed project does not seem feasible to the instructor.

Resubmission policy If a student's proposal is not passed, the student must meet with the instructor within a week of receiving feedback. Proposals can be revised and resubmitted for a new grade.

2.2 Outline (7%)

Description Whereas the research proposal explains the main question that your research project will address, the research outline gives the first taste of what you will actually be saying. Here is where it really pays off to have a narrow, tractable question and thesis. The outline will consist of three parts:

(1) **Abstract (250–300 words):** Building on the preview, the abstract must concisely:

   (a) State the core question that you will be addressing,
   (b) Motivate why this question is significant,
   (c) State your thesis—the conclusion or answer for which you will be arguing,
   (d) Briefly summarize the argument that you will be developing—what are the main premises or supporting reasons for your conclusion.

   The abstract should be written in prose and have the same style and tone as abstracts for published research papers. (See Guide to Assignments for examples.)

(2) **Outline:** Here you will detail the work you will be doing in each section of the paper. You will hierarchically itemize each main section, sub-section, and key claims, arguments, definitions, etc. of the paper. There should be enough text so that these points are comprehensible to your instructor, though they need not be fully worked out.

(3) **Fully Annotated Bibliography:** List at least **six** sources that you have been consulting in your preliminary research. Under *each* citation, include several sentences explaining the relevance and core argument of the paper being cited. These may (but do not have to) include annotated citations from your earlier preview.

Grading The research preview will be graded FULL CREDIT / PARTIAL CREDIT / NO CREDIT.

- NO CREDIT includes failing to submit or fulfill all parts of assignment.
- PARTIAL CREDIT (50%) for minimal substance. E.g., outline contains statements of premises but these are not supplemented by any discussion of the considerations that will be given in favor of those premises.
- FULL CREDIT for adequate previews. Gives some sense of what will be argued and how. Shows evidence that the research project is on track and continues to be feasible.

Resubmission policy Students who do not receive FULL CREDIT must meet with the instructor within a week of receiving feedback. Outlines can be revised and resubmitted for a new grade.

2.3 First Submission (20%)

Description A **3,500–4,000 word** research paper, citing **at least 10 sources**. After the title and before the main text, there must be a **250–300 word abstract** (a refinement of the abstract you wrote for your Preview).

> **Tip:** Do not think of this as a "draft." It should be a complete, polished paper.

Formatting

- Times New Roman (or comparable) 12pt font
- 1 inch margins, double-spaced

- Page numbers on every page
- APA citation style
- You may write with first-person pronouns where appropriate.

You should organize the paper into sections with headings (possibly including sub-sections). E.g.,

> **1. Introduction**
>
> **2. Systematic Constraints on "Better" Explanations**
>
> ***2.1. Simplicity***
>
> ***2.1. Breadth***
>
> ...
>
> **5. Conclusion**

Any time you are relying on an idea or understanding of an idea that is not your own, or any time you rely on a fact that is not common knowledge, you must provide a citation for the source. Use in-text citations with specific page numbers, e.g.:

> The visual system can be explained at three different levels: computational, algorithmic, and implementational (Marr 1982, pp. 24–27).

Include a bibliography at the end with full details for every source that you cite in the text. E.g.:

> Marr, D. (1982). *Vision: A computational investigation into the human representation and processing of visual information.* New York: W.H. Freeman and Company.

Expectations A good paper is one with a well-motivated question, a strong argument, clear explanation of concepts, and which is well-organized. We will coach you on what counts as "well-motivated," "strong," "clear," etc., through conversation and feedback on written assignments. Since what counts as a "strong" argument depends on the thesis, premises, and form of argument that you propose, the way *you* frame the paper plays a big role in how the paper will be judged.

You set the standards of your paper's success, so make your aims clear.

Grading Unless otherwise announced, papers will be graded on the following letter scale:

A+	A	B+	B	C+	C	D+	D	E	F
= 95	= 85	= 77	= 72	= 67	= 62	= 57	= 52	= 45	= 0

Feedback Feedback will consist of in-text comments on your paper and/or a separate document in which high-level comments are given on the work. The feedback will focus on helping you improve the clarity and consistency with which you use and discuss concepts, the large-scale organization of the paper, and the strength of your arguments. I encourage you to contact me to discuss feedback further.

> **Tip:** Part of your grade will reflect spelling and grammar. An "A" [excellent] is unlikely to be given to a paper with prominent spelling and grammatical errors. You are strongly encouraged to consult with the Writing Centre and to connect with a Peer Mentor.

2.4 Revision Plan (5%)

Description A **750–1,000 word** document in which you will (1) distill and convey what you take to be the core criticisms and suggestions in the feedback you received on your initial submission, (2) describe how you intend to address those criticisms and suggestions in the revised submission, and (3) justify why you are choosing to address the feedback in the ways you propose.

> **Tip:** This document should not enumerate corrections for spelling, grammar, and other minor details, other than to say that "Corrections to spelling and grammar will be made." The document should focus on bigger revisions concerning conceptual exposition and argumentation.

Expectations The aim of this document is to get you to be deliberate and thoughtful in your revisions. While you will be given feedback and guidance throughout the writing process, you are responsible for taking this feedback and making decisions about how to best improve your paper. This document is where you will describe the choices you intend to make and where you will justify why you intend to make those choices. In doing so, you will demonstrate that you have carefully read the feedback.

Feedback You will receive feedback consisting of advice on how to implement certain proposed revisions, comments on their feasibility, etc.

Grading The revision plan will be graded on a FULL CREDIT, PARTIAL CREDIT, NO CREDIT scheme.

- NO CREDIT includes failing to submit an assignment that fulfills the basic description.
- PARTIAL CREDIT for assignments that only contain minimal content, does not attempt to motivate the proposed revisions, or severely misinterprets the feedback.
- FULL CREDIT for assignments that show clear understanding of the main points in the feedback, provide details about proposed revisions, and motivate why those changes (rather than others) are appropriate to answer the feedback.

Resubmission policy If you do not receive FULL CREDIT, you can revise & resubmit for a new grade.

2.5 Final Submission and Statement of Revisions (30%)

Description A **4,000–5,000 word** revision of your research paper, citing at least **12 sources**, with a **250–300 word abstract**. The document should be preceded by a **statement of revisions**.

This is the culmination of your year-long project. Our goal is to help you write something that you are proud of. This paper should have the quality and interest of a writing sample for graduate school (whether or not you actually intend to apply).

Statement of Revisions To receive credit for your paper, you must include at the beginning of your document a **Statement of Revisions**. This statement will build on your prior revision plan. In your revision plan, you will have described revisions that you *planned* to make to your paper. In your statement of revisions, you will explain the major revisions that you *did* make, **including relevant page or section numbers that show evidence of those changes**. If your actual revisions deviated from your planned ones, explain how and why.

Grading You will be graded on the same scale as the first submission. Your grade will reflect not only the quality of the paper, but also how well you have implemented revisions based on feedback. A paper that more or less reproduces the initial submission, without any substantial revisions in response to feedback, is likely to receive a lower grade than the original.

3 Presentations (10%)

3.1 Fall Presentation (5%)

Description **10–12 minutes total** for presentation and Q&A. Use presentation **slides**.

Expectations 5–7 minutes for presentation and 5–7 minutes for Q&A. In your presentation, you must (not necessarily in this order)

(1) **State** and **motivate** the central question of your research paper
(2) Present and explain the **existing literature** on that question, including
    (a) Central points of consensus
    (b) Central points of disagreement
    (c) The major positions in that disagreement. For each major position,
        i. One consideration that speaks in favor of that position
        ii. One consideration that speaks against it
(3) Summarize what you take to be the main gap in the literature, which your paper seeks to address

> **Tip:** You do not need to argue for your own thesis. Your aim is just to *teach* your research topic.

Grading You will be graded according to a rubric on the content of the presentation (were your arguments and ideas interesting and coherent?), effective use of slides (did they make your presentation easier or harder to follow?), and your verbal delivery (was your delivery practiced and polished?). Part of your grade will also depend upon your active contributions to the Q&A sessions for other students' presentations.

3.2 Winter Presentation (5%)

Description **15 minutes** total for presentation (using slides) and Q&A.

Expectations 10 min. for presentation, 5 min. for Q&A. You must (not necessarily in this order)

(1) **State** and **motivate** the central question of your paper
(2) **State** and **define** your **thesis** (i.e. your answer to the question)
(3) Present an **argument** for your thesis, including
    (a) Empirical results in its favor
    (b) Theoretical/conceptual considerations in its favor
(4) Explain how your thesis relates to the **existing literature** and respond to **potential objections**
    (a) How does it build upon existing views?
    (b) How does it accommodate seemingly inconsistent evidence?

> **Tip:** You should not simply repeat what you said in the Fall. In the Fall Presentation, you **taught a topic**. In the Winter Presentation, you are **arguing for a thesis**.

Grading Same as Presentation 1.

The Challenges of Modeling Inner Speech on Outer Speech

Sydney Simota

COGS 4901 A Honours Seminar in Cognitive Science

Dr. Kevin Lande

April 21, 2025

Abstract

Inner speech (IS), defined here as conscious, linguistic thought, is inherently subjective and private, making it a notoriously difficult object of study. Its resemblance to spoken language can be used to circumvent this issue. Indeed, much research has been guided by concrete theories of IS that consider it to be an evolved form of outer/overt speech (OS) with suppressed articulation. However, the extent to which IS is similar to OS is still debated. Here, I compare both the production and phenomenology of IS and OS and propose that IS bears differences to spoken language that current OS models cannot account for. First, I describe the concrete theory of inner speech and its reliance on forward/corollary discharge models to explain IS production. I then expose the shortcomings of this reductive theory and provide a multifaceted production model that favors abstract theories of IS. This leads into a discussion on inner speech phenomenology in which I point to differences in pacing and communicative function to argue for a model of IS that overlaps but is distinct from that of OS. Uncovering the nature of IS and distinguishing it from OS will inform linguistic theory, contribute to our understanding of cognition, and better the lives of those with communication disorders.

Introduction

Despite its common, everyday usage, inner speech is a phenomenon that continues to evade scientific explanation. For present purposes, I am defining inner speech as conscious, linguistic thought. That is, internally formulating and 'hearing' thoughts that resemble public language like *I need to finish my paper.* Not everyone reports this voice inside their head, and as we will see, IS does not necessarily take the form of full-fledged sentences (Endicott, 2024, pp. 2, 9). The key distinction is that inner speech events contrast with overt speech utterances that are actually articulated or spoken out loud and in conversation.

How we generate inner speech, its main functions, and the qualities that it has are all still a matter of debate. For instance, Vygotsky (1934/1986) noticed how children often think out loud and proposed that inner speech results from a gradual internalization of private speech (OS directed at oneself) as we age. Hence, we use IS much like OS, for behavioral regulation and problem-solving. On the other hand, psycholinguistic accounts and Baddeley & Hitch's (1974) phonological loop paint IS as an error-monitoring system and a working memory component that serves to support OS and develops before it (Alderson-Day & Fernyhough, 2015, pp. 933-934).

Inner speech resembles overt speech in some way, but just where the two start to diverge, and whether these differences are significant is a major point of contention (Perrone-Bertolotti, 2014, pp. 221-222). This raises the question: can models of outer speech account for the features of inner speech? The answer to this question could have a significant impact on the lives of those with speech deficits resulting from aphasia, stuttering, and/or paralysis. While these populations have coherent inner thoughts, they struggle to outwardly express themselves due to cerebral or motor impairments. Finding the locus of generation of inner speech could advance assistive

technologies and brain computer interfaces designed to rebuild their communication and autonomy. More generally, investigating IS's relation to executive functioning could benefit our understanding of emotion regulation, problem-solving, and planning in both neurotypical and neurodivergent populations including autistic and schizophrenic individuals (Alderson-Day & Fernyhough, 2015; Petrolini et al., 2020).

There are two main hypotheses concerning the relationship between OS and IS. According to the concrete hypothesis, IS is produced in the same way as OS but just lacks the same articulatory execution. In contrast, abstraction views propose that IS likely branches off earlier than the motor execution phase or that IS does not figure within the same linguistic mechanism employed by OS at all (Perrone-Bertolotti et al., 2014, p.222). These takes on production also form the basis of theories on the nature and functions of inner speech with concrete proponents again suggesting that IS is more similar to overt conversation and abstract proponents emphasizing where they are dissimilar (Loevenbruck et al., 2018).

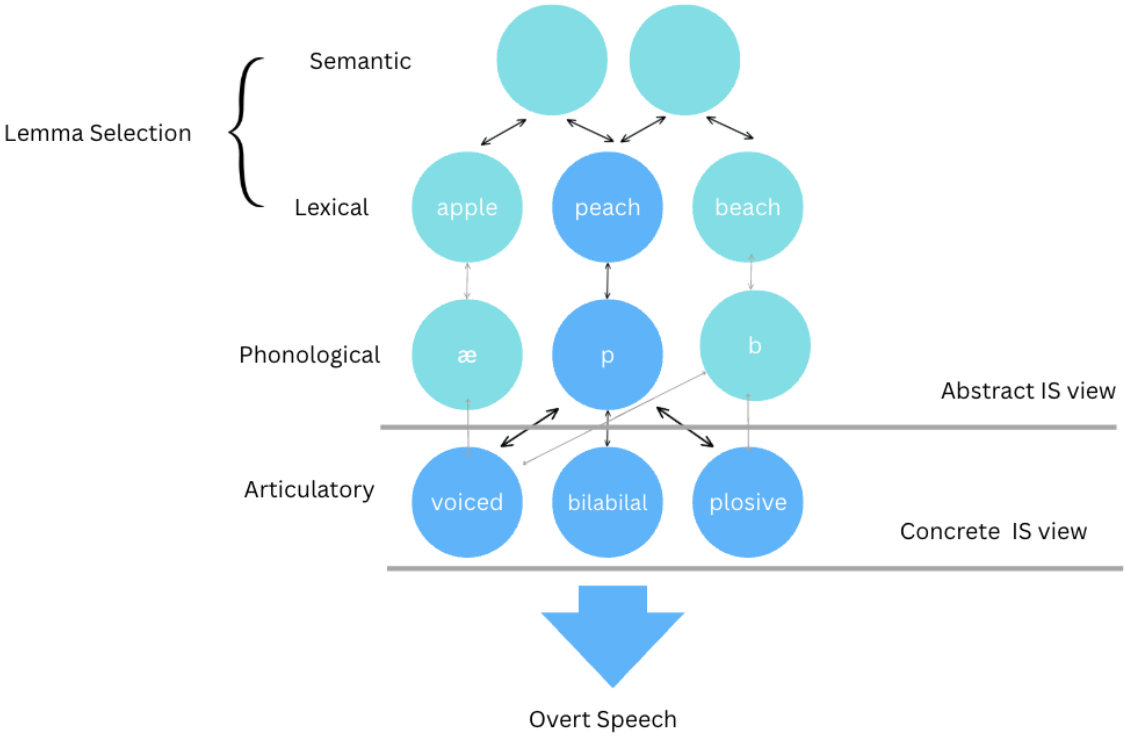
Much research is guided by the concrete perspective that IS is an evolved form of overt speech with suppressed articulation. However, my goal will be to caution against modeling IS too closely off the presupposed nature of OS. Although IS and OS are apparently similar, research has continued to uncover IS-specific nuances such as varying brain activity, abbreviation, and function. Thus, I will advocate for further investigation into arguments from abstraction and a model of inner speech that overlaps but remains independent from that of OS. I will begin by describing the concrete theory of IS production and its supporting evidence. I will then expose the limitations of this evidence and substantiate promising theories from abstraction. Finally, I will differentiate IS and OS phenomenology based on their pacing and dialogality. Comparing and contrasting IS and OS in this way will reveal their partially

overlapping, non-hierarchical relationship.

1.0 Producing OS vs IS

Figure 1

Steps to over speech production



Note. Adapted from "Motor movement matters: The flexible abstractness of inner speech," by Oppenheim & Dell, 2010, *Memory & Cognition, 38*(8), p. 1148 (https://doi.org/10.3758/MC.38.8.1147). Copyright 2010 by The Psychonomic Society, Inc.

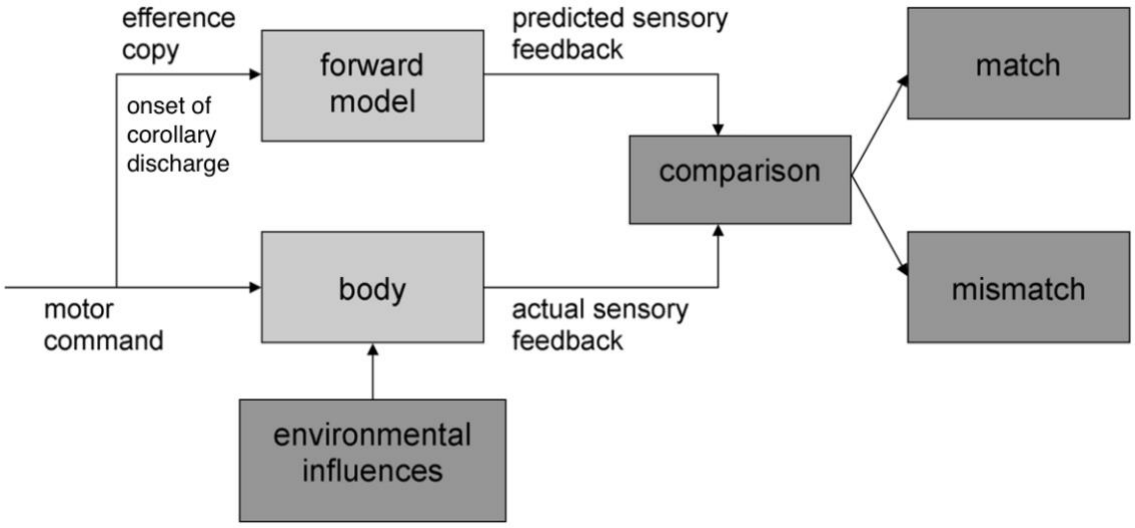
It is important to begin by sketching the standard model of overt speech production. Imagine you want to say the word *peach*. The first step is conceptualization: the brain searches for and selects the word concept or the *lemma* for *peach* amongst other lemmas that bear conceptual or structural similarities to the target lemma like *apple* or *beach* (Grandchamp et al.,

2019, p. 2). Next, at the phonological level, we search for and select the actual sounds that form the word. Finally, at the phonetic or articulatory level, the sounds are matched to their respective motor commands. Executing these commands ends the process with the outward expression of "peach." The concrete model view transposes these steps of the speech-motor system onto IS up until the last step of overt articulation. However, abstraction proponents think fewer or none of these steps take place during inner speech (Loevenbruck, 2018).

1.1 The concrete view elaborated

Figure 2

The feed forward model of motor control



Note. Adapted from "Motor imagery training for children with developmental coordination disorder – study protocol for a randomized controlled trial," by Adams et al., 2016, *BMC Neurology 16*(4), p. 4 (https://doi.org/10.3758/MC.38.8.1147). Copyright 2016 by BioMed Central.

The concrete view draws the line between IS and OS at the level of articulatory execution, and inner speech is thought to result from a forward model process enabling error detection (Gregory, 2022, p. 239). Forward modeling is used to explain how the central nervous system generates motor movements. For any given motor command, the brain creates efference copies that prime the CNS to expect certain sensorimotor feedback following the commands' execution. If there is a discrepancy between what's expected and the actual sensory feedback received, an error is detected, and attempts at correction ensue (Adams et al., pp. 4-5).

Overt speech is of course a sensorimotor process, requiring the movement of the speech musculature. Thus, concrete models of IS equate the phenomenon to an aborted or inhibited version of the forward model behind OS. The idea is that when the motor execution of speech is not enacted, the efference copies are still consciously represented. This is what constitutes inner speech- an internal representation of incomplete motor movements.

1.2 Concrete Supporting Evidence from Neuroimaging

A common argument made for the concrete model appeals to similarities in neuroimaging. For instance, Palmer et al. (2001) asked participants to complete a word stem either out loud or internally while undergoing fMRI. They found overlapping activation, with both conditions resulting in similar stimulation of Brodmann's area 6, consisting of the premotor cortex and supplementary motor area, and Brodmann's area 44, essential to speech production. However, the primary motor cortex showed much stronger activation during the overt speech condition, consistent with the view that IS can be reduced to OS lacking full motor execution. Perrone-Bertolotti et al.'s (2014) review of similar data strengthens this claim. FMRI of both inner and overt speech across a variety of tasks including word completion, generation, reading, repetition, and naming consistently share a common network of language centered activity involving Broca's

area, Wenicke's areas, and the inferior parietal lobule in the brain's left hemisphere (pp. 223-226). While these overlaps are not conclusive evidence, they do contribute to the idea that IS and OS are generated from the same system.

1.3 Concrete Supporting Evidence from Corollary Discharge

A more compelling line of evidence for concrete IS comes from the detection of corollary discharge throughout IS production. As shown in Figure 2, corollary discharge is a component of the forward model that accompanies the efference copies of motor commands. Predicted sensorimotor impact is established by efference copies and corollary discharge is what allows us to distinguish self-generated effects from external effects (Scott, 2023, p. 1824). This distinction is achieved through perceptual attenuation. When you speak out loud, or touch your arm, or actively shift your gaze, corollary discharge weakens the sensory impact of your action, allowing you to identify it as your own as opposed to the effects of someone else's voice, touch, or push. Thus, if IS is equivalent to resounding efference copies then it should also cause perceptual attenuation via corollary discharge.

Scott (2013) tested for such attenuation by measuring the strength of the Mann effect in IS vs non-IS conditions. The Mann effect is a phenomenon in which the same ambiguous sound between "da" and "ga" is interpreted as "da" if preceded by an "ar" sound but as "ga" when preceded by an "al" sound. Scott operationalized the strength of this effect as the difference between the percentage of "da" categorizations across "ar" and "al" trials (2013, p. 1825). In all conditions participants were primed with an audio track of either "al" or "ar" for 115ms, the experimenters then played the Mann effect sound and asked participants to report what they heard. Results showed that the Mann effect dampened when participants internally repeated the "al" or "ar" sound during priming (pp.1825-1826). Participants also interpreted the target sound in a

hearing condition where they simply listened to the “al” and “ar” sounds and a contrasting condition where they engaged in IS of the opposite sound (imagining “al” but hearing “ar”). Across these conditions, target categorizations were the least influenced by the Mann effect when participants matched their IS to the “al” and “ar” sounds of the priming phase. The same was found in a speaking control experiment. Both internally and outwardly saying “al” or “ar” decreases susceptibility to the Mann effect (p.1828).

This correlation between inner and overt speech’s impact on auditory perception works in favor of the forward model and the idea that IS is a step towards OS. It suggests that both phenomena generate corollary discharge that attenuates perception. The presence of corollary discharge in IS has also been supported by EEG findings. When measuring the event related potentials of phoneme processing, Jack et al. (2019) found a reduction in the N1 component of the ERP when participants produced IS of the same phoneme in tandem with playback of recordings. Again, this suggests IS behaves much like OS, attenuating and preparing to differentiate the perception of self-generated speech.

1.4 The appeal of the concrete model

Introspection may lead us to believe that IS and OS have the same linguistic presentation. We are capable of saying the same sentences out loud and in our heads. Hence, the concrete model offers a neat explanation of how inner and outer speech are related. The claim that both are produced in the same way by the same system is intuitively appealing, and the above similarities found in their neural correlates and effects on perception reinforces this point of view. However, as we will explore in the next section, limitations of such evidence legitimize questions on whether a complete subsumption of IS under OS is warranted.

2.0 Defining Abstract IS

While it's more convenient to assume that inner speech is actual speech, evidence from abstraction shows that IS lacks more than just motor execution and can be generated from outside of the speech production system. Abstract literature does not push a singular opposing take on the forward corollary discharge model. Some theories uphold the overt speech production, forward model, but propose IS surfaces at a level below that advanced by concrete theories. More extreme takes completely remove inner speech from the OS speech model. In Gauker's (2018) view, what we call inner speech is not true inner speech, but rather a misrepresentation of a generally unperceivable inner language that manifests as auditory imagery. Inner speech then is more akin to imagery and memory as opposed to productive speech processes. Gregory (2022) proposes a similar idea that inner speech is imagined speech or a representation of speech. Consider how you might imagine opening a door or walking. This motor imagery triggers activation in the brain similar to that of actual movement, but motor imagery is not considered a necessary or conscious step in movement. By analogy, if inner speech is imagined speech, then its existence is not predicated on the speech-motor system (Gregory, 2022, p.232). This notion that IS utilizes auditory imagery preserves its modal phenomenology. The feeling of "hearing" yourself speak in IS in this case originates from imagining yourself speak. My goal here will be to explain why such theories deserve further research, by highlighting the limitations of concrete model predictions and providing initial empirical support for an imagined speech stream.

2.1 A difference deeper than motor execution

While it may be a radical claim to say that inner speech is completely divorced from the forward model, psycholinguistic experiments suggest inner speech is at least less detailed than concrete views assume. One way to study speech production is by eliciting speech errors via tongue twisters. Overt speech tends to show two types of errors when this is done. According to

the lexical bias effect, we are more likely to make errors if they result in real words i.e. mistaking *reef leech* for *leaf reach* is more likely than mistaking *wreath league* for *leeth reeg* (Oppenheim & Dell 2008, p. 529). Secondly, the phonemic similarity effect refers to our tendency to make mistakes between sounds that are more similarly produced. We are more likely to mistake *reef leech* for *leaf reach* than we are to mistake *reef beech* for *beef reach* because the production of the phoneme /r/ has more in common with /l/ than /b/ (Oppenheim & Dell 2008, p.529).

Neither of these effects are motor command or execution issues, they have their origin in speech planning. Hence, if IS is OS cut off at the motor level, we might expect these types of errors to be present in IS as well. When participants were asked to recite tongue twisters and report any mistakes they made after each trial, their mistakes showed both the lexical bias effect and the phonemic similarity effect in overt and mouthed speech conditions. However, after internally reciting tongue twisters, they only reported mistakes in line with the lexical bias effect. (Oppenheim & Dell 2008, 2010). The lack of phonemic similarity errors suggests that inner speech does not just lack motor execution, but also articulatory planning. While IS can represent word concepts and their sounds, inner speech does not seem to carry any information at the level preceding the execution phase which matches sounds to their upcoming place and manner of articulation. Simply put, we can catch word-based errors in inner speech because it is expressed at the lexical level, but not phonemic errors because it is underspecified articulatorily. Hence IS is likely more abstract than concrete models let on, and drawing this finer grained distinction helps to explain the phenomenological differences I will elaborate on in section 3.

2.2 Questioning the Common Brain Network Argument

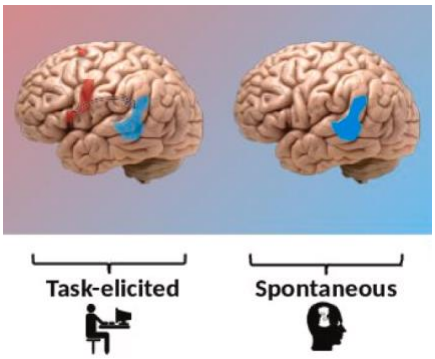
In addition to psycholinguistic findings, the value of concrete theories' appeal to a shared neural network is undermined by dissimilarities in IS and OS activation patterns. Despite their

commonalities in the key language centers of the brain, Perrone-Bertolotti et al. (2014) also noted that IS triggers greater activation than OS in regions including the left precentral gyrus, middle frontal gyrus, temporal gyrus, etc (p.223) While some of this activity can be explained as inhibitory mechanisms or response conflict (producing but not speaking speech), the diversity in IS activation across experiments requires a more thorough explanation. In fact, there seems to be different varieties of inner speech that emerge depending on the task and experimental conditions at play.

For example, Pratts et al.'s (2023) metanalysis of 22 neuroimaging studies (deduced from the 296 studies screened) found IS brain activity varied depending on whether studies elicited deliberate or spontaneous IS. While a deliberate IS condition might ask a participant to internally recite the national anthem, a spontaneous IS condition could have them describe their internal state after a random beep. Consistent with the concrete view of IS, studies that elicited deliberate inner speech conditions converged on activation in brain regions used in speech production such as the inferior frontal gyrus and the premotor and supplementary motor area. However, studies that elicited spontaneous IS converged on areas of speech perception, notably the left and middle temporal gyrus (Pratts et al., 2023, p.4). These contrasting findings suggest that in spontaneous conditions- which are arguably more true to life- IS is produced through perceptual simulation rather than corollary discharge.

Figure 3

Brain regions recruited by deliberate vs spontaneous IS



Note. Adapted from "Bridging phenomenology and neural mechanisms of inner speech: ALE meta-analysis on egocentricity and spontaneity in a dual-mechanistic framework," by Pratts et al., 2023, *NeuroImage*, *282*, p. 4 (https://doi.org/10.3758/MC.38.8.1147). Copyright 2016 by Elsevier Inc.

The theory is that upon processing OS, we encode its perceptual features in our auditory cortex (temporal lobe), and these features are then reactivated and recombined to generate novel perceptual simulations (Pratts et al., 2023, p.2). In short, inner speech seems to come in different varieties- some of which do not rely on the speech production system and therefore lack explanation via concrete models. Further support for this variety in IS mechanisms comes from Tian et al. (2016): while imagining articulation showed fMRI results consistent with the sensorimotor speech production system, hearing imagery showed activity in regions related to memory. Thus, it is possible that IS is produced by multiple channels- a forward model and a perceptual simulation model reminiscent of Gauker (2018) and Gregory's (2022) proposal of an imagined inner speech.

2.3 The potential of the abstract model

Together these findings show there is room to question the concrete view of IS. Further study would be required to completely overturn the concrete view. With many potential routes of inquiry in this domain, researchers should prioritize spontaneous inner speech conditions and

mixed methodologies to assess the validity of a perceptual simulation model of IS. For example, imaging combined with experience sampling and phoneme repetition could help track the presence of corollary discharge in spontaneous vs deliberate IS. Breaking from the lab context by employing mobile EEGs could also help obtain more naturalistic IS data. The pitfalls from which these empirical needs arise demonstrate my larger argument: the definition of inner speech as unspoken overt speech does not hold up to scrutiny. The process we identify as the source of IS also has repercussions on how we interpret the experience of IS, which I will now address in section 3.

3.0 Distinguishing IS and OS phenomenology

Consider a thought you've had since you began reading this paper. Can you recall what triggered that thought, how fast it occurred, or the way it was represented in your mind? Would you be able to say the same exact thing out loud? If not, how would your outward expression differ from your inner thoughts and why? While it seems possible to repeat the same sentences out loud and in our heads, the natural, spontaneous IS speech stream often presents differently to OS. Here I will highlight two phenomenological features that further distinguish IS from OS: its pace and dialogality. I argue that these differences generate varieties of IS that do not fit the unarticulated, concrete theory and that represent a distinct form of communication.

3.1 The Pace of IS vs OS

3.1a Speed. Studies have found the rate of inner speech to be comparatively faster than overt speech in both novel generation and recitation tasks (Brysbaert & Vantieghem, 2023; Korba, 1990; Netsell, 2016). Concrete view proponents attribute this to the lack of mobility and need for pauses in IS. However, Brysbaert & Vantieghem (2023) found that overt and covert speech pace depends on more than just articulatory movement or lack thereof. They performed

multiple regression and cluster analysis on several metrics related to speech rate and literacy. Most importantly, they measured articulation speed in words per minute (wpm) by having participants read and recite the months of the year and count to ten as fast as possible. They also measured reading speeds (in wpm) by having participants read texts both overtly or covertly and report when they were done. A correlation between all three of these measures (articulation speed, overt reading speed, and covert reading speed) would support the idea that they are part of the same mechanism. But results showed a strong correlation only between articulation and reading in overt conditions. Silent reading was found to belong to an entirely different cluster, closely correlated with separate measures taken of the participant's vocabulary, age, familiarity with authors, and the number of books they had read within the past year. While this does not invalidate the feedforward model, at the very least these differing correlations threaten views that distill IS to OS at all levels save full-on articulation. The lack of a predictive relationship between articulation and IS speed aligns with the aforementioned studies by Oppenheim & Dell (2008, 2010), suggesting that IS has an abbreviated form stripped of articulatory or phonetic content and perhaps linked more to memory than productive processing.

3.1b Condensation. Indeed, IS often surfaces and is intelligible in a more condensed form than OS (Vygotsky, 1934/1986). This attributes IS's faster pace not only to a lack of movement, but also to a lack of syntactic, lexical, or phonological detail. For instance, in Korba (1990) participants were timed as they silently performed verbal problem-solving tasks. Immediately after they reached a solution, they were instructed to write down all of the inner speech they had used to problem-solve as close to verbatim as possible. They were then asked to expand these IS episodes into fully intelligible verbal reports. By linking their initial problem-solving speed to the length of these overt reports, it was estimated that average IS speed would

likely surpass 4,000 words per minute- a speed that would be physically impossible in an overt condition (Korba 1990, 1049). Although self-report data has its weaknesses, taken together with the studies from Sections 2.1 and 3.1a, it seems likely that IS can surface in a shortened format that allows for a quicker turnaround than OS.

It can be argued that condensation is a similarity shared between IS and OS as overt speech utterances also stretch or shrink depending on the context. However, the manifestation of this condensation and the contexts in which it applies are different. Overt speech varies depending on social and pragmatic concerns. We modify our speech depending on our conversation partner, the background information we assume they know, and our relationship to them. Nonetheless, when we abbreviate words or use casual speech with friends, we generally abide by grammatical structure and do not speak in keywords or drop function words (conjunctions, prepositions, etc.) as is predicted in IS (Grandchamp et al., 2019, p. 2). As seen in Korba et al. (1990), speech slows greatly from IS to OS precisely because of this need to accommodate for a partner's comprehension. However, the cause of condensation in IS is not related to social circumstance or communicative purpose, rather it is thought to stem from cognitive demand. According to Fernyhough (2004), IS most often surfaces in a condensed form that expands when we encounter situations that recruit greater cognitive control. This could tie in nicely with Gauker's (2018) thinking that inner speech is always present but not always conscious.

3.2 How IS and OS "dialogality" differ

The "dialogic" quality of IS is often used to argue for a close correspondence between IS and OS. Vygotsky (1934/1986) first hypothesized that IS results from an internalization of external conversation that begins in childhood. The existence of this kind of dialogic inner

speech is supported by findings from McCarthy-Jones & Fernyhough's (2011) Varieties of Inner Speech Questionnaire: 77.2% of 235 young adult participants reported engaging in IS with alternating perspectives like in a conversation (p. 1590). This quality of IS can work in favor of Martínez-Manrique & Vicente's (2015) activity view of IS which equates IS to speaking internally and describes its functions as a subset of the same functions served by OS. Indeed, we can motivate ourselves, talk down to ourselves, or problem-solve, all like we would with another person. However, to say that IS and OS have the same underlying functions based on similarities in their discursive format is, in my view, an oversimplification.

While dialogic IS and OS present similarly and can accomplish similar tasks, this does not entail that they have the same goals or employ the same mechanisms. Overt dialogue is necessarily exchanged with (a) partner(s) and is widely thought to follow Grice's maxims of conversation. According to this model, in a typical dialogue, both parties convey and expect just enough information that is relevant to the context (Grice, 1975). The overarching goal is communication, but without an external conversation partner, IS is unbound by these rules. It is unnecessary, for instance, to establish referents for pronouns, topics can shift abruptly or flow in ways that would be unnatural in an OS conversation, and IS does not provide social stimulation. As Gregory (2017) puts it, internal dialogue can be compared to playing chess with yourself. In this simulated back and forth you are constantly aware of your next move, removing the basic quality of conversation being a revelatory exchange of thought.

Furthermore, the presence of intrusive thoughts and rumination are in violation of the cooperative properties that Grice (1975) affords to external dialogue. Intrusive thoughts are unintentional and often unwanted inner speech events that feel uncontrollable. Ruminations are repetitive thoughts concerning the same subject matter. These types of inner speech events are in

stark contrast to Grice's idea that we generally communicate truthfully using the necessary amount of relevant information with an external conversation partner. Of course, Grice's maxims are idealistic; we can easily conceive of a repetitive conversation involving undesirable comments. Yet, even if inner intrusions and ruminations are likened to repeated and unwarranted external commentary, the two still stem from different mental states. Whereas straying from Grice's maxims externally can imply deceit or confusion, internal intrusions and ruminations are often distressing and correlated with depression and anxiety (Nalborczyka, 2017).

Describing inner speech as dialogic may be a helpful metaphor to make sense of its phenomenology, but drawing functional comparisons based on this observation is misleading due to the different contexts in which OS and IS apply. Rather than understanding IS in the shadow of OS, focus should be shifted to examine the unique purpose IS serves in cognition. For example, Gauker (2018, pp.54-55), proposes that all conceptual thought takes place in IS, whether we are conscious of it or not. Viewing IS as the input to higher cognitive processes such as reasoning and problem-solving does not altogether conflict with interpreting it as an internal form of communication. But likening IS to OS with a hypothetical conversation partner risks underselling inner speech's scope and occluding its idiosyncrasies.

Conclusion

It is intuitively appealing to assume that inner speech is produced and experienced the same as overt speech without outward expression. However, it is ill-advised to accept this concrete view given legitimate evidence in favor of an abstract IS conceptualization. Despite the apparent similarities between IS and OS, contrasting results from brain imaging, psycholinguistic lab studies, and deeper phenomenological observation demonstrate that IS can differ from OS across multiple dimensions. Further research is required to characterize IS as concrete or abstract

or existing in multiple varieties, but it is clear that the complexity of IS cannot be subsumed under current overt speech models.

Inner speech is not directly observable and thus has traditionally been resistant to scientific inquiry. Nonetheless, emerging technologies such as brain computer interfaces and mobile EEGs promise new ways to understand and utilize the phenomenon. More data of inner speech in naturalistic environments should be collected to strengthen our knowledge of what it really is, how it works, and how we can use it to develop tools for communication.

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