How Do You Know If You're Lost or Not? Epistemic and Pragmatic Action During Navigation

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Introduction

- Navigation ebbs and flows between **decision making** and **goal-oriented** action. If you don't know where you're going, you will probably stop walking and look around to gain your bearings. Conversely, if you are well-oriented, you will likely walk straight ahead to your destination, and look around minimally.
- Our lab previously showed looking around behavior indexes navigators' relative orientation and predicts path efficiency [1]. Looking around seems to mark times of uncertainty or decision making. The current work extends these findings by categorizing ongoing navigational behavior.
- Specifically, we suggested a person who **stops walking to look around** is gathering information or making decisions (**epistemic** action), and a person **walking without looking around** is acting to achieve a goal (**pragmatic** action). Thus we categorized navigational behavior as **information-gathering (epistemic)** or **goal-oriented (pragmatic)** [2] and related these actions to navigational success.

Research Questions

Does ongoing navigational behavior reflect underlying navigational cognition?

What insights into navigational success can refining such an analysis provide?

Experimental Methods & Data Analysis

Materials and sample:

- *Virtual Environment (VE):* developed with Unreal Engine 2 [3]; approx. 68,400m^2, 16 target landmarks
- "Map": aerial view of VE (1050x1050px) with labeled landmark locations
- n = 107 (undergraduate students), 73 female

Procedure:

1. Study the VE aerial view (below) for 60 seconds
2. Navigate 10 trials (walk landmark-to-landmark within VE)

Data Analysis:

- Constructed **20 Multi-Level Mixed-Effects** (MLME) to investigate how **epistemic** and **pragmatic** action proportions at each percentage trial time interval of 5%, 10%, 15%, … 100% predicted overall path efficiency

Path Efficiency (PE)

- *Path efficiency* (PE) compares the length of the actual path traveled with optimal path length: $PE = \frac{PL_O}{PL_A}$
- Highest PE is 1.0 (perfectly follows optimal path), and infinitely approaches zero.

3 hypothetical paths between the same 2 landmarks, showing approximate PE.

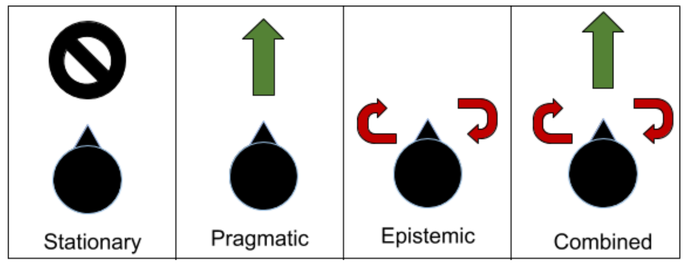
Path Efficiency = 1.0

Path Efficiency = 0.7

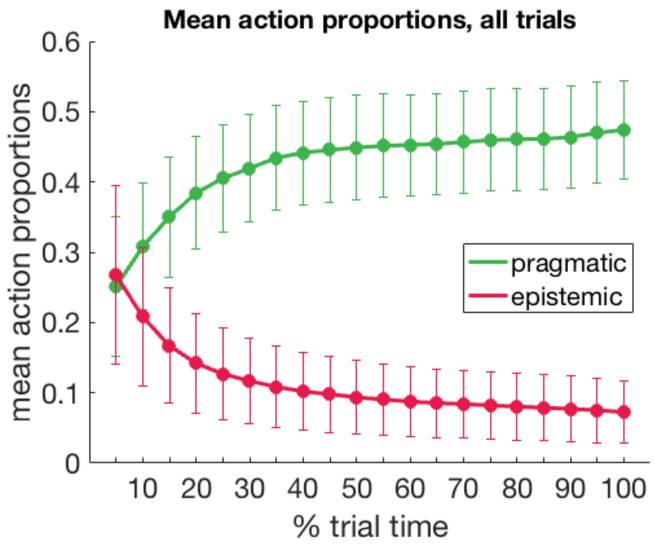
Path Efficiency = 0.4

Action Types

Stationary: neither walking nor moving
Pragmatic: walking toward a goal
Epistemic: looking around to gather knowledge
Combined: walking and looking around simultaneously

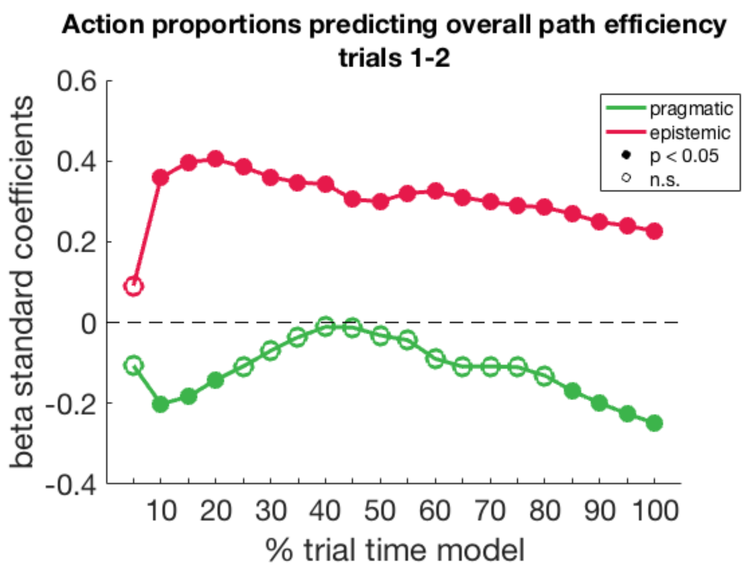


Results



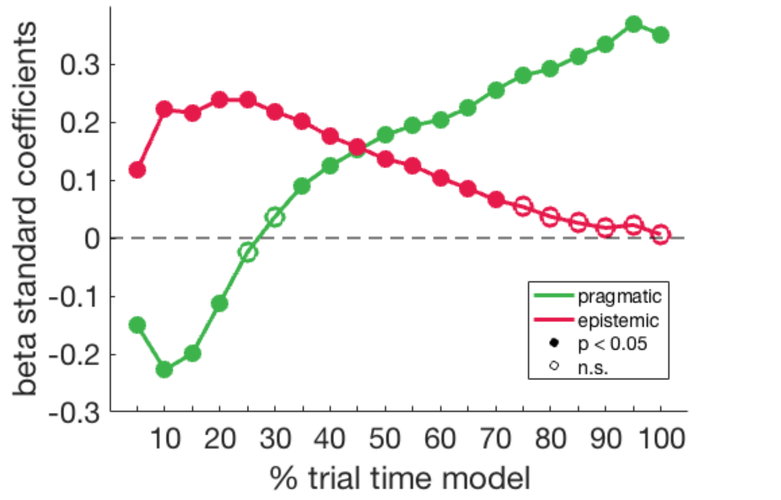
- On average, participants start trials with similar action proportions
- As trials continue and, presumably, navigational certainty increases, pragmatic actions comprise a larger proportion of actions performed

Results



- *Beta standard*: represents effect of predictor (action proportions) on dependent variable (PE)
- Each point on the x axis marks a separate MLME model, with **epistemic** and **pragmatic** action proportions predicting overall PE
- Preliminary analyses showed qualitative difference between first 2 and last 8 trials, led to separating Trials 1 & 2 from others
- **Epistemic** actions positively predicted overall PE throughout trial, **pragmatic** actions marginally negatively predicted PE

Results



- Each point on the x axis marks a separate MLME model, with **epistemic** and **pragmatic** action proportions predicting overall PE
- Trials 3-10: consistent crossover between **pragmatic** and **epistemic** action proportion predictivity
- Early trial times: **Epistemic** actions positively predict PE, **pragmatic** actions negatively predict PE
- Late trial times: **Pragmatic** actions positively predicts PE

Discussion

Major findings:

(1) Environmental learning effect: In Trials 1-2 **epistemic action proportions** positively predicted PE throughout, **pragmatic action proportions** negatively predicted PE. In later trials, **epistemic** predictivity did not hold throughout

(2) Crossover predictivity: In Trials 3-10 earlier **epistemic action proportions** positively predicted overall PE, earlier **pragmatic action proportions** negatively predicted overall PE. Eventually this relationship reverses: by the end of a trial, **pragmatic action proportions** positively predict PE, while **epistemic action proportions** do not predict PE.

How does this inform what we know about navigational cognition?

- People navigate more efficiently when they take time to **gather information** early (both within a single trial and generally over the whole experiment) and then make effective **goal-oriented** use of that information.
- In early trials, the extent that people **gather information** consistently positively predicts navigational efficiency
- In later trials, this relationship changes about halfway through a trial. In the first half, **decision-making actions** are more strongly associated with overall navigational efficiency. In the second half, **goal execution** links more strongly with navigational efficiency.

Future Directions

- Consider continuous measures (e.g. consistent heading measurements) compared to our simple categorization
- How do **stationary** and **combined** actions fit into these results?
- How exactly does our categorization system relate to our lab's previous findings – especially continuous measure of looking around behavior?
- How well do these models predict PE (overall MLME model effect size?)

References

[1] Taylor, H. A., Houck, L. A., Haga, Z. D., & Brunyé, T. T. (2017). You Look Lost: Understanding Uncertainty and Representational Flexibility in Navigation. In *Representations in Mind and World* (pp. 42-56). Routledge.

[2] Kirsh, D., & Maglio, P. (1994). On distinguishing epistemic from pragmatic action. *Cognitive science*, *18*(4), 513-549.

[3] Unreal Engine 2, Epic Games, Raleigh, NC