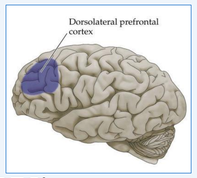
Left Dorsolateral Prefrontal Cortex's Role in Inductive Reasoning

Pablo A. Escotto
Department of Social Sciences
Mount Saint Mary College, Newburgh, NY 12550

Introduction

- **Induction:** Inferring a plausible general rule from particular premises.
- **Deduction:** Identifying a guaranteed truth from general observations.



- **Prefrontal cortex (PFC)**: key neural correlate of inductive reasoning
  - specifically, the dorsolateral PFC (DLPFC)
  - more specifically, the left-hemispheric DLPFC (Goel & Dolan, 2000; Goel et al., 1997; Jia et al., 2011; etc.)

- Claim to test: Left DLPFC functions as source of and integrator of background information during inductive inferences (i.e. working memory, memory retrieval, etc.) (Goel & Dolan, 2004; Rotella & Heit, 2009; Badre et al., 2007).

- **Transcranial Magnetic Stimulation** (TMS)
  - Noninvasive method of disrupting the electrical activity of certain neurons by generating a magnetic field near the brain.
  - TMS has been used to interrupt the activity of specific groups of neurons: experimental method of identifying neural contributions to some cognitive process (D'Ardenne et al., 2012)

Predictions

- If left DLPFC functions mainly as a memory bank/integrator during inductive reasoning, then disturbing its activity should preferentially impair performance on high memory load inductive tasks compared to low memory load inductive tasks.

- If left DLPFC serves some function in the process of induction itself (e.g. in generation or application of the abstract rule), then disturbing its activity should impair performance equally across both high and low memory load inductive tasks.

Validity Check Methods

- 500 subjects
  - Given 30 samples of both "Heavy" and "Light" induction task items (15 of each).
  - Measure: number of correct answers within each kind of induction task.
  - Remove items from either condition that earn no better than chance (60%) correct rate throughout trials
  - Retain items from both conditions that sustain comparable success rate throughout trials

Main Study Methods

- 1,000 subjects
  - Given 10 inductive inference questions
    Based on two premises (**P**), asked to determine plausibility of inference statement (**I**) – Yes/No
    Subjects will be divided among two conditions
  - **Conditions**
    1) **Heavy Memory Load, e.g.**
       P1- The British Monarchy had a well-developed naval force.
       P2- The Spanish Monarchy had a well-developed naval force.
       I- Pre-18th century Naval forces depend on monarchic rule to develop well.
    2) **Light Memory Load, e.g.**
       P1- Squares in this bag are blue.
       P2- Diamonds in this bag are blue.
       I- Other shapes in this bag are also blue.

- Localized TMS will be applied to left DLPFC during the tasks, to interrupt normal activity.

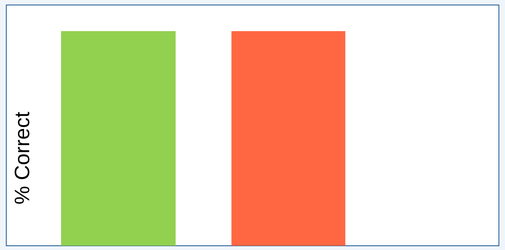
- Results will be measured as % correct over total trials and number of correct answers within each inductive inference task.

Limitations

1) Difficulty in designing "Light" items that limit any kind of background information content.
2) Difficulty in designing "Heavy" items not too difficult to successfully answer
3) Memory load activated by given items might be slightly different for each individual
4) Question design: Yes/No includes a 50% chance error, limiting items that can be considered valid
5) PFC development lasts into mid-20s, removing children & teens from sample

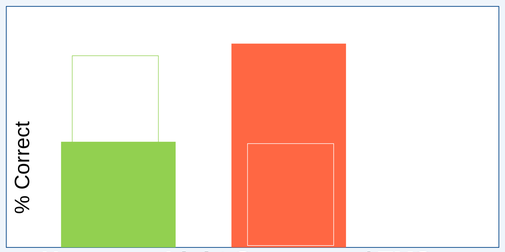
Projected Data Format

= Heavy = Light



Heavy vs. Light Success w/o TMS

- Both "Heavy" and "Light" items retained from validity check should exhibit similar success rates (well above 60% mark)



Heavy vs. Light Success w/ TMS

- "Heavy" results should (or should not) be uniquely reduced by TMS

Significance

1) Basic research always contains the pearl of unforeseen potential future practical applications.
2) Knowledge for knowledge's sake.
3) Differentiating between cognitive processes like memory retrieval, memory integration, and conscious cognitive operations pays dividends in fields as diverse and crucial to societal function as education, mental health counseling, and brain injury rehabilitation.

Selected References

- Badre, D., & Wagner, A.D. (2007). Left ventrolateral prefrontal cortex and the cognitive control of memory. *Neuropsychologia, 45*. 2883-2901. doi:10.1016/j.neuropsychologia.2007.06.015.
- D'Ardenne, K., Eshel, N., Luka, J., Lenartowicz, A., Nystrom, L.E., & Cohen, J.D. (2012). Role of prefrontal cortex and the midbrain dopamine system in working memory updating. *PNAS, 109*(49). 19900-19909.
- Goel, V., & Dolan, R. J. (2000). Anatomical segregation of component processes in an inductive inference task. *Journal of Cognitive Neuroscience*, *12*(1), 110-119. doi:10.1162/08989290051137639
- Goel, V., & Dolan, R. J. (2004). Differential involvement of left prefrontal cortex in inductive and deductive reasoning. *Cognition*, *93*(3), B109-B121.
- Goel, V., Gold, B., Kapur, S., & Houle, S. (1997). The seats of reason? An imaging study of deductive and inductive reasoning. *NeuroReport, 8*. 1305-1310.
- Jia, X., Liang, P., Lu, J., Yang, Y., Zhong, N., & Li, K. (2011). Common and dissociable neural correlates associated with component processes of inductive reasoning. *Neuroimage*, *56*(4), 2292-2299. doi:10.1016/j.neuroimage.2011.03.020
- Miller, E.K., & Cohen, J.D. (2001). An integrative theory of prefrontal cortex function. *Annual Review of Neuroscience, 24*. 167-202.
- Miller, E.K., & Wallis, J.D. (2009). Executive function and higher-order cognition: Definition and neural substrates. In: Squire, L.R. (ed.) *Encyclopedia of Neuroscience, 4*. 99-104. Oxford: Academic Press.
- Rotella, C.M. & Heit. E. (2009). Modeling the effects of argument length and validity on inductive and deductive reasoning. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 35*(5), 1317-1330. doi: 10.1037/a0016648

Contact Information

You may contact the author for more information at:
pesc5696@my.msmc.edu