When are Parkinson's Patients Impaired (or Not) at Category Learning

M. Gluck, C. Myers, D. Shohamy
Rutgers-Newark
Center for Molecular & Behavioral Neuroscience

1. Why are BG important for category learning?
   → Perhaps feedback is key.

2. Further manipulation of task variables

Converging Evidence Suggests BG Important for Feedback Learning

1. **Electrophysiology**: BG modify responses based on (rewarding?) feedback (e.g. Ljungberg et al., 1992;Schultz, 1997)
2. **fMRI**: BG active during feedback learning, not observational learning (Poldrack et al., 2001).
3. **Neuropsych**: Parkinson's patients impaired on some feedback learning tasks (Knowlton et al., 1996; Myers et al., 2003).

⇨ *However, necessity of BG for feedback learning not demonstrated directly.*

Goal of Study

Compare Parkinson's patients on probabilistic category learning under *feedback* and *no-feedback* ("observational") training

Prediction

Parkinson's patients will be
- ***impaired*** when learning is feedback-based
- ***not impaired*** when learning is observational.

"Mr. Potatohead"

Hat	.8	.2
Glasses	.6	.4
Moustache	.4	.6
Bowtie	.2	.8

Features on Mr. Potatohead predict category outcome (vanilla or chocolate) probabilistically

Feedback Condition

Observational Condition

Press "next" to see another customer

Subjects: PD & Control

		Age	Education	MMSE	H-Y	Years PD
FB	PD	61.3 (6.4)	16.6 (2.4)	29.2 (0.8)	2.3 (0.6)	6.2 (3.2)
	CON	59.0 (6.4)	17.0 (2.4)	29.8 (0.4)	N/A	N/A
OB	PD	64.5 (6.0)	15.9 (3.3)	29.0 (1.2)	2.1 (0.7)	5.4 (4.7)
	CON	64.1 (6.0)	16.9 (2.3)	29.0 (0.9)	N/A	N/A

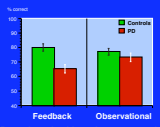
FB = feedback-task, OB = observational-task, MMSE = Mini Mental State Exam: age, education and PD duration in years. SD in parentheses.

- Non-demented and non-depressed.
- Intact cognitive function.
- Tested on medication.

Results for Mr. Potatohead

⇨Consistent with prior studies: PD impaired with feedback learning

Results for Mr. Potatohead



⇨ PD not impaired learning same task with 'observational' learning

Learning strategies

Math analyses determine fit of individual data to models of learning strategies

Prior studies: Most subjects use specific subset of strategies under feedback conditions (Gluck et al., 2002)

⇨ Do PD and controls use same strategies with observational learning?

Learning Strategies

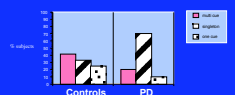
Prior studies: 3 Main Learning Strategies

1. Multi-cue (learn all 4 cues;optimal)
2. Singleton (learn 4 single-cue patterns)
3. One-cue (respond based on one cue)

For Details See:

Gluck, M. A., Shohamy, D., & Myers, C. E. (2002). How do people solve the "weather prediction" task?: Individual variability in strategies for probabilistic category learning. Learning and Memory, 9, 408-418.

Feedback Learning Strategies



- Almost all subjects use one of previously defined strategies.
- PD show different pattern of strategy use than controls

Observational Learning: No Strategies

Almost NONE of the subjects in any group use the strategies defined earlier.

Many subjects appear to learn a RULE, responding correctly to a subset of patterns/exemplars.

⇨ Subjects learn the task in a *qualitatively different manner* under feedback vs. observational conditions.

Summary

PD impaired on PCL only when learning is feedback-based, not observational.

Feedback vs. observational learning invoke different strategies in both controls and PD.

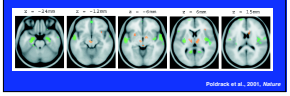
⇨ Consistent with role for BG in modifying behavior based on response-contingent feedback as suggested by our prior imaging study with R. Poldrack (next slide.)

Feedback vs. *Observational* Differentially Recruit Striatum and MTL

Direct comparison:

FB > Obs: Striatum and thalamus, midbrain

Obs > FB: MTL and PFC



Poldrack et al., 2001, *Nature*

Does this suggest a double dissociation?:

	Feedback	Observ.
BG damage (PD)	Impaired	OK
MTL Damage (Amn)	?OK?	?Impaired?

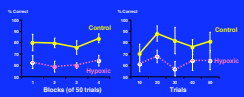
Does this suggest a double dissociation?:

	Feedback	Observ.
BG damage (PD)	Impaired	OK
MTL Damage (Amn)	?OK?*	?Impaired?

* Prior data suggested early MTL learning OK (Knowlton, Squire, & Gluck, 1994; Knowlton, Mangels, & Squire, 1996)

Exp 1. Weather Prediction

Hopkins, R., Myers, C., Shohamy, D., Grossman, S., & Gluck, M. (In press). Impaired category learning in hypoxic subjects with hippocampal damage. Neuropsychologia.

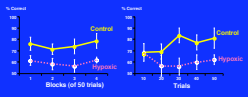


In contrast to Knowlton et al. (1994, 1996) we find MTL/Amnesic deficit both early and late in training.

Why?: These hypoxic amnesics have verified MTL damage, while earlier studies had mixed etiologies with broader damage.

Exp. 2. Mr. Potatohead

Hopkins et al. Neuropsychologia. In press.

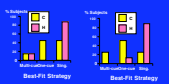


Same result with Mr. Potatohead task.

Comparative Strategy Analyses

Hopkins et al. Neuropsychologia. In press.

(A) Weather Task (B) Mr. Potatohead



No clean double dissociation:

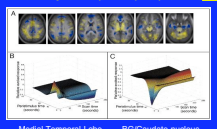
	Feedback	Observ.
BG damage (PD)	Impaired	OK
MTL Damage (Amn)	Impaired	??

But..consistent with earlier imaging and modeling:

BG and MTL both important for PCL but in different ways, and at different times during learning (early MTL, late BG)

Event-related fMRI of Weather Prediction

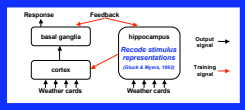
Poldrack, Clark, Pare-Blagoev, Shohamy, Creso-Moyano, Myers, & Gluck, Nature (2001)



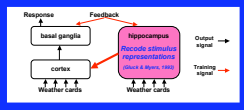
Medial Temporal Lobe BG/Caudate nucleus

Results: Early MTL activity, late BG activity

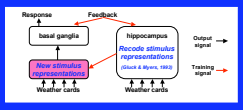
The Computational Model:



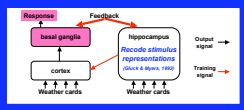
The Computational Model:
Early in Training



The Computational Model:
Late in Training



The Computational Model:
Late in Training



When are Parkinson's Patient's Impaired (or Not) on Category Learning

Gluck, Myers, & Shohamy. Rutgers-Howard Neuroscience

1. Why are BG important for category learning? Perhaps feedback is key.

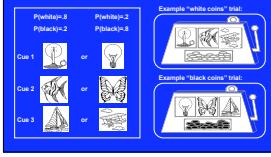
2. Further manipulation of task variables to better understand functional roles of BG and MTL in category learning

Myers et al. (2003) CNS Poster

1. Are PD simply slower at probabilistic category learning (PCL), or is there a qualitative difference in how they approach PCL, relative to controls?

2. Is the PD deficit unique to the (very difficult) weather task, or does it extend to other (easier) probabilistic category tasks?

"Slots"



Slots: Simpler PCL

Stimuli

Three independent cues.

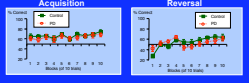
Each cue probabilistically associated with each outcome

Each pattern deterministically associated with each outcome
* subject potentially achieve 100% correct (vs. 67% WP)

Fewer solution strategies than in "weather" task:
* no "singleton" patterns

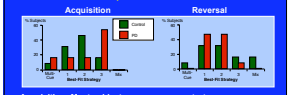
Transfer: Unsignaled reversal

Slots: PD vs. Matched Controls



- Acquisition: PD are not different from controls.
- Reversal: PD are not different from controls.

Slots Strategy Analysis:
PD shift, Controls Reverse



- Acquisition: Most subjects use a one-cue strategy
- Reversal: All but 2 controls best-fit by same strategy as in acquisition; all but 2 PD shift from a one-cue strategy to another (different) one-cue strategy.

=> Whereas Controls keep (but reverse) their earlier strategy, PD "avoid" reversal by shifting to a new, equally-predictive cue.

Slots: General Discussion

- PD are not impaired at acquisition.

Thus, PD deficit observed in "weather" task may depend on specific features of that task, including overall difficulty, need to encode configural cues, pattern-response conflict, etc., rather than reflecting a general PD deficit in probabilistic classification learning. **Future: manipulation of these variables independently**

- No PD impairment on reversal.

PD "avoid" reversal by shifting to another, equally-effective strategy

Lack of PD impairment on this shifting is consistent with the general lack of impairment by medicated PD patients on other intradimensional shift tasks (e.g. Downes et al., 1989; Gauntlett-Gilbert et al., 1999).

Bibliography

Gluck, M., Shohamy, D., & Myers, C. (2002). How do people solve the "weather prediction" task? Individual variability in strategies for probabilistic category learning. Learning and Memory, 9(6), 408-418.

Hopkins, R., Myers, C., Shohamy, D., Grossman, S., & Gluck, M. (in press). Impaired category learning in hypoxic subjects with hippocampal damage. Neuropsychologia, to appear.

Myers CE, Shohamy D, Gluck M, Grossman S, Kluger A, Ferris S, Golomb J, Schnirman G, Schwartz R. (2003). Dissociating hippocampal vs. basal ganglia contributions to learning and transfer. Journal of Cognitive Neuroscience, 15:185-193.

Poldrack RA, Clark J, Pare-Blagoev J, Shohamy D, Creso Moyano J, Myers C, Gluck MA (2001) Interactive memory systems in the human brain. Nature 414:546-550.

Shohamy, D., Myers, C., Onlaor, S., & Gluck., M. (2003). The role of the basal ganglia in category learning: How do patients with Parkinson's disease learn? Manuscript under editorial review.

Slots Methods

Subjects

- 13 individuals with mild-to-moderate idiopathic PD
  - 10 males, 3 females; mean age 62.4 years; mean education 16.8 years.
  - All tested on dopaminergic medication; clean of other medication including anticholinergics; screened for depression and dementia.
- 13 healthy controls
  - 6 males, 7 females; mean age 63.0 years, mean education 15.9 years. Neither age nor education differed significantly from the PD group (age: $t(24)=0.31$, $p>.500$; education: $t(24)=0.75$, $p=.462$).
  - Screened for absence of any neurological or psychiatric disorder, including depression; free of any medication that could impair cognition.

Procedure

- Task and data analysis same as in Experiment 1.