Physiologic Correlates of Learning in A Classroom Environment: Overview & Initial Data Analysis

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Brief bio

• Interested in the biological basis of thought since HS
• Chemistry & Philosophy double-major at Haverford College
• HMS (first fully new-pathway class)
• Medical Internship at BWH
• Neurology Residency at the Longwood Program
• Fellowship in Cognitive & Behavioral Neurology at BWH
• Research Postdoctoral fellowship with Dan Schacter at Harvard University in Experimental Psychology & Cognitive Neuroscience of Memory
• Major research focus: Understanding exactly how memory breaks down in Alzheimer’s disease, and what strategies can be used to maintain/improve memory in these patients
Colleagues, post-docs, RAs, & Students

• Corinne Nagle, MA (graduate student)
• Michelle Tat, PhD (post-doc)
• Ann Zumwalt, PhD, Director of Anatomy Course at Boston University School of Medicine
• Rebecca Deason, PhD (former post-doc)
• Bruno Frustance (former RA)
• Sean Flannery (former RA)
• & others
New Job in 2013:
Enhance Education of 3000+ Healthcare Professional Trainees at VA Boston

- 1658 Medical & Dental
  - 396 Students
  - 1262 Residents & Fellows, All Specialties
- 788 Nursing
  - 332 BSN, 217 AD RN, 135 LPN, 64 Graduate, 40 other
- 183 Pharmacy
- 91 Physician Assistant
- 77 Optometry
- 45 Psychology

- 21 Nurse Anesthetists
- 15 Physical Therapy
- 13 Audiology / Speech
- 10 Social Work
- 6 Radiology Tech
- 5 Occupational Therapy
- 1 Dietician
- 1 Podiatry
- 1 Non-clinical
  - Health Info. Tech. Admin, Engineering
How to improve education?
How do we measure success?

• Most Trainees rotate at VA Boston for 2 to 12 weeks (average 5 weeks)
• Short—but intense
• Interested in trying evidenced-based manipulations, such as the testing effect.
• How do we know if the manipulation will engender long-lasting learning?
• Particularly important for healthcare professionals!
Holy Grail

• Develop a test that can be given immediately at the end of a course that would predict if the learning will be long lasting.

• Teaching manipulations could then be easily assessed for their long-lasting effects.

• Apply what I have learned regarding experimental psychology and cognitive neuroscience of memory to student and trainee learning
Participants

• 34 students enrolled in Medical Gross Anatomy at BU School of Medicine

• Behavioral Analyses

• EEG Event-Related Potential (ERP) Analyses

• ERPs are small fluctuations in the spontaneous electrical activity of the brain (EEG) time-locked to a stimulus.

• Averaging a number of EEG samples eliminates “random” fluctuations.
Advantages & Disadvantages to Using EEG

- Non-invasive
- Little discomfort (see cap)
- Inexpensive
- High temporal resolution 10s ms
- Measures activity at the surface of the cortex near the scalp (e.g., does not measure hippocampal activity).
- No generalized solution for localization of the sources of ERP activity.
176 Anatomical terms presented in random order

132 (44+44+44) Relevant terms
*Same terms presented each session

44 Obscure terms
*Changed for each experimental session

Student Responses

Can Define
*confirmed w/post-test

Familiar

Don’t Know
Timeline of Experimental Sessions

Session 1: August
Prior to course start

Session 2: December
Following Course completion
ERP Marker

Session 3: May
Follow-up
Can define memory
Data Collection
ERP Old/New effects: Hits – CR

• Hit = “yes, I’ve seen that before” to a studied item
• Correct Rejection (CR) = “no, I haven’t seen that before” to a non-studied item
• Miss = “no, I haven’t seen that before” to a studied item
• False Alarm = “yes, I’ve seen that before” to a non-studied item
• Subtraction of Hits – CR allows removal of perceptual and other signals that are the same—other than memory.
Familiarity vs. Recollection
Post-retrieval processing

Who is that person...
ERP Old/New effects: Hits – CR

- **Familiarity: Early frontal effect**
  - 300-500 ms post-stimulus (N400)
  - Maximal over frontal electrodes
  - Not novel

- **Recollection: Parietal effect**
  - 500-800 ms post-stimulus (LPC)
  - Maximal over parietal electrodes (particularly left)

- **Consciousness**

- **Post-retrieval processing:** Late frontal effect
  - 800-1500 ms (R frontal effect)
  - Additional processing needed
Response Type by Session for 132 Learned Terms

- **Session 1**: Can Define (0.2), Familiar (0.1)
- **Session 2**: Can Define (0.4), Familiar (0.6)
- **Session 3**: Can Define (0.4), Familiar (0.6)
Timeline of Experimental Sessions

Session 1
August
Prior to course start

Session 2
December
Following Course completion

Session 3
May
Follow-up

16 week Gross Anatomy Course
ERP Marker
Can define memory
Statistical Analysis: $p$-value map

Non-parametric Permutation Analysis

Can Define – Familiar

Can Define - Don’t Know

800ms 1000ms 1200ms
ROI 6- Left Posterior Inferior

EEG Activity (µV) vs Time (ms)
Our Results thus far.....

• ERP analysis revealed a possible physiological marker of long-term learning located over the left parietal region, 800-1200 milliseconds post-stimulus onset.

• This area showed significantly more positive activity for items rated as “Can Define” compared to “Familiar” and “Don’t Know” 6 months later.
Next Steps...

• Using this potential biomarker of long-term learning can we accurately predict whether an educational intervention will show persistent benefits 6 months later?

• Experiment being planned:
Test of the learning biomarker

- Two groups of participants invited to learn definitions to a set of 132 obscure, no longer used, English words
- Group 1: learns words over 4 weeks with spaced learning and repeated testing.
- Group 2: learns words over 2 days, cramming with repetition
- Both groups undergo EEG testing immediately after final learning session (Test 1) and 6 months later (Test 2).
- Tests 1 & 2 each have 132 studied + 44 non-studied obscure words
Hypotheses

• Goal is to match memory performance between the groups at Test 1.

• Behavioral Prediction: Group 1 (spaced learning/repeated testing) will perform better than Group 2 (cramming) at Test 2, 6 mo later.

• ERP biomarker prediction: At Test 1 (when behavioral memory performance is matched) Group 1 will show a larger 800-1200 ms parietal effect compared to Group 2, predicting their improved performance at Test 2, 6 mo later.
Thoughts? Suggestions?

- Other potential learning biomarkers?
- Would you be interested in using a learning biomarker?