A NOVEL SEQUENCE LEARNING PARADIGM OFFERS CONTINUOUS AND SEPARABLE MEASURES OF EXPLICIT AND IMPLICIT SEQUENCE LEARNING

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BACKGROUND:

Question: *Do implicit (unconscious) and explicit (conscious) learning occur simultaneously and independently?*

No: 1. Awareness modified sleep dependent benefits in an Serial Response Time (SRT) task, suggesting that implicit learning did not occur in the presence of explicit learning (Robertson et al., 2004).

2. Some imaging studies show little evidence for overlap of implicit-explicit learning using the SRT task (Honda et al., 1998, Hazeltine et al., 1997).

Yes: 1. Implicit learning occurred in parallel and to the same degree regardless of awareness in an SRT task (Willingham and Goedert-Eschmann, 1999).

2. An imaging study found overlapping areas of activation on the SRT paradigm with or without explicit awareness (Willingham et al., 2001).

Why the discrepancy? Problems with SRT paradigm:

1. Awareness often occurs even in the absence of explicit instruction, making it hard to distinguish between explicit/implicit learning.
2. No continuous measure of learning, as comparisons are made between pattern and random blocks of trials (Willingham et al., 1989).

Advantages of the eiASRT (Explicit/Implicit Alternating Serial Response Time) Task:

Explicit and Implicit Distinction:

1. Alternating regularity insures that learning is implicit with incidental instructions.
2. Adding cues allows for explicit knowledge of the sequence with intentional instructions.
3. Adding blocks in which the cues are absent removes explicit knowledge of the sequence. Learning exhibited in these blocks is implicit.

Continuous Measures:

1. RT difference between high & low frequency triplets in all blocks:……..……..measures implicit learning in subjects given incidental instructions
2. RT difference between high & low frequency triplets during uncued blocks:……..measures implicit learning in all subjects
3. RT difference between pattern and random high frequency triplets in cued blocks:…...measures explicit learning in subjects given intentional instructions

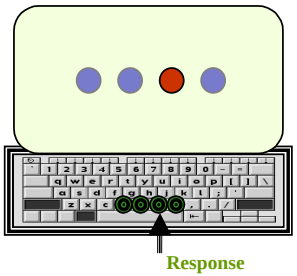
METHODS:

Alternating Serial Response Time Task (ASRT)

• Repeating sequence every other trial, alternating with random events (e.g. 1r2r3r4r…).
• Nine epochs of 5 blocks each, 80 trials per block.

Explicit/Implicit Alternating Serial Response Time Task (ei ASRT)

• CUED epochs 1, 2, 4, 5, 7, 8: Event colors alternate; Gray trials follow a pattern and black trials do not.
• UNCUED epochs 3, 6, 9: All trials black.
• For CUED epochs, subjects are explicitly told the nature of the regularity (Intentional instructions) or are not told of any regularity (Incidental instructions).
• For UNCUED epochs, no subject is told of the regularity, although the regularity is identical to that in the cued epochs.



Participants:

• 24 undergraduates, 2 males
• Average age = 19.8, range = 19 to 21

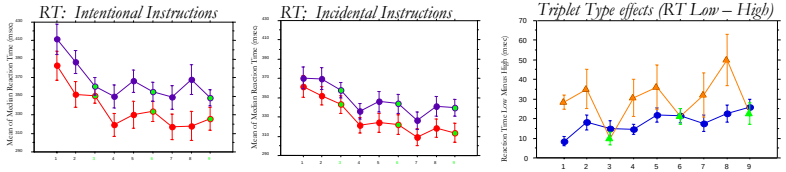
Tests of Explicit Awareness:

• Sequence Generation Task
• Interview
• Post-test Generation Task
• Card Sorting

RESULTS: SEQUENCE LEARNING

Implicit Sequence Learning: RT for High Versus Low Frequency Triplets

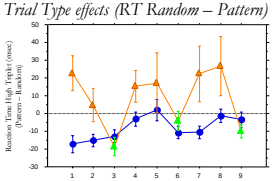
•Implicit sequence learning occurs for high versus low frequency "triplets" of trials (Howard et al. 2004).
•Low frequency triplets always fall on random trials. High frequency triplets may fall on pattern or random trials.



• Both groups: get faster with practice, are faster on high versus low frequency triplets, and this hi/low difference changes with practice (all p's<0.01).
• No main effect of instruction, so the instructions did not affect overall RT
• Significant instruction x epoch x triplet type interaction (p< 0.01)
  • Instructional groups did not differ on the uncued epochs (3, 6, and 9)
  • Separate anovas for cued and uncued epochs
    • Both yield an epoch x triplet type interaction (p< 0.01) indicating learning occurred across both types of blocks.
    • For uncued epochs, there were no main effects or interactions with instruction.
    • For cued epochs trend for a triplet type by instruction interaction (p<0.06).

Explicit Sequence Learning: RT for High Frequency Triplets Only

Trial Type effects (RT Random – Pattern)



• Looking only at high frequency triplets for pattern versus random trials removes implicit learning component, leaving only explicit sequence learning

•Anovas reveal an epoch by instruction interaction (p<0.02), a trial type by instruction interaction (p<0.04) and an epoch by trial type by instruction interaction (p<0.01).

RESULTS: EXPLICIT AWARENESS

1. Intentional Group: All 12 subjects figured out the pattern (awareness of pattern reached on average on block 3 +/- 2.4 of the first epoch) so *learning during the CUED epochs was explicit in the intentional group.*

2. Incidental Group: No subject figured out the pattern, so *learning during the CUED epochs was implicit in the incidental group.*

3. No subject, irrespective of instructions, had awareness of the pattern during all black epochs so *learning demonstrated during UNCUED epochs (3,6,9) was implicit in both groups.*

CONCLUSION:

• We developed an explicit-implicit counterpart to the ASRT in which awareness is within experimenter control, and learning measures are continuous and separable.

• Subjects exhibited the same amount of implicit learning irrespective of awareness.

• Therefore, implicit and explicit learning can occur simultaneously and independently of each other.

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