New Semantic Learning and Generalization in Severe Amnesia

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Background

Patients with severe amnesia are severely impaired at learning new semantic information.

Rigorous training with errorless learning techniques have been successful at teaching some new semantic information to these patients.

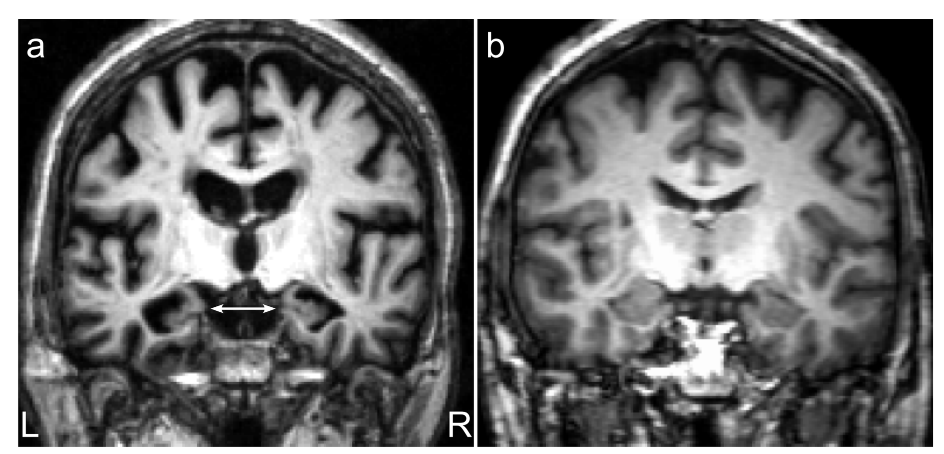
However, learning is hyperspecific and fails to generalize following this training.

Perhaps errorless learning technique induces this hyperspecificity by eliminating the variability that defines semantic information and normally allows for generalization.

Will training with variability in the stimuli increase generalization of the studied materials?

Patient T.E.

- 68 year old male; suffered from severe anoxic episode in 2000
- Severe anterograde and retrograde amnesia
- Volumetric MRI comparison to 5 age/gender matched controls:
  - Reduced right hippocampal volume of 38%, p<.02
  - Reduced left hippocampal volume of 31%, p<.02
- Unable to quantify, but clear damage to entorhinal, perirhinal, and parahippocampal cortices.
- Additional cortical atrophy due to anoxic episode, but behavioral profile indicates selective amnesia with other cognitive functions relatively intact.



Structural MRI: a) patient T.E., b) age-matched control

Summary of Neuropsychological Testing

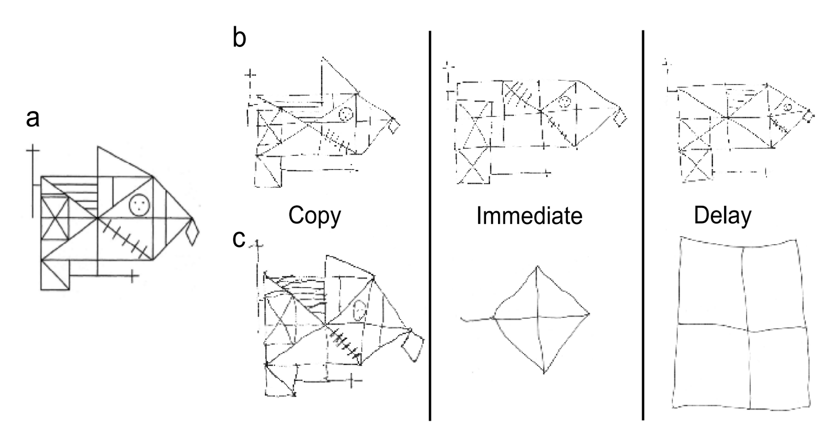
Standardized Test	T.E.'s Score
Warrington Recognition Memory Test	54% correct*
WMS III Auditory Delayed Memory	58*
WMS III Visual Delayed Memory	56*
WMS III General Memory	49*
WMS III Working Memory	88
Digit Span	6 digits
WAIS III IQ Score	102

For WAIS III and WMS III, standardized mean is 100 with st dev of 15.
* indicates tests in which T.E. was severely impaired

Semantic Test Battery (Schmolck et al. (2002))

Test Name	Controls	HF	MTL+	T.E.
4 Pointing/Naming Tasks	98.9	100	78.1	90.1
Semantic Features	91.9	96.9	80.9	84.4
Category Fluency	128.9 items	112 items	75.7 items	54 items*
Category Sorting	97	98.5	97	100

* Patient H.M. named 42 items total on Category Fluency



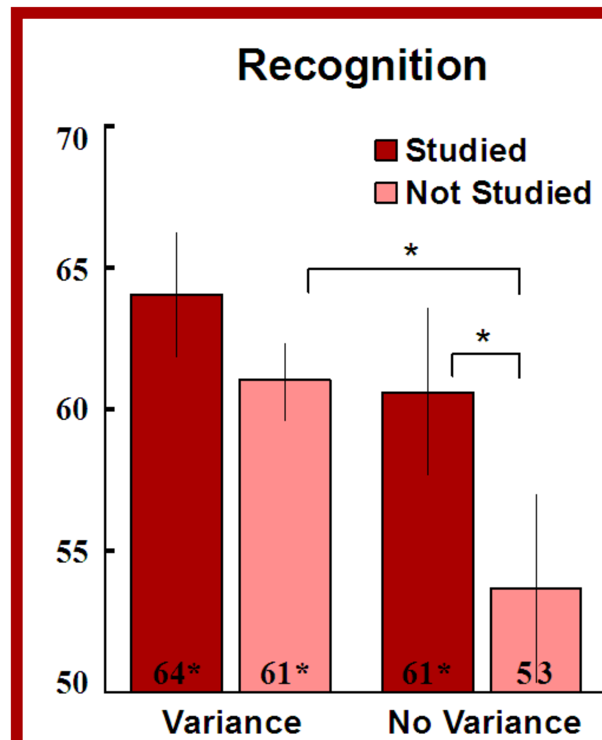
Rey-Osterrieth Test: a) template, b) age-matched control, c) patient T.E.

Methods & Design

- Variance (3 versions 1x each) and No Variance (1 version 3x) study conditions (16 sets in each condition)
- Studied and Not Studied versions of each at test
- 8 test sessions (recall & recognition), each separated by 4 study sessions

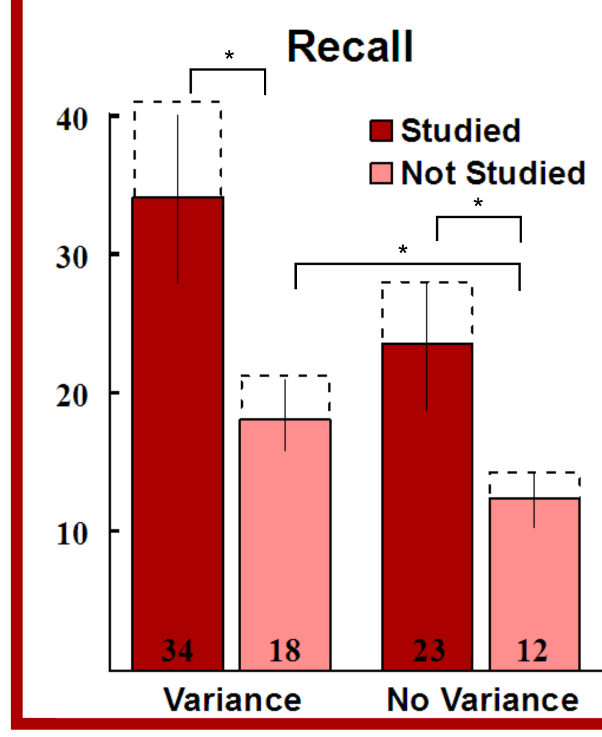
Condition	Recall/Recognition Cue	Recall Answer	Recognition Choices
Variance, Studied	TRAIN frightened ??? TRAIN scared ??? TRAIN startled ???	"kangaroo"	KANGAROO DOVE
Variance, Not Studied	TRAIN shocked ??? TRAIN surprised ??? TRAIN terrified ???	"kangaroo"	KANGAROO DOVE
No Variance, Studied	SHEPHERD ate ??? SHEPHERD ate ??? SHEPHERD ate ???	"apple"	APPLE OLIVE
No Variance, Not Studied	SHEPHERD swallowed ??? SHEPHERD consumed ??? SHEPHERD gobbled ???	"apple"	APPLE OLIVE

Results



- Overall better performance in Variance than No Variance (p<.01)
- Overall better performance in Studied than Not Studied (p=.057)
- **Better generalization with Variance training**
  - Variance, Not Studied > No Variance, Not Studied
  - Variance, Studied ≈ Variance, Not Studied
  - No Variance, Studied > No Variance, Not Studied

- Chance performance on the recognition test is 50% (* p<.05). Graphs show mean across 8 sessions ± SEM



- Overall: Variance > No Variance and Studied > Not Studied
- **Some evidence of better generalization with Variance training**
  - Variance, Not Studied > No Variance, Not Studied
  - No Variance, Studied > No Variance, Not Studied
  - But, Variance, Studied > Variance, Not Studied
- Dashed lines represent recall when semantically related responses are included (i.e. responding "bear" instead of the trained "grizzly")
- Stimulus imbalance? No. Matched prior to testing & control data (n=3, 2 study sessions, 1 test) show similar performance across conditions.
- Scaling effect? No. On Test 8, Studied recall matched across conditions, but large No Studied difference (23% vs. 13%)

Test Type	Variance, Studied	Variance, Not Studied	No Variance, Studied	No Variance, Not Studied
Visual Cued Recall	88% (4.2)	88% (6.2)	82% (7.8)	81% (10.2)
Auditory Cued Recall	87% (7.2)	87% (6.6)	81% (10.2)	81% (10.8)
Visual Recognition	97% (2.5)	97% (2.8)	99% (0.7)	99% (0.7)

Conclusions

Semantic learning in severe MTL amnesia need not be hyperspecific if training is designed to encourage generalization.

- Hyperspecificity in standard errorless learning replicated (No Variance condition)
- Hyperspecificity reduced (generalization increased) by introducing variation in the surface features during training (Variance condition)
- Training with variance emphasizes the underlying meaning of the semantic items, thus creating a semantic concept that can be generalized to novel items with a different surface structure but related meaning.
- Data can be interpreted in a computational framework (McClelland, et al., 1995) in which an MTL system rapidly learns arbitrary patterns of activity and then gradually trains the neocortical system. Here, inclusion of variability in the training set provides a better proxy for the MTL system than that provided by traditional errorless learning paradigms. The inclusion of variability more closely models normal learning contexts and provides the opportunity to develop cortical representations that are sensitive to the semantic aspects and tolerant of noise in the surface features.

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