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Global Hebb Repetition Effects for Tactile Sequences

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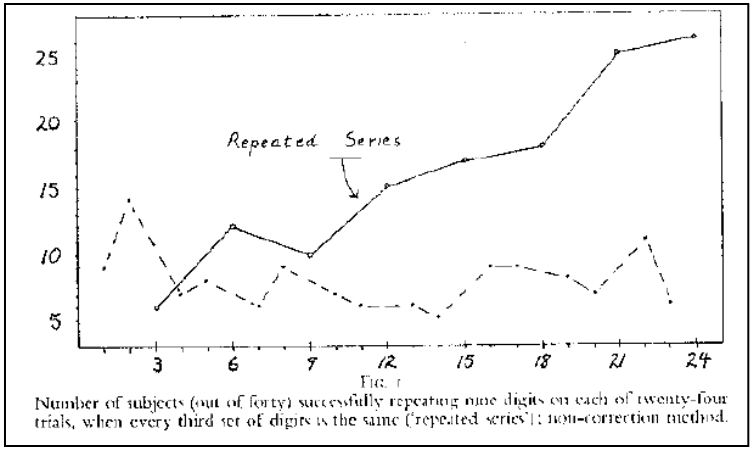
The Hebb Repetition Effect

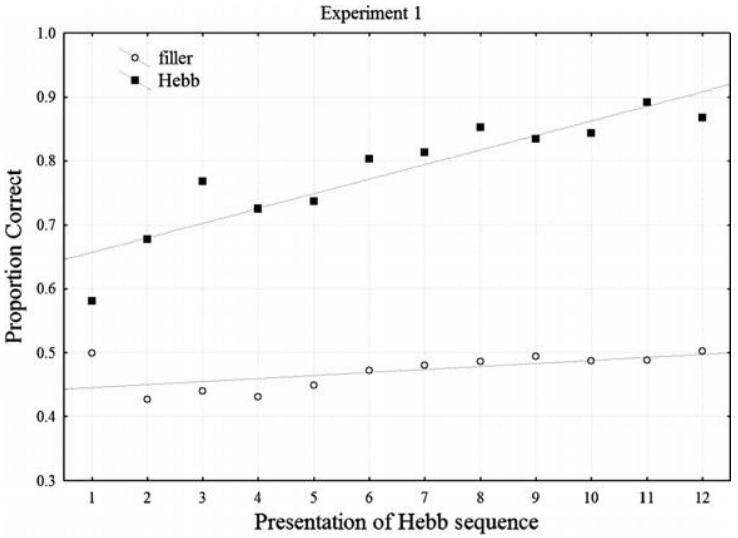
- The Hebb (1961) repetition procedure
  - "*The experimenter read aloud a series of nine digits at the rate of about one per second. The subject was instructed to listen carefully and repeat the digits in exactly the same order … There was, however, one special feature about which the subject was not informed. On every third trial (3rd, 6th, 9th … 24th) the same series was repeated, and the object of the experiment was to discover what effect this had*" (p. 41)
- Found gradual improvement in the repeated sequences
  - Indexed by the number of ps who recalled the entire sequence



Number of subjects (out of forty) successfully repeating nine digits on each of twenty-four trials, when every third set of digits is the same ('repeated series'); non-correction method.

The Hebb Repetition Effect: Importance?

- Traditionally this effect has focussed upon phonological memory
  - The Hebb repetition mechanism has been implicated in novel word learning
- Hebb repetition effect with 3-syllable (nonword) sequences (Szmalec et al., 2012) and …
  - Lexicalisation effects for nonwords repeatedly presented (Szmalec et al., 2012)
    - Shown by slower lexical decision making



Szmalec et al. (2012, Experiment 1)

Cross-Modal Hebb Repetition Effects

- But … sequence learning is a more widespread process and the Hebb repetition effect is not confined to phonological memory …
- Effects found cross-modally, e.g.
  - Unfamiliar faces (Horton et al., 2008)
  - Spatial position of dots (Couture & Tremblay, 2006)
  - Spatial position of auditory stimuli (Parmentier et al., 2008; Lafond et al., 2010; Johnson et al., in progress)
  - Odours (Johnson et al., 2013)
  - Motor memory (Johnson et al., in prep)

Cross-Modal Hebb Repetition Effects

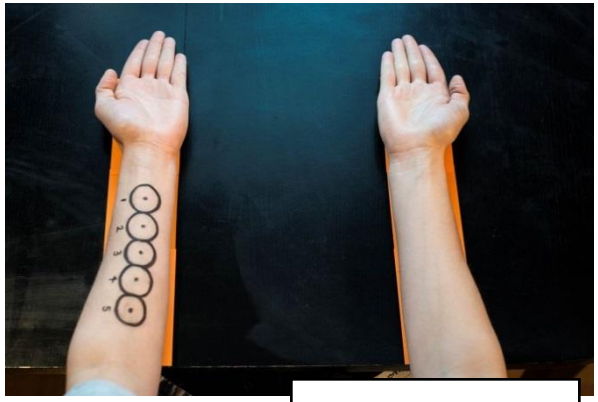
- Analogous cross-modal sequence learning mechanism or amodal process?

- Supports cross-modal qualitative similarities in order memory (e.g. Ward et al., 2005; Guérard & Tremblay, 2008)

Amodality characterised by consistent pattern of neuronal activation irrespective of localisation (Parmentier, 2011)

Experiment 1: Establishing a Tactile Hebb Repetition Effect

- Blindfolded participants (n=30) receive 30 trials
- Each trial comprises 5 different tactile stimulations to the non-dominant arm
  - Using the pre-drawn locations
- Participants reconstruct the sequence using the dominant hand
  - Correct response if within the circle
- Every third trial is repeated

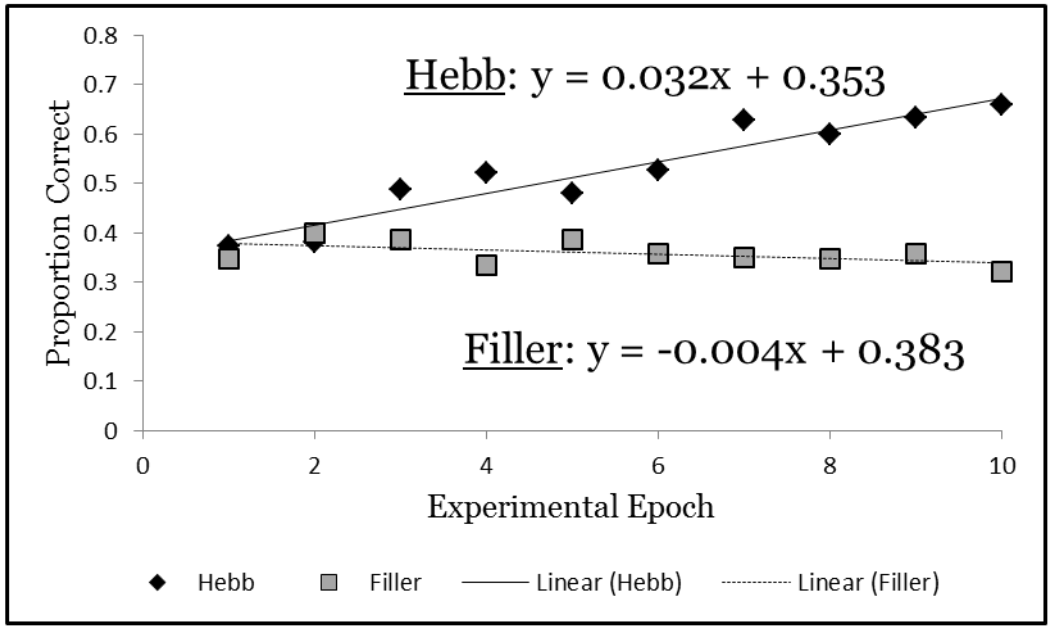


Learning

Retrieval

Experiment 1: Establishing a Tactile Hebb Repetition Effect

- Sequence type by (3-trial) experimental epoch interaction, $F(9,261) = 5.33$, $p<.001$, $\eta_p^2 = .16$



- Recall improved for the repeated (Hebb) sequence but not the non-repeated (filler) sequences

Amodal Sequence Learning Mechanism?

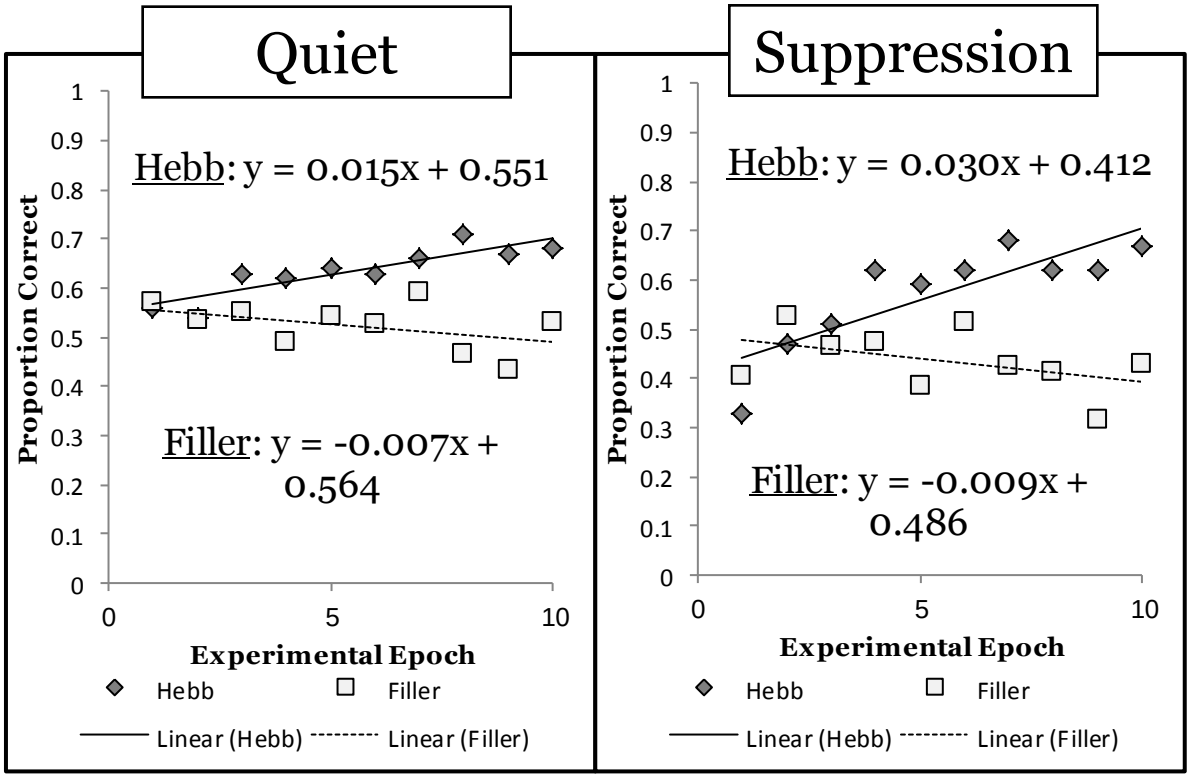
- More evidence of Hebb repetition learning across different modalities
- Supports an amodal learning mechanism where sequences are represented in an abstract code
- But …
  - Concurrent articulation impairs tactile memory (Miles & Borthwick, 1996)
  - Sub-vocal rehearsal is a strategy used to remember tactile sequences (Mahrer & Miles, 2002)
- Participants may have recoded the tactile positions as verbal code and rehearsed these verbal labels
  - Verbal, rather than tactile, Hebb repetition effect?

Experiment 2: Testing the Role of Verbal Recoding

- Partial-replication of Experiment 1
- Participants (n=24) completed the task twice in a counterbalanced order
  - Condition 1: learning under conditions of quiet
  - Condition 2: learning under articulatory suppression (*repetition of "1, 2, 3, 4"*)

Experiment 2: Testing the Role of Verbal Recoding

- Sequence type by experimental epoch interaction = Hebb Repetition Effect
- But … no interaction with suppression



Experiment 2: Testing the Role of Verbal Recoding

- Articulatory suppression impaired recall
  - Consistent with tactile motor Hebb data (Johnson et al., in prep)
  - Verbal suppression blocks central resources needed to remember spatial locations (Miles & Borthwick, 1996)
- Importantly: the effect of suppression did not moderate the learning gradient of the Hebb sequence
  - Equivalent learning despite blocking of verbal rehearsal

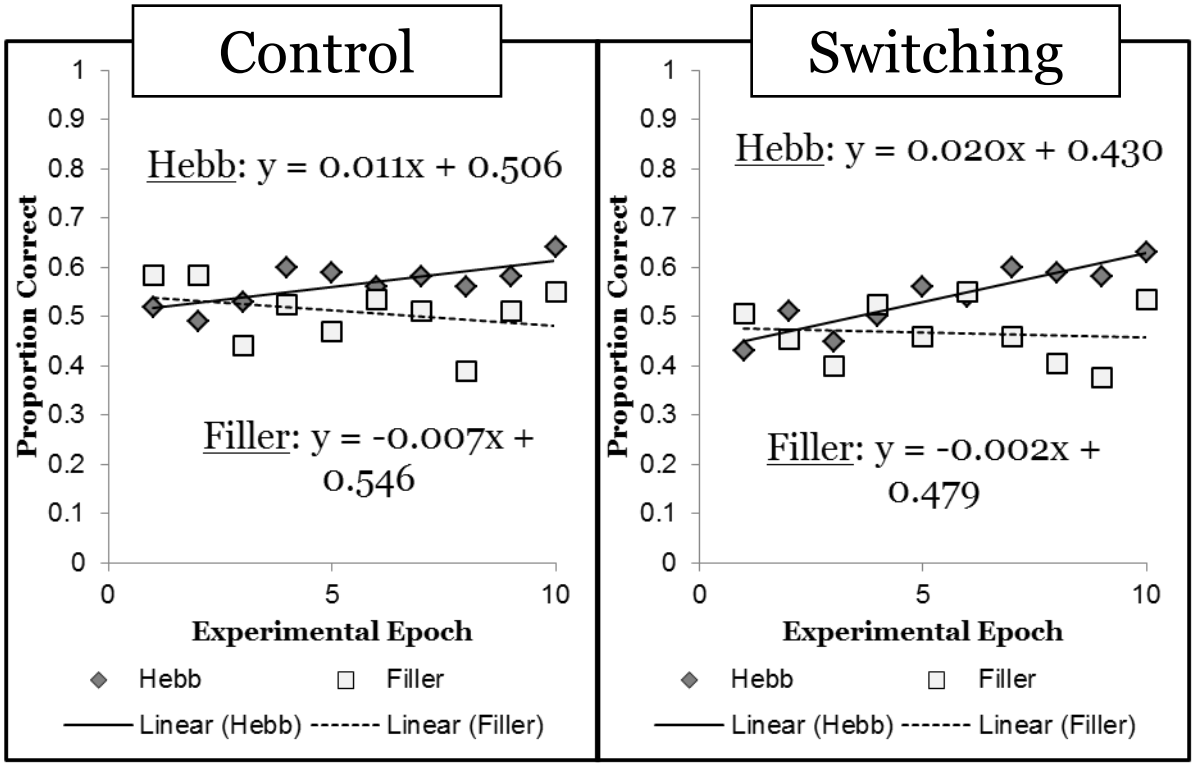
- Is learning of the sequence restricted to the tactile location?

Experiment 3: Is Sequence Acquisition Specific to the Tactile Locations at Learning?

- Is the rate of learning affected by switching the arm on which the sequence is presented?
- Participants (n=24) completed the task twice in a counterbalanced order
- Condition 1: replication of Experiment 1
- Condition 2: each sequence alternates the arm on which the sequence is presented.
  - Participants recall with dominant hand
  - 5 Hebb sequences are presented to the right arm and 5 to the left arm

Experiment 3: Is Sequence Acquisition Specific to the Tactile Locations at Learning?

- Sequence type by experimental epoch interaction = Hebb Repetition Effect
- But … no main effect of switching and no interaction with switching



Representation of the Tactile Sequence: Amodal?

- Tactile Hebb repetition effects consistent with other stimuli (Experiment 1) and not reliant upon verbal recoding (Experiment 2)
- Not affected by the arm on which the sequence is presented (Experiment 3)
- Abstract/amodal representation of the sequence?
  - Order memory is represented by the pattern of neuronal activity irrespective of the actual neurons employed (Parmentier, 2011)
    - Explains amodality whilst accounting for differences in the cross-modal localisation of activity (e.g. Smith et al., 1996)

Representation of the Tactile Sequence: Perhaps not Amodal?

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But …

- Null effect of switching in Exp. 3 could be explained by the motor response at recall (used dominant hand)
  - Retrieval important in Hebb repetition learning (Cohen & Johansson, 1967)
  - Follow-on study switching recall arm
- Visual-spatial re-coding of the sequence (Mahrer & Miles, 2002)
  - Visual interference typically through tapping (e.g. Andrade et al. 2002)
  - Follow-on study with visual footage of learning to disrupt spatial representations

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Key References

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