Global Hebb Repetition Effects for Tactile Sequences

Johnson, A. J.,* High, C., & Miles, C.
andjohnson@bournemouth.ac.uk
@Psychology__Andy
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
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)
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)
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
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

**Graph:**
- **Hebb:** $y = 0.032x + 0.353$
- **Filler:** $y = -0.004x + 0.383$
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

[Graphs showing proportion correct vs. experimental epoch for Hebb and Filler conditions in Quiet and Suppression conditions with linear fits.]
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)
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
Key References


