The Influence of Exploratory Choice on Semantic Search

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BACKGROUND

- While much research has focused on the determinants of exploratory choice, less is known about the consequences of exploratory states for information processing.
- Exploration has been associated with changes in learning rate, the balance of bottom-up vs. top-down control, and norpinephrine-linked arousal [1, 2, 3].
- Additionally, exploration across tasks may rely on shared resources, as evidenced by priming between spatial and lexical search [4, 5].
- Here we ask whether exploratory choice in a bandit task will affect semantic fluency performance, which has been shown to resemble patch foraging [6].

METHODS

1. Leapfrog Bandit
   - A simplified bandit task [7]
   - 100 trials
   - Two armed
   - Deterministic reward
   - Fixed distance between options
   - Options “take turns” being the best, changing based on underlying P_exp
   - Goal: Always choose the option that is currently the best. Requires balancing exploration and exploitation.

   Hypotheses
   - H1: Global Switching begets switching—priming greater exploration in the bandit task will lead to more switching/decreased semantic similarity in semantic fluency.
   - H2: Local Gain modulation—arousal-induced increases in neural gain directly following exploration will increase semantic similarity/decrease switching by reducing semantic competition.

2. Semantic Fluency
   - Name animals for 75 s
   - Scored for fluid clusters (proportion clustered words out of total fluency) and switches (transitions between words not belonging to the same cluster)
   - Pairwise cosine similarity computed from vector space model [8]

Subjects

Study 1 (volatility manipulation): N = 39 (26 F, Mage = 23.1 ± 4.3); 21 low volatility, 18 high volatility
Study 2 (last explore/change manipulation, low volatility): N = 57 (42 F, Mage = 20.9 ± 3.2); 18 explore/change, 22 explore/no change, 17 no explore/no change

RESULTS

Volatility Condition Effects Study 1

- Subjects explored to a greater degree in the high volatility than the low volatility condition (M = 0.16, t(37) = 7.45, p < 0.0001).
- But there were no differences between conditions in animal naming performance, including total fluency (not pictured; all ps > 0.18).

Local Effects

- Item similarity was greater when subjects explored on one of the last two trials prior to animal naming (left; M = 0.018, t(37) = 2.53, p = 0.016). No other differences were significant (all ps > 0.37).
- This effect was driven by those who explored and did not see a change (right), who had significantly greater item similarity than explore/change (M = 0.030, t(15) = 3.37, p_corrected = 0.008) and no explore/no change (M = 0.029, t(30) = 3.61, p_corrected = 0.003).
- There was no difference between explore/change and no explore/no change (M = −0.001, t(25) = −0.12, p_corrected = 0.91).

Individual Differences in Exploration

- Exploratory choice was significantly correlated with clustered words (r(55) = 0.28, p = 0.036) and switches (r(55) = 0.25, p = 0.056).
- Correlations were driven by the explore/no change group (item similarity: B = −0.25, t(50) = −2.63, p_corrected = 0.03; clustered words: B = −1.16, t(50) = −2.91, p_corrected = 0.016; switches: B = 2.91, t(50) = 3.06, p_corrected = 0.01; p_corrected from other groups all > 0.59).

SUMMARY & CONCLUSIONS

- There was no effect of bandit environmental volatility on animal naming (H1).
- Effects of recent choice and outcome were inconsistent between studies (H2), potentially reflecting noise or an interaction with volatility condition.
- However, the explore/no change group exhibited differential performance in both studies, suggesting that frustrated expectations in the bandit task carried over into animal naming, altering foraging in semantic space. This effect interacted with individual differences in overall bandit exploration.

REFERENCES