Control by Association:
Transfer of Implicitly Primed Attentional States across Linked Stimuli

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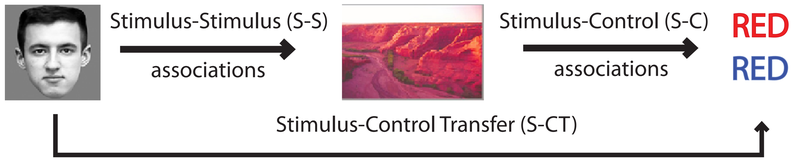
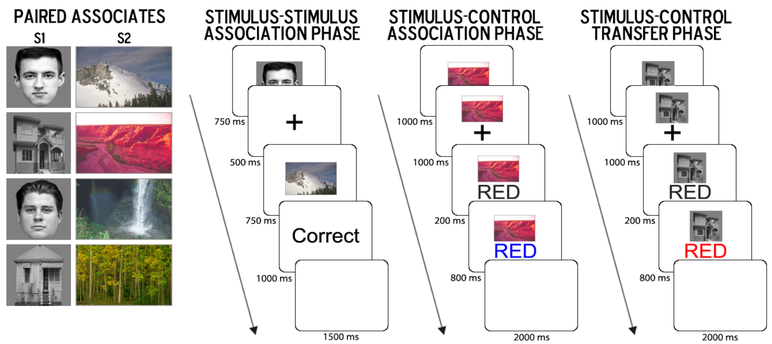
Learned control-states are adaptive.

Implicit probabilistic cues (e.g., stimulus location, sensory modality) have been found to facilitate the retrieval of context-appropriate **attentional control-states** (e.g., high attentional focus).

Contextual cues can guide strategic adjustment to demands; stimulus-control learning is thus **highly adaptive**, but greater flexibility can be achieved if learned control-states are transferred across associated stimuli or contexts (cf. Wimmer and Shohamy, 2012, *Science*).



Probing the transfer of control-states:



S-S Phase:
a face/house (S1) image predicted a particular scene (S2) image to form paired associates in memory.

Analysis:
validity main effect

S-C Phase:
S2 images predicted stimulus congruency in a Stroop task to create implicit "control-demand cues."

Analysis:
cue x congruency

S-CT Phase:
S1 "transfer probes" preceded the onset of Stroop trials but were not predictive of congruency.

Analysis:
run x probe x congruency

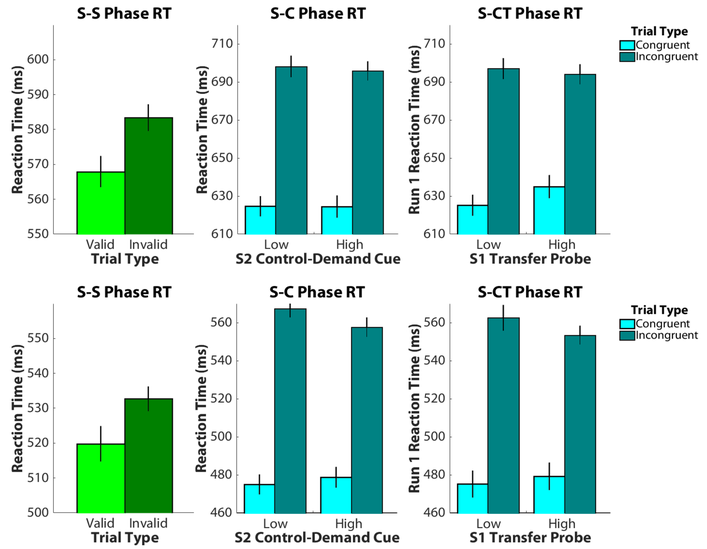
Post-test questionnaire: we assessed memory of S-S phase paired-associates and explicit understanding of the task structure, and *confirmed that most participants learned these associations implicitly.*

E2 is an in-person replication of E1, with an enhanced stimulus-control learning effect.

We ran 76 and 73 MTurk workers for E1 and E3, and 44 in-person subjects for E2. **All materials are available at: http://github.com/christinabejjani/controltransfer.**

E1 & E2: Can control-state associations implicitly transfer across linked stimuli?

S1 images associated with S2 high control-demand images should produce a smaller congruency effect in the transfer phase compared to S1 images associated with S2 low control-demand images.

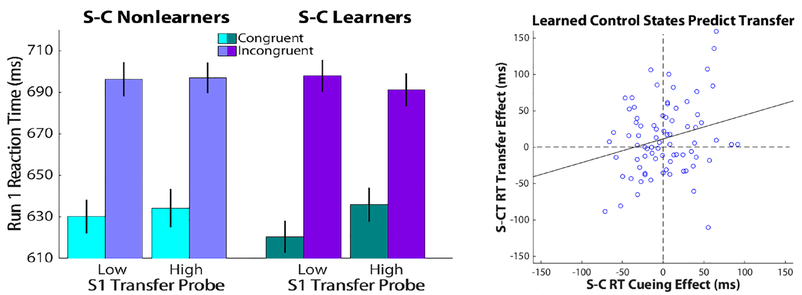


S-S Phase:
validity (E1: $p < 0.001$, $\eta_p^2 = 0.17$; E2: $p = 0.011$, $\eta_p^2 = 0.14$)

S-C Phase:
cue x congruency (E1: $p > 0.250$, $\eta_p^2 = 0.01$; E2: $p = 0.002$, $\eta_p^2 = 0.20$)

S-CT Phase:
run x probe x congruency (E1: $p = 0.019$, $\eta_p^2 = 0.07$; E2: $p = 0.035$, $\eta_p^2 = 0.10$)

We observe evidence of a control transfer RT effect; is this due to individual differences in S-C learning?



S-C Nonlearners:
run 1 probe x congruency (E1: $p > 0.250$, $\eta_p^2 = 0.01$; E2: $p > 0.250$, $\eta_p^2 = 0.04$)

run x probe x congruency (E1: $p > 0.250$, $\eta_p^2 = 0.01$; E2: $p > 0.250$, $\eta_p^2 = 0.01$)

S-C Learners:
run 1 probe x congruency (E1: $p = 0.017$, $\eta_p^2 = 0.14$; E2: $p < 0.001$, $\eta_p^2 = 0.41$)

run x probe x congruency (E1: $p = 0.027$, $\eta_p^2 = 0.13$; E2: $p = 0.010$, $\eta_p^2 = 0.20$)

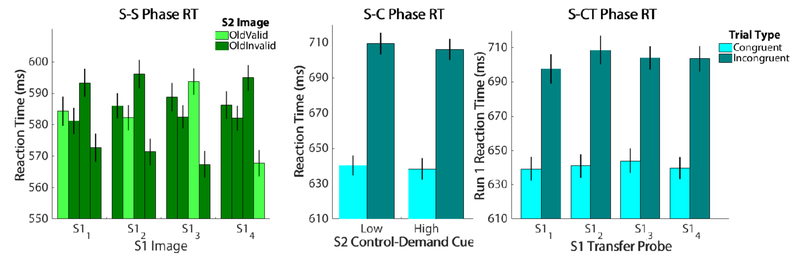
Learned control-states predict transfer
(E1: $r = 0.23$, $p = 0.045$; corrected: $r = 0.24$, $p = 0.045$)

(E2: $r = 0.34$, $p = 0.024$; corrected: $r = 0.34$, $p = 0.023$)

E1 & 2 suggest that the control-states learned in the S-C phase drove the observed transfer effect through the S1-S2 association.

E3: Does control-state transfer depend on the initial S-S associations?

Here, we scramble the S1-S2 associations in the S-S phase, such that no paired-associates could be formed. Do we still observe transfer?



S-S Phase:
S1 x S2 image ($p > 0.250$, $\eta_p^2 = 0.01$)

S-C Phase:
cue x congruency ($p > 0.250$, $\eta_p^2 = 0.00$)

S-CT Phase:
run x S1 x congruency ($p > 0.250$, $\eta_p^2 = 0.00$)

E3 suggests that transfer of control-state associations depends on the initial associations linking the stimuli pairs.

Control-states are implicitly associated with, and transferred between, contextual cues.

- **This work establishes a novel learning mechanism supporting the generalization of cognitive control.**
  - While transfer has been demonstrated for stimulus-response and reward associations, this study provides the first evidence for the transfer of stimulus-control associations across paired-associates.
- **This learning mechanism may form the basis of the human ability to generalize cognitive strategies over related contexts.**
  - People can learn to recruit high attentional focus in a flexible context-dependent manner, modulating their response to demands from closely linked contexts without explicit awareness of task structure.

Future Questions:

1) Does control-state learning and transfer depend on causal learning and mental task structure?

2) Do these control-state associations generalize across control processes?

Note that this poster has been accepted as a Brief Report for publication in Psychonomic Bulletin and Review, http://dx.doi.org/10.3758/s13423-018-1445-6.