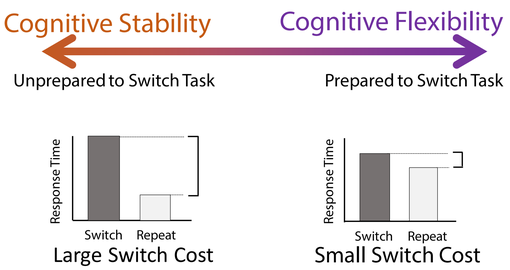
Disentangling the roles of cue visibility and knowledge in learning cognitive control

Ziwei Zhang, Christina Bejjani, Jack Dolgin, and Tobias Egner | Department of Psychology and Neuroscience and Center for Cognitive Neuroscience | Duke University
correspondence to christina.bejjani@duke.edu, @chbejjani, @jbdolg, @Egnerlab | Supported in part by NIMH R01 MH 087610

Background: Subliminal Cueing of Control

Farooqui and Manly (2015, Psych Sci) raised the possibility that control-learning is more effective when cues of control demand are presented subliminally.



Our Design (https://osf.io/7jfbp/):
- Manipulate conscious cue perception & predictive cue knowledge independently
- 2x2 design with an overall 25:75 switch:repeat context, a task-switching paradigm with two predictive cues and one nonpredictive cue

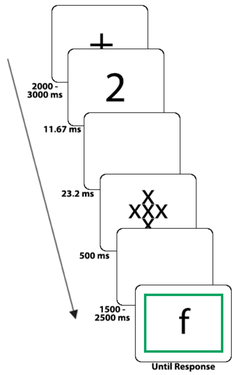
	cue visibility 1: subliminal	2: supraliminal
cue knowledge 1: implicit	subliminal, implicit (E1)	supraliminal, implicit (E3)
2: explicit	subliminal, explicit (E2)	supraliminal, explicit (E4)

Behavioral Prediction:
- Participants will use contextual cues to modulate control such that switch costs[1] will be reduced following predictive vs. nonpredictive cues[2,3].

Hypotheses:
- If the conclusions from Farooqui & Manly (2015) were warranted, we should observe smaller switch costs for subliminal (E1-2) vs. supraliminal (E3-4) cueing[4,5].
- Traditional views on control, however, would predict the smallest switch costs under the supraliminal and explicit knowledge conditions (E4).
- Current theories of action control[6] would predict the smallest switch costs under the implicit knowledge condition (E1, E3).
- If pre-emptive control operations[7] can be prepared and triggered by the cues ("action-triggers"), we should observe smaller switch costs in E2-4 vs. E1.

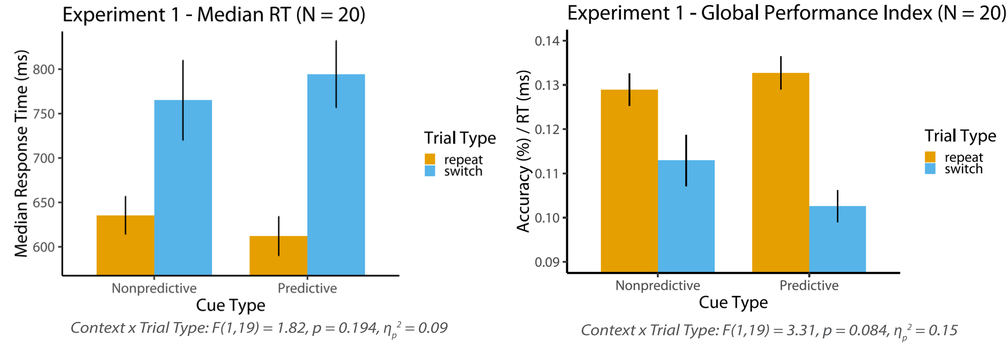
References:
[1]Monsell (2003). Trends in Cognitive Sciences. [2]Bugg & Crump (2012). Frontiers in Psychology. [3]Abrahamse et al. (2016). Psychological Bulletin. [4]van Gaal, De Lange, and Cohen (2012). Frontiers in Human Neuroscience. [5]Kunde, Reuss, and Kiesel (2012). Advances in Cognitive Psychology. [6]Hommel (2013). Frontiers in Psychology. [7]Kunde, Kiesel, and Hoffmann (2003). Cognition.

E1: Subliminal, Implicit



Methods:
- After 50 trials, response threshold set to 60th percentile for correct response on repeat trials
- After 100 trials, the threshold is revised.

Post-test Questionnaire:
- 3 participants correctly identified and noticed the cue type
- Masking was successful, since participants could not identify cues

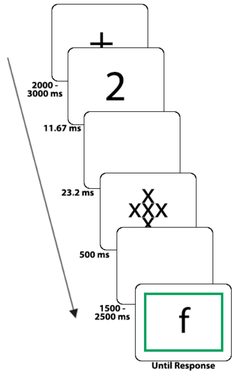


Context x Trial Type: $F(1,19) = 1.82$, $p = 0.194$, $\eta_p^2 = 0.09$

Context x Trial Type: $F(1,19) = 3.31$, $p = 0.084$, $\eta_p^2 = 0.15$

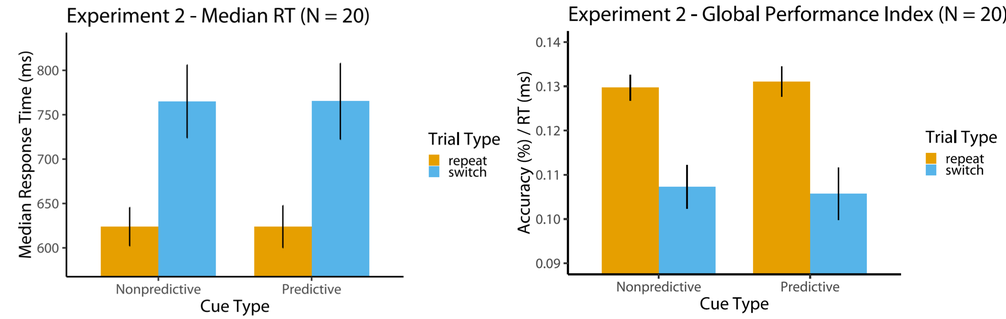
- Sequential bayes factor analysis suggests that data collection is complete; we *fail to replicate* Farooqui & Manly (2015)
- Equivalence testing suggests that the index is statistically different from, and not equivalent to, zero ($t(19) = 4.78$, $p = 1.0$; null: $t(19) = 6.71$, $p < 0.001$).

E2: Subliminal, Explicit



Methods:
- Explicit instructions at the beginning about the roles of each number cue (e.g., nonpredictve, predictive switch/repeat)

Post-test Questionnaire:
- Masking was successful, since participants could not identify cues, but they couldn't remember the cue associations.
- We may need to rerun E2 and add in attention checks

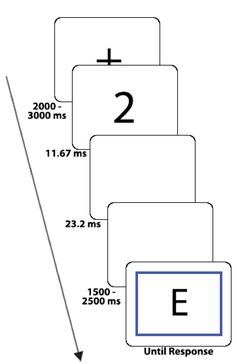


Context x Trial Type: $F(1,19) = 0.01$, $p = 0.946$, $\eta_p^2 = 0$

Context x Trial Type: $F(1,19) = 0$, $p = 0.985$, $\eta_p^2 = 0$

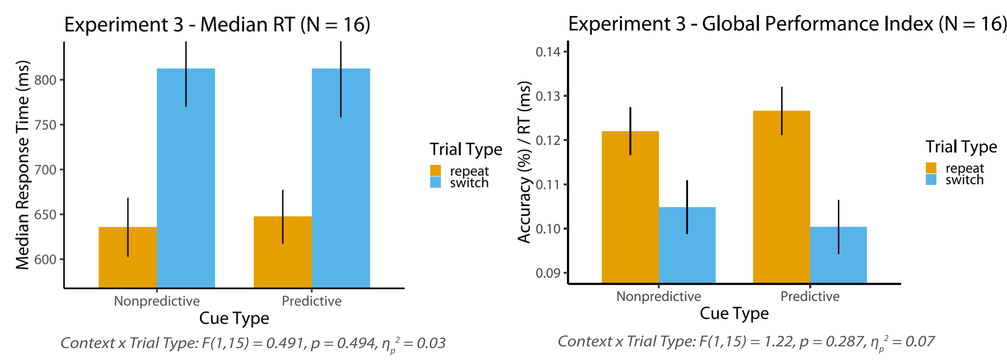
- Sequential bayes factor analysis suggests that we *need* to collect more participants. However, we may rerun E2.
- Equivalence testing suggests that the index is statistically not different from, and not equivalent, to zero ($t(19) = -0.50$, $p = 0.310$; null: $t(19) = 1.42$, $p = 0.172$).

E3: Supraliminal, Implicit



Methods:
- Cues no longer masked; need n=20

Post-test Questionnaire:
- 5 participants reported noticing a systematic relationship between the cues and hard/easy trials.
- Participants rated the number cues as being less predictive than 50% ("somewhat predictive")
- Participants didn't match the cues to their trial types above chance



Context x Trial Type: $F(1,15) = 0.491$, $p = 0.494$, $\eta_p^2 = 0.03$

Context x Trial Type: $F(1,15) = 1.22$, $p = 0.287$, $\eta_p^2 = 0.07$

- Equivalence testing suggests that the index is statistically different from, and not equivalent to, zero ($t(15) = 11.62$, p = 1.0; null: $t(15) = 13.34$, $p < 0.001$).
- Overall, participants do not appear to be using the contextual cues to guide the application of control settings.