The selective action of cfunc control

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Preregistration – Experiment 4

Author note

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Background

The conceptual background for this experiment can be found in the preregistration document for experiment 1 (https://osf.io/zv5r6/). Further context for this experiment by the preliminary results from experiments 1, 2 and 3. Briefly, the three previous experiments employed a paradigm based on car races. Each trial had two components: i) a sample racecar screen which showed the performance of a sample racecar (i.e., moving either quickly or slowly and either forwards or backwards) and communicated via Crels and Cfuncs how the performance of each racecar compared with that of the sample racecar (i.e., either the same or different speed and same or different direction), and ii) a car race screen that would show the racecars race. Participants were told to pick as many winners as they could, a task that required effective action of Crels and Cfuncs.

The training provided to establish cfuncs for speed and direction differed across the three experiments. When establishing the cfunc for direction in experiments 1 and 2, the relationships between the racecars' properties and the sample racecar's properties differed only in terms of direction. This meant that both racecars went the same speed, even if that speed was different to the sample racecar, but one racecar went in the same direction as the sample racecar and the other racecar went in the opposite direction to the sample racecar. When training the cfunc for speed, both racecars went the same direction, but one racecar went the same speed as the sample racecar and the other racecar went a different speed as the sample racecar. Effectively, when training a given cfunc the procedure selectively varied the relationships between the stimuli with regard to that stimulus property. In these experiments, roughly 50% of participants had response accuracies $\geq$ 83% (50/60) at test. Cfunc training in experiment 3 took a different tack. The properties of the stimuli were selectively varied, and by extension so were the relationships between the stimuli with regard to their properties. For example, when establishing the cfunc for direction in experiment 3 the all racecars, including the sample racecar, went in the same speed. Similarly, when establishing the cfunc for speed all racecars went the same direction. Blocks targeting speed and direction were intermixed to aid participants in discriminating that speed or

direction was relevant in a given block. In experiment 3 only 10% of participants had accuracies ≥ 83% (50/60) at test.

The cfunc training in Experiment 4 will revert to the selective variation of the relationships between stimuli with regard to their properties found to be somewhat effective in experiments 1 and 2. To increase the number of participants producing high test accuracy scores, elements of the training provided in experiments 1 and 2 have been combined. Specifically, in experiment 2 only the crel and cfunc pairs relevant to the cfunc being established were presented, whereas in experiment three the crel and cfunc pairs relevant to both cfuncs were presented. The training in experiment 2 more efficiently established each cfunc; 74% of participants successfully completed both cfunc training components in experiment 2 compared to 54% in experiment 1. However, the training in experiment 1 more effectively generalized to the test, with 83% of participants successfully completing the training in experiment 1 passed the cfunc test, compared to 64% in experiment 2. Participants in experiment 4 will be exposed to the training from experiment 2, followed by the training in experiment 1, before being exposed to mixed training trials and cfunc testing as per the procedures from the three previous experiments. Like experiment 3, experiment 4 includes a negative cfunc test involving a series of trials that do not present programmed cfuncs.

Changes relative to experiment 3

1. Stimuli in each Cfunc training phase will vary along both stimulus property dimensions, and the relationships between the stimuli with regard to their properties will be selectively varied across trials.
2. Each cfunc will be training in two separate stages before mixed training trials. In the first stage only the crel and cfunc pair relevant to the cfunc being trained will be presented. In the second stage both crel and cfunc pairs will be presented. In these stages the crel and cfunc pairs for speed and direction will occur in the same location in the selection box. In the mixed trials phase, the locations of the crel and cfunc pairs for speed and direction will be counterbalanced as in all previous experiments.

3. Due to the extended cfunc training trials, the maximum number of cfunc training blocks will increase from 9 to 15 blocks.
4. The negative cfunc test presents a subset of the regular cfunc test trials. Specifically, the trials in which the performance of the winning racecar is identical to or opposite to the sample racecars, because in these trials the winning racecar can be selected without reference to programmed Cfuncs, which could artificially inflate accuracies.

Method

Sample

Data collection will be conducted online via Prolific Academic. Participants will be paid at a rate of £7.50 per hour.

Planned sample size & stopping rules

Data collection will stop when 20 participants who have passed Crel training within the experiment (i.e., accuracy $\geq 20/30$) have been exposed to all Cfunc training and testing.

Inclusion criteria. English as a first language, between the ages of 18-65, 90% approval rating for previous studies on Prolific, no previous participation in similar studies from our research group, passing the Crel test in the experiment (i.e., accuracy $< 20/30$).

Exclusion criteria. Incomplete data, responding "yes, exclude my data" on the self-exclusion question, failing to provide correct responses after 3 blocks of the Crel training phase, or failing the Crel test (i.e., accuracy $< 20/30$).

IVs.

1. Crels: ■ = same, ▼ = different vs ▼ = same, ■ = different
2. Cfuncs: ✦ = speed, ◗ = direction vs ◗ = speed, ✦ = direction

DVs.

1. Response accuracy
2. Response time

Procedure

The procedure is designed to establish Crel and Cfunc properties for stimuli and assess their efficacy in specifying derived transformations of stimulus functions. The procedure can be decomposed into five phases: i) establishing Crels for the relations of same and different; ii) testing Crels for the relations of same and different; iii) establishing selective action of Cfuncs for speed and direction on transformations of functions via relations of same and different; iv) testing the selective action of Crels and Cfuncs established in the previous phase; v) testing for the generalization of the experimentally established Crels and Cfuncs.

Phases 1 and 2: establishing and testing Crels. A delayed MTS procedure used in a previous study (https://osf.io/w2n9g/) will be employed to establish the symbols ■ and ▼ as Crels for the relations of same and different. Participants will receive the instruction "Select the appropriately colored circle". At the beginning of each trail a Crel will be presented for 1000ms. After an SOI of 300ms, an arrangement of three circles of equal size, two of which will be the same color, that will serve as sample and comparison stimuli (e.g., a red circle at the top of the screen, a red circle at the bottom left, and a green circle at the bottom right). They will then select a comparison stimulus for each Crel (e.g., selecting the circle that is the same color as the circle at the top of the screen after seeing the Crel for same). The locations of the stimuli will be counterbalanced across trials. Selections for the left and right comparisons will be made with the 'E' and 'I' keys. Immediately after correct selections the message "Correct!" will appear in green text at the center of the screen for 500ms. The message "Wrong!" will appear in red text in the same location for 1000ms after incorrect responses. The MTS will present up to three thirty trial blocks, and will terminate early if participants achieve an accuracy score $\geq 17/20$ across the previous 20 trials in a block. The established Crel properties will be tested in one 30 trial block presenting different colored circles and without response feedback. The experiment will terminate at this point for participants with accuracies $< 20/30$ on the Crel test.

Phases 3, 4 and 5: establishing and testing Cfuncs. Phases three, four and five present a series of trials in which both the speed and direction of racecar stimuli are

relevant. There is a generic format common to these phases. Each trial consists of two parts, a sample racecar screen which is followed by the race screen. The layout of these components is shown in Figure 1. The sample racecar screen presents a sample racecar in the center of the screen, and allows participants to see how it performs (i.e., whether it moves to the left or right, and does so quickly or slowly). Selection boxes are presented beneath the sample racecar. Each selection box displays the sample racecar on the left, a racecar on the right, as well as two programmed Crels and two Cfuncs between the racecars. The selection boxes specify via the Crels and Cfuncs how each racecar will perform compared to the sample racecar. Within each selection box the Crels will always be located to the left of the Cfuncs, but the Cfuncs for speed and direction will be presented in the upper and lower positions within each selection box an approximately even number of times across trials. This sample racecar screen also presents a white start line, and a checkered finish line. The white start line remains in a fixed location at the center of the screen. The finish line is presented at the same location on both screens within a trial, but will appear at the left and right of the screen an approximately equal number of times across trials. This manipulation ensures that the direction of the racecars is relevant to selecting the winning racecar. This part of the study begins with a brief walkthrough that orients participants to these elements.

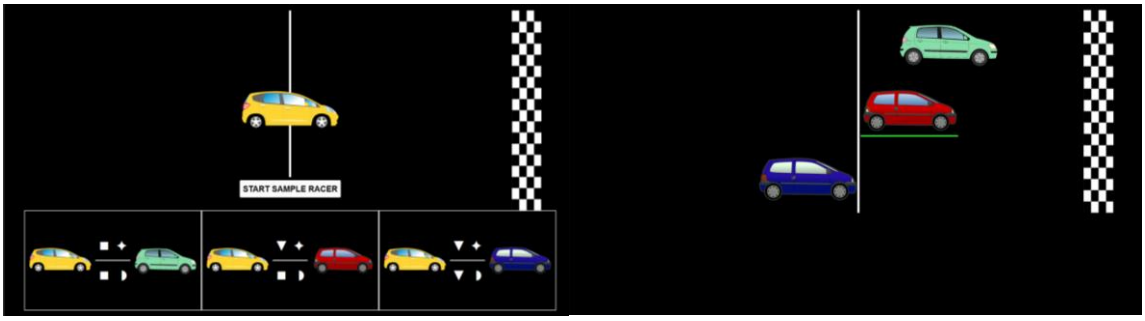

Figure 1. Screenshots of the sample racecar screen (left), and an screen shot of race from the race screen (right) from the Cfunc training task that employed in phases 3 and 4 of the experiment.

The Cfuncs for direction and speed will be established in different blocks using different kinds of trials. In this part of the experiment only two selection boxes appear

beneath the sample racecar. Four kinds of block will be presented. First, trials targeting Cfunc for direction in which racecars will differ in their relationship to the sample racecar only in terms of direction (i.e., both racecars will go the same speed, even if this is different to the sample racecar, but critically the racecars will go in different directions relative to the sample racecar). Second, trials targeting cfunc for speed in which racecars differ in their relationship to the sample racecar only in terms of speed. In these first two blocks only the crel and cfunc pair relevant to the cfunc being established will be presented. The third and fourth kinds of block will match the first two kinds of block in structure but crel and cfunc pair relevant to the cfunc not being trained will be presented also (i.e., crel and cfuncs specifying direction and speed will be presented). Each kind of block will be repeated a maximum of three have been completed or the training criterion has been met (i.e., $\geq 17/20$ across the previous 20 trials in a block), whichever comes first. After completing each kind of block an instruction will inform them they are about to begin the next phase - "Phase complete! You are about to begin a new phase." Participants will also receive additional training trials in which the racecar stimuli vary along both Cfunc dimensions. This will involve trials in which three selection boxes appear beneath the sample racecar and both the speed and direction of these three racecars vary within and across trials.

The selective action of the experimentally established Crels and Cfuncs will be tested in three ways. The first test will take the same format as the car race with three selection boxed described above, and will simply involve the removal of the programmed consequences for 60 trials. The second test will also employ the car race format, but will not present the programmed Cfunc stimuli for 30 trials. The third test is similar to the final test employed by Stewart, Barrett, McHugh, O'Hora, & Barnes-Holmes (2013) which assessed control selection responses. We will use a based test to assess whether the established Crels and Cfuncs generalize to relations between new stimuli, pictures of a bicycle, a truck, a helicopter and a plane oriented to the left or the right. Before completing the generalization test participants will rate each stimulus in terms of their speed via six item scale from "Very slow" to "Very fast", and their direction as either "To the left" or "To the right". On a given trial in the generalization

test a pair of stimuli will be presented in four selection boxes similar to those described above for Cfunc training. The four selection boxes will differ in the precise constellation of Crels and Cfuncs that appear between the vehicle stimuli (see Figure 2). Participants will be required to select the appropriate box for each pair of stimuli and arrangement of Crels and Cfuncs. The generalization test will consist of 30 trials and feedback will not be provided.

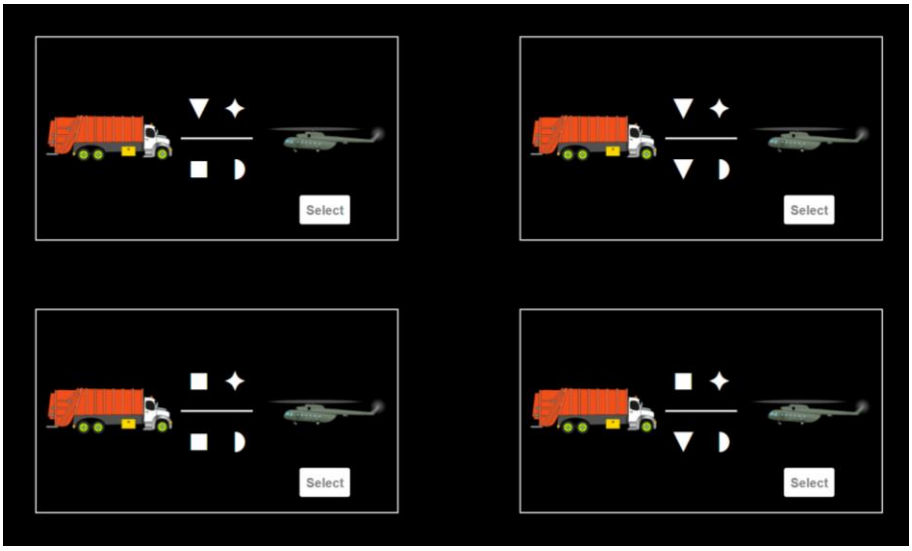

Figure 2. A screenshot of the generalization test in phase 5.

Measures

All measures implemented in lab.js (Henninger, Shevchenko, Mertens, Kieslich, & Hilbig, 2019).

Statistics of interest

1. Number of trials to complete Crel training
2. Number of correct selections in Crel test
3. Number of trials to complete Cfunc training
4. Number of correct selections in the 'racecar' Cfunc test
5. Number of correct selections in Cfunc generalization test
6. Number of participants achieving an accuracy score $\geq 83\%$ in the Cfunc test

Hypotheses

H1. This procedure will produce accurate responding in the 'racecar' Cfunc test.

H2. More than 50% (i.e., 10/20) participants will achieve a test accuracy of 83% or greater in the Cfunc test employing the car race format.

Results

Analytic strategy

Data processing and exclusions.

Data will be processed and analysed in R.

Hypothesis tests.

H1. The primary hypotheses will be investigated with a one sample t-test with a 50% null and a one tailed alpha of 0.05. We predict that participants responding will be at more than 50% accuracy. Note that the 'racecar' Cfunc test provides three response options. 33% accuracy is chance level responding. However, this represents a low bar for demonstrating stimulus control via Cfuncs, and so we adopt a higher null.

H2. The secondary hypothesis will be investigated using a fishers exact test.

References

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