Psychonomic Bulletin & Review manuscript No.
(will be inserted by the editor)

Category Learning Effects on Memory

Kevin O'Neill · Audrey Liu · Siyuan Yin · Timothy Brady · Felipe De Brigard

Received: date / Accepted: date

Abstract Category learning...

Keywords First keyword · Second keyword · More

Introduction

Methods

Participants 867 participants were recruited via Amazon Mechanical Turk (`https://www.mturk.com`). All participants were from the United States, had at least 100 approved hits, had an overall hit approval rate of at least 95%, and received $2.00 compensation for their participation. Data from 133 participants were excluded because of failure to learn the assigned category below 85% accuracy during the last 20 trials of learning (a benchmark used in De Brigard et al. (2017)), or excessive response time (greater than the mean + three standard deviations, XX seconds), so data were analyzed with the remaining 733 individuals. All participants were provided informed consent in accordance with the Duke University IRB.

Materials Stimuli consisted of MATLAB (2018b)-generated flowers, used previously in De Brigard et al. (2017). These flowers vary over five features, with each feature having three possible values: number of petals (four, six, or eight), petal color (blue, green or yellow), center shape (circle, triangle, or square), center color (orange, purple, or turquoise), and number of sepals (one, two, or three). Figure 1 demonstrates three flowers that encapsulate all possible values of the five features. All flowers were displayed on the center of the screen with a white background.

K. O'Neill
Center for Cognitive Neuroscience
Duke University
E-mail: kevin.oneill@duke.edu

Fig. 1 Example stimuli encompassing the range of values for each feature. From left to right: 4 blue petals, orange circle center, 1 sepal; 6 green petals, purple triangle center, 2 sepals; and 8 yellow petals, blue square center, 3 sepals. See more De Brigard et al. (2017) for further details.

Procedure Procedure followed Experiment 4 of De Brigard et al. (2017), with a few revisions. This paradigm includes a learning, study, and test phase. Participants began the experiment by reading an instruction screen for a minimum of 30 seconds which detailed the five stimulus features and the possible values those features could take. This instruction screen also displayed two example stimuli for illustration. Participants were instructed that they would see flowers on the screen, one at a time, and were asked to determine whether each flower belonged to the species *avlonia*. Participants were told that *avlonias* differed from other flowers in one simple way (e.g., only *avlonias* have four petals), but that they must discover what makes *avlonia* flowers unique. Participants were told that they must initially guess, but that they would eventually learn what makes a flower an *avlonia*. Crucially, the feature and value that constituted and *avlonia* was counterbalanced across participants. During each of the three phases of the experiment, each value of each feature was displayed in 1/3 of the trials for that phase, so that the co-occurrence of all feature/value combinations was uniform. In this way, 1/3 of all flowers presented were members of the learned category (*avlonia*). Participants were also assigned a not-learned category, constituted by a value of a different feature, of which they were unaware. The not-learned

category was never mentioned to the participants, statistically independent of the learned category, and counterbalanced across participants.

In addition to the category manipulations in De Brigard et al. (2017), we introducted two further manipulations on learning: whether the participant was explicitly instructed of the the learned category's discriminating feature and value or not (instruction), and whether the participant actively categorized flowers during learning, or merely watched the screen categorize the flowers as *avlonias* or not-*avlonias* (practice). These factors were manipulated fully between-subjects.

First, participants learned to categorize flowers into the species *avlonia*. For the practiced condition, participants completed 72 self-paced trials in which they pressed the "y" key if the flower was an avlonia, or the "n" key otherwise. Immediate feedback ("Correct" or "Incorrect") was presented after each key-press for 1s. For the not-practiced condition, participants passively viewed 72 trials in which a flower was shown for 3s, and a categorization ("Avlonia" or "Not Avlonia") was presented immediately after for 1s. Of the 72 flowers presented, 16 flowers were in the learned category but not the not-learned category, 16 flowers were in the not-learned category but not the learned category, 8 flowers were in both categories, and 32 flowers were in neither category.

In the study phase, participants were asked to memorize 18 flowers. Each flower was shown for 5s following a 1s inter-trial interval. None of these flowers were shown previously in the learning phase. Of these 18 flowers, 4 flowers were in the learned category but not the not-learned category, 4 flowers were in the not-learned category but not the learned category, 2 flowers were in both categories, and 8 flowers were in neither category. Participants were told that they would receive a bonus if they could remember a high number of flowers (XX participants were in fact given a $\$X.XX$ bonus for a hit rate exceeding 85%).

Finally, in the test phase, participants were told that they would see 54 flowers, one by one, and asked to press the "y" key if the flower was old (presented during the study phase), or to press the "n" key otherwise. Each trial was self-paced with a 1s inter-trial interval. Of these 54 flowers, 18 were presented during study. Of the remaining 36 flowers (lures), 8 flowers were in the learned category but not the not-learned category, 8 flowers were in the not-learned category but not the learned category, 4 flowers were in both categories, and 16 flowers were in neither category. None of the lures appeared in the learning or study phases.

Results

Learning Because participants in the not-practiced condition did not make any responses during learning, we limit this analysis to participants in the practiced condition. As

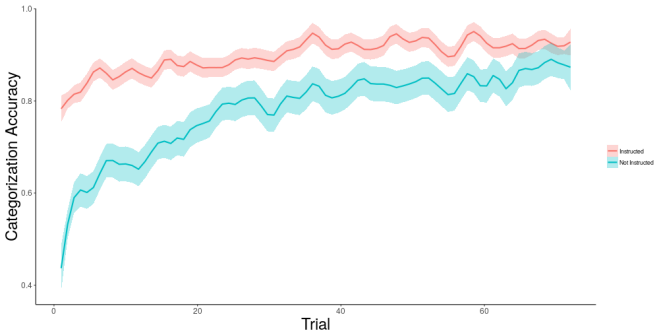

Fig. 2 Learning curves for participants in the practiced condition.

Fig. 3 Hit rates.

Fig. 4 False alarm rates.

Fig. 5 Sensitivity.

found in De Brigard et al. (2017), participants in the not-instructed condition started at near chance (64.31%) categorization accuracy in the first 20 trials, and gradually rose to 86.15% accuraccy in the last 20 trials. In contrast, partipants in the instructed condition began at 82.42% accuracy, and gradually rose to 89.00% accuracy. This confirms that explicit instruction allowed participants to successfully learn the *avlonia* category before practice.

Memory Performance

Signal Detection Theory

Discussion

Acknowledgements

References

De Brigard F, Brady TF, Ruzic L, Schacter DL (2017) Tracking the emergence of memories: A category-learning paradigm to explore schema-driven recognition. Memory & cognition 45 1:105–120

Fig. 6 Bias.