Fish Task, version 14

Instruction Manual written by Catherine E. Myers

Last Updated: 29 April 2022

Contents

Terms and Conditions of Use

The Fish v. 14 task software was programmed by Catherine E. Myers. This task implements an acquired equivalence paradigm, as described in Myers et al. (2003) *Journal of Cognitive Neuroscience*, 15(2):185-193. Development and testing of this software was funded by the Department of Veterans Affairs, Office of Research and Development, through the Clinical Sciences Research & Development Program. This software is in the Public Doman and may be freely copied and used in non-commercial products, provided that the original reference is appropriately cited and the following statement is included: "This software [is adapted from software which] was written by Catherine E. Myers, under funding from the Department of Veterans Affair, Office of Research and Development."

No guarantees are given or implied.

Use of this software implies acceptance of these terms.

Task Description

The Fish task is an acquired equivalence task, in which training to treat two stimuli as equivalent should increase generalization between them. The design is based on that described in Myers et al. (2003). Specifically, during several training stages, subjects first learn to associate antecedent stimuli (here, faces) with different consequents (here, colored fish). Included in the training are several antecedents that are implicitly equivalent, in the sense of being mapped to the same consequents. During a final training stage, some antecedents are paired with new consequents. The training phase is followed by a testing stage that interleaves retention trials with previously-trained pairs as well as generalization trials: e.g., given that Face A is mapped to fish X, and Faces A and B are equivalent, will subjects assume that Face B also goes with fish X? Healthy adults reliably show acquired equivalence, which is disrupted in patients with hippocampal-region dysfunction, including amnesic patients with bilateral hippocampal destruction (Myers et al., 2008) and non-demented elderly with hippocampal atrophy consistent with prodromal Alzheimer's disease (Myers et al., 2003).

Past and Ongoing Work with this Task/Software

Aging and Alzheimer's disease (AD):

- Older people with cognitive decline make increasingly more errors as memory load is increased across training stages, but are then spared at generalization (Collie et al., 2002). (A preliminary version of these results was presented as a poster in Collie et al., 2001).
- Patients with mild AD show mild impairments on training but profound impairments on generalization (Bódi et al., 2009). (A version of this work was also presented in Hungarian, in Bódi et al., 2010).
- Preliminary work in persons from families with genetic mutations causing familial AD showed that gene carriers (most of whom were asymptomatic but a few of whom had mild cognitive impairment) made significantly more errors on generalization compared to non-carriers, suggesting generalization deficits may predate onset of clinical symptoms (Myers et al., 2013). This study is ongoing in John Ringman's lab in UCLA as of Fall 2015.
- Nondemented elderly with hippocampal atrophy (HA) confirmed via structural brain imaging (MRI) learn well but generalize poorly (Myers et al., 2003).

Amnesia:

- Amnesic patients with bilateral hippocampal damage (due hypoxic brain injury) show spared initial learning but impaired generalization; amnesic patients with basal forebrain injury (ACoA aneurysm rupture) show the opposite pattern of slow initial learning but spared generalization (Myers et al., 2008).
- Preliminary data from patients who developed Korsakoff syndrome (KS) secondary to voluntary fasting (prison inmates in Turkey who participated in hunger strike to protest planned stiffening of incarceration conditions by Turkish government during 2001-2002)

show KS patients are impaired on acquisition but perform as well as controls during acquisition (Jonas et al., 2010).
- These results – together with those from the AD studies – are generally consistent with the premise that initial learning does not require the hippocampus, but the representations that support subsequent transfer do depend on hippocampal mediation.

Parkinson's disease (PD):
- PD patients tested on normal dopaminergic medication show slow learning but spared generalization (Myers et al., 2003). (Preliminary version presented as a poster in Myers et al. (2000).) Preliminary results on effects of PD medication appeared in Myers et al. (2007).)
- These results are generally consistent with the premise that basal ganglia and the mesostriatal dopamine system (disrupted in PD) are involved in stimulus-response learning, but the representations that support subsequent transfer depend on hippocampal mediation.

Post-traumatic stress disorder (PTSD):
- Trauma-exposed Israeli police and Hungarian civilians with PTSD show spared learning but poor generalization compared to trauma-exposed controls without PTSD (Levy-Gigi et al., 2012). (A preliminary version of these data was presented as a poster in Levy-Gigi et al., 2001). Note however: a later reanalysis suggested a more nuanced interpretation where there is strong bimodality in the PTSD data with some subjects generalizing well.
- US veterans self-assessed for PTSD symptoms show a positive correlation between cluster B (re-experiencing) symptoms and generalization (Kostek et al., 2014). (Preliminary versions of these data were presented as posters in Lavrador et al., 2011, and Kostek et al., 2013).

Schizophrenia (SZ):
- SZ patients showed spared learning, but impaired generalization, suggesting hippocampal (or medial temporal lobe) dysfunction; in patients, number of training errors correlates with daily chlorpromazine-equivalent dose of antipsychotics (Kéri et al., 2005). (A version of this study was published in Hungarian in Nagy et al., 2005).
- Generalization was impaired in both "deficit" and "non-deficit" SZ patients, but feedback-guided associative learning was impaired only in deficit patients (Farkas et al., 2008).

Drug/Alcohol Dependence:
- Cocaine-dependent subjects make more errors than non-drug-using controls on learning (particularly stage 2, which requires learning new discriminations while maintaining old ones) but are subsequently fine on generalization (Vadhan et al., 2008).
- Subjects with past (not current) alcohol dependence are as good as matched healthy controls on acquisition, but are impaired at generalization (Máttyássy et al., 2012).

Epilepsy
- Khalil et al. (2015) reprogrammed the "Fish" task, and used it to examine learning and generalization in epileptic patients.

Healthy Adults:
- Preliminary data suggest that healthy Hungarian subjects with the His/Tyr variation of the 5-HT2A receptor gene (previously reported to impair declarative memory compared to more

common His/His genotype) were ok on learning but showed more errors on transfer phase than His/His subjects (Myers et al., 2006).

- Meeter et al. (2009) ran several additional variants of the task to examine underlying mechanisms. (Software for these versions is not currently supported.) In Experiment 1: after the "standard" Fish task, subjects learned to pair faces with words; during a subsequent yes/no recognition test (was this face previously paired with this word?), subjects made more errors when a face was shown with a word that had been paired with a previously-equivalent face ("critical lures") than when a face was shown with a word that had been paired with a non-equivalent face ("control lures"). In Experiment 2: word-face training preceded the Fish task, and there was now no more tendency to mistake critical lures than control lures; this implied that the results in Exp 1 reflect representational changes that occur during the Fish task and generalize to later word-face training. Experiment 3 attempted to determine whether the representational changes reflect feature salience or associative mediation accounts of acquired equivalence, and provided some evidence for the latter account.

Instructions for Running Fish v. 14 Software

This task is as described in Myers et al., (2003). Fish v.14 is an implementation of the task software that has been programmed under PsychoPy v2021.2.2. PsychoPy (Peirce, 2007; 2009) is an environment for stimulus generation and experimental control, licensed under the GNU General Public License, and running under python. The Fish v. 14 software has been tested in PsychoPy v2021.2.2 under MS Windows 10 Enterprise; it is expected but cannot be guaranteed that future/later releases of PsychoPy may also be able to run the Fish v.14 software.

Please report any problems with the Fish v. 14 software to Catherine Myers at Catherine.Myers2@va.gov; however, the Fish v. 14 software is provided "as is" and no guarantee is made or implied, and routine technical support cannot be offered without prior collaborative agreement.

For assistance with installing or using the PsychoPy environment, visit the PsychoPy website at www.psychopy.org.

To Run the Software

1. **First, you will need PsychoPy installed on your computer** in order to run the Fish v. 14 software. This can be downloaded from the PsychoPy website at www.psychopy.org. PsychoPy runs under a variety of hardware and OS, including Mac, Linux, and PC; it requires a graphics card that supports OpenGL. The PsychoPy website includes instructions for downloading a standalone (executable) version, as well as instructions for manual installation and tips for troubleshooting.
2. Copy the Fish_14_PsychoPy2021 folder onto the hard drive, and unzip if needed. The folder should contain:
    a. **fish14.psyexp** is a PsychoPy file that contains the program code.
    b. **fish14_ExpStim.xlsx** is a spreadsheet that contains instructions for running the experiment. **Do not modify the contents of this file** (unless you know what you're doing), or it will modify the order and mapping of trial stimuli and responses.
    c. **fishPix** is a folder containing the picture (.png) files used as stimuli in the experiment. These include the face stimuli (girl, man, woman, boy), fish stimuli (yellow, green, purple, blue), and feedback stimuli (win, lose, TheCircle, blank). **Do not change the name or location of any of these files** or the Fish14 software will not run.
    d. If you mistakenly modify/delete any of these files, the program may not run properly. You may need to go back and download fresh (unaltered) versions of the files into your folder.
3. Doubleclick on the PsychoPy icon to open the PsychoPy environment, then under the File menu, choose Open, and then browse to select **fish14.psyexp**.
4. A Psychopy Builder window will open that looks something like the below. The window contains several control icons at the top; underneath are a number of tabs (e.g. "doFB1," "runTrial," "train_instr") indicating different routines within the experiment. The body of the window will show the items and timing for the routine whose tab has been selected (here, "runTrial"). The bottom of the window contains a flowchart for the experiment.

You should not modify anything within the PsychoPy window unless you are intentionally altering the experiment. Any alterations made and saved in the PsychoPy window will alter the 4ish14.psyexp program, which may cause the software to crash or behave erratically, in which case you may need to reinstall a fresh copy.

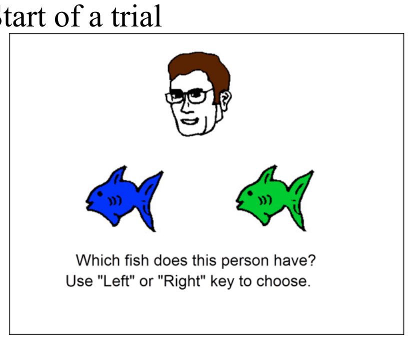
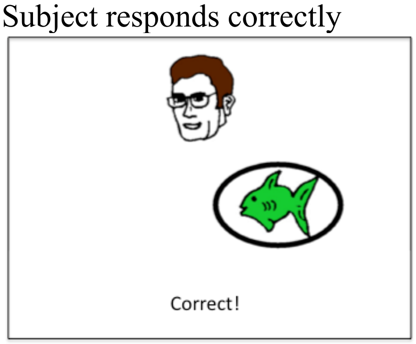
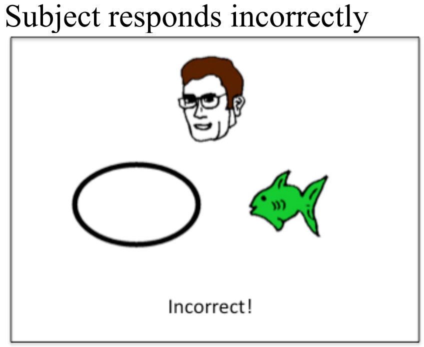
5. To run experiment, click on the green "play arrow" icon at the top of the PsychoPy window, or select Tools → Run from the menu bar at the top of the Builder window (or Control-Shift-R).
6. A dialog pop pops up asking for subject session and ID number. Enter subject ID as prompted.
    a. **IMPORTANT**: Use a numeric or alphanumeric code for the subjectID (e.g. 101, 102, 103...) since this ID number will be incorporated into the name of the output file; spaces or other non-alphanumeric characters may generate illegal filenames (depending on your operating system) which could result in the data being lost!
7. The software will create several output files and log files. The most important one will be entitled something like "ID_fish14.csv" where "ID" is the ID number you specified earlier. Additional files with the same naming convention but with .log and .psydat files will also be created; for most purposes, you can ignore these. Output files will typically be placed in a folder called "data" in the same location where fish14.psyexp is located. In addition, PsychoPy creates a file called fish14_lastrun.py after each run; most users can ignore this file also.
8. Use of this software implies acceptance of certain terms; these are specified on a screen which appears at the start of each use. View these terms and then press the space bar to

accept these terms and proceed to the experiment, or use the escape key to exit the software.

9. At the start of the experiment, an instruction screen will appear (screenshot below).
10. At this point, the keyboard should be masked so that only the arrow keys are available, and the left and right arrow keys are labeled LEFT and RIGHT. The subject can use either or both hands to enter responses.
11. Seat the subject at a comfortable viewing distance from the computer. Make sure the colors appear bright and that the screen is positioned/angled so that the subject can see colors clearly.
12. Read the instructions aloud to the subject, or have the subject read aloud to you. The instruction screen is shown below. If the subject asks for clarification, you may read the instructions again as needed and/or point out the arrow keys, but do not provide any other information. The subject clicks the LEFT or RIGHT arrow key to begin training.

> Welcome to the experiment.
>
> You will see drawings of people who each have some pet fish.
> Different people have different kinds of fish.
> Your job is to learn which kind of fish each person has.
>
> Each time you see a face, press the LEFT or RIGHT key,
> depending on which fish you think the person has.
> In the beginning, you will have to guess.
>
> Try to learn the correct answers, because you will be tested later.
>
> Press the LEFT or RIGHT key to begin.

13. Training phase begins (example shown below). On each trial, the subject sees a face and two colored fish and is asked to guess which fish that person has. The subject should respond by pressing either the "LEFT" or "RIGHT" key to indicate the left or right fish. The selected fish is circled; then feedback ("Correct" or "Incorrect") is shown while the incorrect fish is removed from the screen.

Start of a trial	Subject responds correctly	Subject responds incorrectly
		

14. The training phase is divided into 3 stages, as illustrated in the table below.

a. Training stage 1 intermixes trials on which Face 1 is mapped to Fish 1 (not Fish 2) and trials on which Face 2 is mapped to Fish 2 (not Fish 1). Here and throughout the task, the two fish can appear in either left-right order on the screen.

Training Stage 1	Training Stage 2	Training Stage 3	Test Phase
Face 1 → Fish 1 (not 2)	Face 1 → Fish 1 (not 2) Face 2 → Fish 2 (not 1)	Face 1 → Fish 1 (not 2) Face 2 → Fish 2 (not 1)	Face 1 → Fish 1 or 2? Face 2 → Fish 1 or 2?
Face 3 → Fish 2 (not 1)	Face 3 → Fish 1 (not 2) Face 4 → Fish 2 (not 1)	Face 3 → Fish 1 (not 2) Face 4 → Fish 2 (not 1)	Face 3 → Fish 1 or 2? Face 4 → Fish 1 or 2?
		Face 1 → Fish 3 (not 4) Face 3 → Fish 4 (not 3)	Face 1 → Fish 3 or 4? Face 3 → Fish 3 or 4?
			Face 2 → Fish 3 or 4? * Face 4 → Fish 3 or 4? *

Table 1. Summary of trial types in each stage/phase in the task.

b. Training stage 2 then begins without explicit warning to the subject, and intermixes trials with the previously-trained pairs, and new trials in which Face 2 is paired with Fish 1 (making Face 2 equivalent to Face 1) and Face 4 is paired with Fish 2 (making Face 4 equivalent to Face 3).
c. Training stage 3 then begins without explicit warning to the subject, and intermixes trials with the previously-trained pairs, and new trials in which Face 1 is paired with Fish 3 (not Fish 4) and Face 3 is paired with Fish 4 (not Fish 3).
d. Note that assignment of particular images to Faces 1-4 and to Fish 1-4 is **not randomized across subjects in this version of the software**.

15. Each training stage runs for a maximum number of trials or to a performance criterion of several consecutive correct responses. Transition to the next stage begins immediately and is not signaled to the participant.
    a. Following experimental parameters from Myers et al. (2003) and elsewhere, each training stage is set to terminate after a maximum of 5 blocks, where each block is contains one of each trial type, in random order. Thus, stages 1, 2, 3 run for a maximum of 20, 40, 60 trials respectively.
    b. Programming note: The number of blocks per phase is set in the "trials" loop for each stage, which can be accessed via the program flowchart at the bottom of the PsychoPy window.
    c. Also following experimental parameters from Myers et al. (2003) and elsewhere, each training stage terminates early if the subject reaches a criterion of n consecutive correct responses, where n is 2 times the number of trial types in the block: i.e., 4, 8, 12 for stages 1, 2, 3.
    d. Programming note: The criterion for each training stage is set in the code component for end-of-routine accompanying the feedback routine for the prior stage (or, for stage 1, the code component accompanying the training instruction routine).
16. At the start of the testing phase, the following instruction screen appears:

> Good!
>
> In this part of the experiment, you will need
> to remember what you have learned so far.
> You will NOT be shown the correct answers.
>
> At the end of the experiment, the computer will tell you
> how many you got right.
>
> Good luck!
>
> Press the LEFT or RIGHT key to begin.

17. The testing phase intermixes retention trials (all previously-trained trial types), and generalization pairs in which Face 3 or 4 is presented with Fishes 3 and 4. To display acquired equivalence, subjects should map to Face 3 to Fish 3 (by equivalence with Face 1) and Face 4 to Fish 4 (by equivalence with Face 3). The subject's choice is circled on the screen but no other feedback is provided in this phase. The testing phase consists of 3 blocks, with each block consisting of all 16 trial types (trial order randomized within a block), or 48 trials total. Programming note: the number of blocks is set in the test_trials loop in the flowchart in the PsychoPy window
18. When the program finishes (signaled by "Thank you" screen), use space bar to exit the program.
19. Note: It is good practice to administer a color blindness test (e.g. Ishihara) to subjects to ensure that any difficulties during the training phase are not simply attributable to inability to distinguish stimulus features. (Mild color vision abnormality is probably ok, but any subjects with full red-green or blue-yellow colorblindness should probably be excluded.) If you do test for color blindness, this should be done after administering the task, so as not to clue subjects in that color is an important feature in the task.

To Exit

- To terminate early, use ESC key or command-Q (on the Mac) to exit back to the PsychoPy window, then command-Q (or select Quit from the File menu) to exit PsychoPy. The data file should contain all trials and subject responses up until the trial when the program was terminated; however, this cannot be guaranteed.
- When returning to the PsychoPy window, there may be a small text window "PsychoPy output" containing program notes. This can usually be closed or ignored (or moved to the background).

Data Analysis

The data from each subject are saved as a comma-delimited (.csv) text file. This file contains a row of headers, followed by one row per trial.

The first five columns record one face and two fish stimuli (leftFish and rightFish) that appeared on that trial, along with the response that would be designated as correct for that trial (correctResponse = left or right) and a "phase_used" column which notes the training stage where that trial type was first introduced. Thus, trials with phase_used=1 were introduced at training stage 1, while phase_used=4 indicates that the trial type was not introduced until the testing phase.

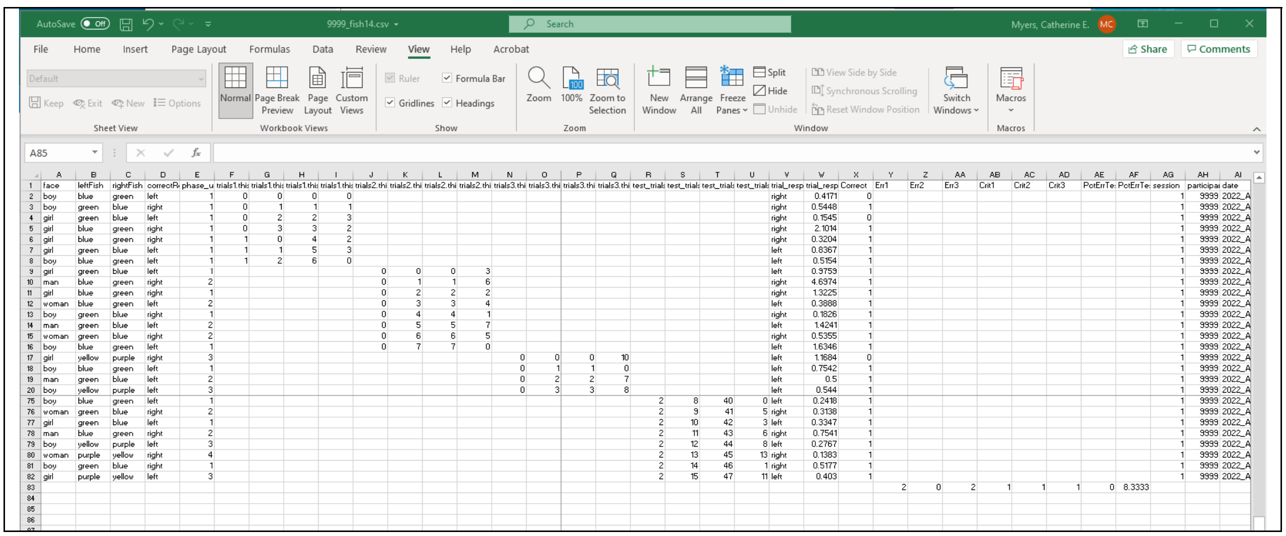
Columns F-U record information about the trials in each stage and can be ignored; however, they provide a visual indication of which trials correspond to stages 1-3 and test phase.

Column V and W record the subject's actual response (left or right) and reaction time (in sec). Column X records whether the response was correct (1) or incorrect (0) by comparison to the correctResponse column (column C).

Columns Y-AB contain summary statistics (last row only).

Columns AC-AL record additional housekeeping information such as session, participant number, experiment name, and version of PsychoPy.

The screenshot below shows portions of an example .csv output file for a hypothetical subject #999; several columns have been deleted for simplicity, and rows 21-74 are not shown.



In this example, the first 7 trials are stage 1 trials, in which either the girl or boy is presented with either the blue or green fish. On the first trial, the subject chose the right fish, which is incorrect (0), with a reaction time of 0.42sec; after another error on trial 3, the next four trials are completed correctly, achieving criterion performance for stage 1.

Stage 2 now begins, intermixing new trials with the man and woman along with the girl and boy. The subject responds correctly on 8 consecutive trials, achieving criterion performance for stage 2.

Stage 3 now begins, intermixing old trial types along with a new trial type: boy or girl with yellow and pink fish. Here, the subject makes one mistakes (and another mistake; row not shown), before executing 12 consecutive correct responses to complete stage 3.

Finally, the testing phase consists of 48 trials: 3 blocks of 16 trials, each intermixing 12 familiar trial types and 4 novel trial types. Here, the subject makes a single error (row 60, not shown), but responds correctly on the remaining 47 trials.

Following Myers et al. (2003) and other publications, data from the training stages and test phase are usually analyzed separately. Summary statistics appear in the last row of the datafile.

First, for each of the training stages, total errors for each stage is reported, along with a flag noting whether criterion was reached (1) or not (0) for each stage. In the above example, the subject made 2, 0, and 2 errors on stages 1, 2, and 3 respectively, and reached criterion on all three stages. Training-stage data are typically analyzed by mixed-design ANOVA with within-subjects factor of training stage, and between-subjects factor(s) of subject group, as appropriate for the experiment. Note that it is not generally a good idea to score training data as percent correct, since different subjects will experience different number of training trials, complicating interpretation of a percentage score.

Second, for the testing phase, percent errors for Old (previously-trained) and New (novel) trial types are scored. These are usually scored as percent errors, since all subjects receive the same number of trials, but the baseline presentation rates differ for Old and New trials. In calculating whether a testing phase trial is Old or New, the phase_used column (column D in the .csv file) is useful: phase_used=1-3 indicates that the trial was introduced during a training stage (and is thus an Old trial type), while phase_used=4 indicates that the trial was introduced only during the testing phase (and is thus a New trial type). Percent errors are summarized in columns AE and AF (last row). In the above example, the subject made 0/36 Old errors = 0% and 1/12 New errors = 8.33%. Test phase data are typically analyzed by mixed-design ANOVA with within-subjects factor of trial type (Old vs. New) and between-subjects factor(s) of subject group, as appropriate for the experiment.

References

Original citation for the acquired equivalence ("Fish") task

Myers, C., Shohamy, D., Gluck, M., Grossman, S., Kluger, A., Ferris, S., Golomb, J., Schnirman, G., & Schwartz, R. (2003). Dissociating hippocampal vs. basal ganglia contributions to learning and transfer. *Journal of Cognitive Neuroscience*, 15(2), 185-193. PMID: 12676056

- Final PDF from publisher's website (may require subscription): http://www.mitpressjournals.org/doi/abs/10.1162/089892903321208123?url_ver=Z39.88-2003&rfr_id=ori%3Arid%3Acrossref.org&rfr_dat=cr_pub%3Dpubmed&#.VvLh0zZf270
- Open access version of the publisher's version/PDF available from Research Gate: https://www.researchgate.net/publication/10821755_Dissociating_Hippocampal_versus_Basal_Ganglia_Contributions_to_Learning_and_Transfer

Other articles and abstracts reporting research using the acquired equivalence ("Fish") task/software

Kostek, J. A., Beck, K. D., Gilbertson, M. W., Orr, S. P., Pang, K. C. H., Servatius, R. J. & Myers, C. E. (2014). Acquired equivalence in U. S. veterans with symptoms of post-traumatic stress: Re-experiencing symptoms are associated with better generalization. *Journal of Traumatic Stress*, 27(6):717-720. PMID 25470729; PMCID: PMC4272630

- Final PDF from publisher's website (may require subscription): http://onlinelibrary.wiley.com/doi/10.1002/jts.21974/abstract
- Open access version of the author's preprint available from PubMedCentral: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4272630/
- Open access version of the athor's preprint available from Research Gate: https://www.researchgate.net/publication/269042242_Acquired_Equivalence_in_US_Veterans_With_Symptoms_of_Posttraumatic_Stress_Reexperiencing_Symptoms_Are_Associated_With_Greater_Generalization

Myers, C. E., Hopkins, R., DeLuca, J., Moore, N., Wolansky, L. J., Sumner, J. & Guck, M. (2008). Learning and generalization deficits in patients with memory impairments due to anterior communicating artery aneurysm rupture or hypoxic brain injury. *Neuropsychology*, *22*(5):681-686. PMID: 18763887

- Final PDF from publisher's website (may require subscription): http://psycnet.apa.org/journals/neu/22/5/681/
- Open access version of the publisher's version/PDF available from Research Gate: https://www.researchgate.net/publication/23230149_Learning_and_Generalization_Deficits_in_Patients_With_Memory_Impairments_Due_to_Anterior_Communicating_Artery_Aneurysm_Rupture_or_Hypoxic_Brain_Injury

Bódi, N., Csibri, E., Myers, C. E., Gluck, M. A., & Kéri, S. (2009). Associative learning, acquired equivalence, and flexible generalization of knowledge in mild Alzheimer's disease.

Cognitive and Behavioral Neurology, 22(2):89-94. PMID: 19506424; doi:10.1097/WNN.0b013e318192ccf0

Bódi, N., Myers, C. E., Gluck, M. A., Csibri, E. & Kéri, S. (2010). Associative learning in early Alzheimer's disease: Contrasting the medial temporal lobe and the basal ganglia memory system. *Acta Psychologica Hungarica*, 97(1):95.

Collie, A., Maruff, P., Wood, S., & Myers, C. (2001). Impaired associative learning in older people with declining associative function. *Cognitive Neuroscience Society Annual Meeting Abstracts 2001*, p. 41.

Collie, A., Myers, C., Schnirman, G., Wood, S. & Maruff, P. (2002). Selectively impaired associative learning in older people with cognitive decline. *Journal of Cognitive Neuroscience*, 14(3), 484-492. PMID: 11970807; doi:10.1162/089892902317361994

Farkas, M., Polgár, P., Kelemen, O., Réthelyi, J., Bitter, I., Myers, C. E., Gluck, M. A., Kéri, S. (2008). Associative learning in deficit and non-deficit schizophrenia. *Neuroreport*, *19*(1), 55-58. PMID: 18281892

Jonas, R. K., Gluck, M. A., Myers, C., Ulasoglu, C., Gurvit, H. (2010). Performance of Korsakoff patients on an acquired equivalence task. *Society for Neuroscience Annual Meeting Abstracts, 2010*, Program 599.21/JJJ26.

Kéri, S., Nagy, O., Kelemen, O., Myers, C. E, & Gluck, M. A. (2005). Dissociation between medial temporal lobe and basal ganglia systems in schizophrenia. *Schizophrenia Research*, 77(2-3):321-328. PMID: 15893916; doi:10.1016/j.schres.2005.03.024

Khalil, R., Elfetoh, N. A., Moftah, M.Z., & Khedr, E. M. (2015). Acquired equivalence associative learning in GTC epileptic patients: Experimental and computational study. *Frontiers in Cellular Neuroscience, 9,* 418.

Kostek, J., Servatius, R., Orr, S., Gilbertson, M. & Myers, C. (2013). Acquired equivalence in veterans with symptoms of post-traumatic stress disorder (PTSD): More severe symptoms are associated with better generalization. Program 122.01, *2013 Neuroscience Meeting Planner*. San Diego, CA: Society for Neuroscience 2013. Online.

Lavrador, S., Ebanks, Y., Beck, K. D., Pang, K. C. H., VanMeenen, K., Gilbertson, M. W., Orr, S. P., Servatius, R. J. & Myers, C. E. (2011). Pathways to PTSD vulnerability: Interactions between behavioral inhibition and hippocampal dysfunction. Program 684.05/GG17. *2011 Neuroscience Meeting Planner*. Washington, DC: Society for Neuroscience, 2011. Online.

Levy-Gigi, E., Kéri, S., Myers, C. E., Lencovsky, Z., Sharvit-Benbaji, H., Orr, S. P., Gilbertson, M. W., Servatius, R. J., Tsao, J. W. & Gluck, M. A. (2012). Individuals with post-traumatic stress disorder show a selective deficit in generalization of associative learning. *Neuropsychology*, 26(6):758-767. PMID: 22846034; doi: 10.1037/a0029361

Levy-Gigi, E., Kéri, S., Myers, C. E., Orr, S. P., Gilbertson, M., Lencovsky, Z., Servatius, R. J. & Gluck, M. A. (2011). Hippocampal-sensitive cognitive assessment of transfer generalization identifies individuals resilient to post-traumatic stress disorder. Program 827.17/WW56. *2011 Neuroscience Meeting Planner*. Washington, DC: Society for Neuroscience, 2011. Online.

Máttyássy, A., Kéri, S., Myers, C. E., Levy-Gigi, E., Gluck, M. A. & Kelemen, O. (2012). Impaired generalization of associative learning in patients with alcohol dependence after intermediate-term abstinence. *Alcohol and Alcoholism*, 47(5):533-537. PMID: 22582184; doi:10.1093/alcalc/ags050.

Meeter, M., Shohamy, D., & Myers, C. E. (2009). Acquired equivalence changes stimulus representations. *Journal of Experimental Analysis of Behavior,* 91(1), 127-141. PMID: 19230516; PMCID: PMC2614814

Myers, C. E., Kéri, S., Guthrie, M., Shohamy, D. & Gluck, M. (2007). Learning and hippocampal-dependent transfer in Parkinson's disease: Effects of medication and disease state. *Society for Neuroscience Annual Meeting Abstracts 2007*, Program #525.15.

Myers, C., Kéri, S., Kiss, I. & Gluck, M. (2006). The effects of a serotonin receptor variation on medial temporal lobe and basal ganglia memory systems. *Cognitive Neuroscience Society Annual Meeting Abstracts, 2006,* p. 135.

Myers, C., Shohamy, D., Schwartz, R. & Gluck, M. (2000). Acquisition and transfer on an acquired equivalence task in patients with Parkinson's disease. *Cognitive Neuroscience Society Annual Meeting Abstracts 2000*, p. 26.

Myers, C., Simon, J., Wharton, D., Medina, L., Alvarez-Retuerto, A. I., Coppola, G., Gluck, M. & Ringman, J. (2013). Impaired generalization of acquired memory pairings in preclinical familial Alzheimer's disease (FAD) mutation carriers. *Neuroscience*, 80(Meeting Abstracts 1):P07.139.

Nagy, O., Kelemen, O., Erdelyi, R., Pataki, M., Janka, Z., Myers, C., Gluck, M., & Kéri, S. (2005). Learned equivalence in schizophrenia: Novel method for the measurement of memory functions of the hippocampus and basal ganglia [Hungarian]. *Psychiatria Hungarica*, 20(5):363-369. PMID: 1642881

Vadhan, N., Myers, C. E., Rubin, E., Shohamy, D., Foltin, R., & Gluck, M. (2008). Stimulus-response learning in long-term cocaine users: Acquired equivalence and probabilistic category learning. *Drug and Alcohol Dependence*, 93(1-2):155-162. PMID: 17976927; PMCID: PMC2247471

Citations for the PsychoPy programming environment

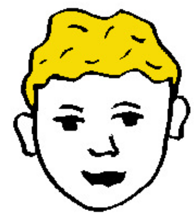
Peirce, J. W. (2007). PsychoPy - Psychophysics software in Python. Journal of Neuroscience Methods, 162(1-2):8-13.

Peirce, J. W. (2009). Generating stimuli for neuroscience using PsychoPy. Frontiers in Neuroinformatics, 2:10.

Appendix: Task Stimuli

The four face images below are used as antecedents. Note that there are three binary dimensions: gender (male/female), age (adult/child), and hair color (blond/brunette). The four fish images below are used as consequents (Fish A, Fish B, Fish C, Fish D). Images appear approximately 1" high on the screen.

Face Images (used as antecedents)

1	2	3	4
			

Fish Images (used as consequents)

1	2	3	4