STRESS AND RULE ADHERENCE

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ABSTRACT

One experiment investigated the influence of a validated stressor, the Fear Factor Stress Test, on rule adherence behaviors. Using a computer generated virtual space, the C-G Arena, participants were given instructions to find visible and invisible targets in either a stress manipulated condition (the Fear Factor Stress Test) or control. Instructions regarding the location of the target were manipulated between experiments to explore how rules with varying levels of accuracy are obeyed. One group received minimal instructions, one received accurate instructions, and one received a set of instructions that did not match the environmental contingencies. Results in all conditions showed that participants adhered to the prescriptive rule even when the rule did not reflect the environmental contingencies. In the stressful conditions, participants showed increased adherence behaviors, results consistent with the literature illustrating that stress increases habit behaviors. Results will be discussed in reference to rule adherence, stress, and future interpretations of the Yerkes-Dodson law.

Introduction

The human capacity for learning primarily depends on our ability to apply inductive reasoning and adhere to rules. Inductive reasoning is considered to occur in phases (Rips, 1999); first, contact with contingencies in the environment are stored in memory, second, a pattern and prediction is generated regarding these contingencies, third, these predictions may update previous observations, and finally, generalizations of predictions are confirmed through experience.

Skinner (1969) distinguished between behaviors acquired this way, otherwise known as contingency-shaped behavior (trial-and-error learning) and those acquired through rule-governed behavior, otherwise known as adherence to rules. Skinner defined a rule as a verbal stimulus that points to a reinforcement relation. Theoretically, social and natural contingencies consequent on rule adherence shape and maintain it (Hayes, Brownstein, Zettle, Rosenfarb & Korn, 1986). By this view, natural contingencies shape contingency-shaped behavior whereas social contingencies initially shape rule adherence. Over time, social reinforcers shape adherence to rules, which becomes habitual. Habitual rule adherence, however, may come at a cost; sometimes people follow rules that they should not follow.

Under some conditions, adults blindly follow verbally stated rules, even when environmental contingencies do not match the rules stated by the rule giver (e.g. Kaufman, Baron, & Kopp, 1966). Jacobs, Doll, and McKenna (in preparation) recently found similar results in a spatial navigation task; participants follow misleading prescriptive rules even when correct environmental contingencies are obvious. It seems rule adherence is a norm, and the complex process of contingency-shaped learning occurs when rules fail completely. Due to a

long history of reinforced rule adherence, however, people tend to emit the behavior, deferring to habit over taxing cognitive strategies.

What happens when the neural mechanisms responsible for switching between rule adherence and contingency-shaped behavior is compromised? Comparative animal studies investigating rule adherence have examined this question by manipulating stress during rule encoding or rule expression. Park, Wood, Bondi, Del Arco, and Moghaddam (2016), for example, induced pharmacological anxiety in rats performing a set-shifting task that required them to discriminate between different rules to investigate activity in the prefrontal cortex (PFC) and its interaction with stress related hormones. The PFC appears to play a role in representing rules as evidenced by individuals who have trouble following rules after PFC damage (Szczepanski & Knight, 2014). Park et al. (2016) found a hypofrontality in the dorsomedial PFC and orbitofrontal cortex (OFC) during high stress and observed a systematic dose-response curve among stress, hypofrontality, and behavioral impairment in the task. In short, rats showed an inability to switch between rules and kept to one strategy during high levels of stress and hypofrontality.

The PFC, however, does not work in isolation. The PFC and hippocampus function as a unified network for cognitive processes such as spatially paired association tasks and other goal-oriented memory tasks (Lee & Solivan, 2008). These brain regions are in constant communication during high-order cognitive processing, and stress plays an integral role in their interaction.

Here, we investigate the influence of stress on rule-adherence by combining three methods. The first is a task, the CG Arena (Jacobs, Laurance, & Thomas, 1997), which requires contributions from both the PFC and hippocampus to complete. The second is a task, the Fear

Factor Stress Test (FFST, du Plooy, Thomas, Henry, Human, & Jacobs, 2014), which produces a consistent and long-lasting stress response in men and women. The third is a manipulation that varies the correspondence between the environmental contingencies and the rules describing those environmental contingencies (e.g., Doll, Jacobs, Sanfey, & Frank, 2009).

By using the C-G Arena (Jacobs, Laurance, & Thomas, 1997), a custom-designed software program patterned after the Morris water maze task (Morris, 1981), it is possible to investigate rule-adherence in a spatial environment with human participants. Coupling this with instructions that vary in their level of accuracy relative to the task contingencies permits us to examine rule adherence in humans, even when the rules are misleading. Finally, by manipulating stress using the Fear Factor Stress Test (du Plooy et al., 2014), it is possible to investigate the effects of stress on rule-adherence in this environment.

If stress increases habitual rule adherence and decreases switching from rule adherence to contingency-shaped behavior, it should increase participants' likelihood to adhere to the prescriptive rule and rule-adherence behavior should remain consistent in conditions where the rules vary in accuracy to the task.

Methods

Participants

Forty-eight (48) individuals (34 females, 14 males), ranging in age from 18-35 years old were recruited through the University of Arizona participant pool. Participants received course credit in exchange for participation. Participants were randomly assigned to one of six groups before beginning the experiment.

Materials

Apparatus

A personal computer and custom-designed software (CG-Arena) generated a display on a 17" LCD computer monitor. The monitor displayed a multicolored view of a room containing a circular arena, patterned after the preparation described by Morris (1981). The computer screen displayed a first-person view of a room as if the eyes of the participant were 5 units from the floor. Participants used a keyboard to navigate throughout the displayed space and a pair of headphones to receive audio feedback.

The CG-Arena preparation consisted of two individual rooms: A "Practice Room" used by participants to orient themselves to the navigational controls, and an "Experimental Room" containing a target for the Ps to locate analogous to the Morris water maze task (Morris, 1981).

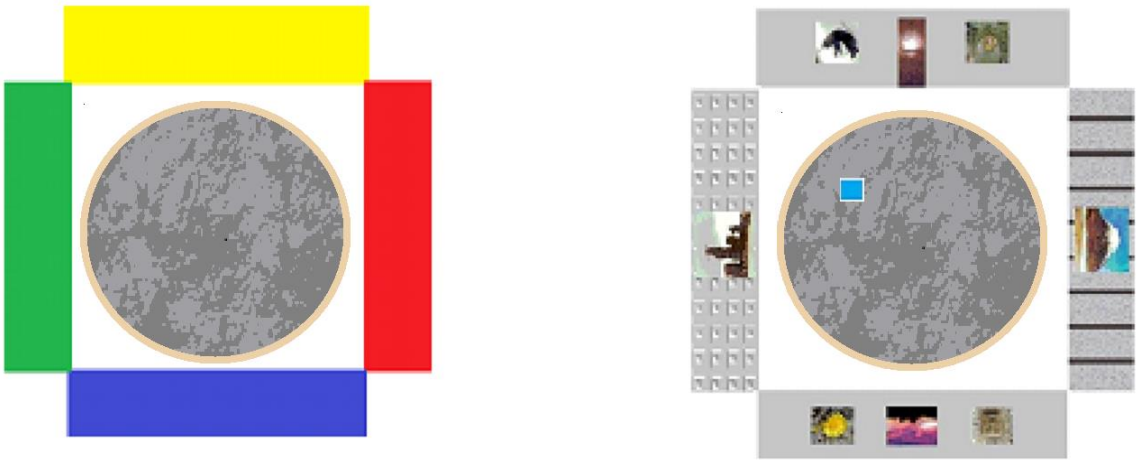
The Practice Room: The Practice Room consisted of a computer-generated display of a 200x200x45 unit room, which housed a circular arena wall on the floor of the room. The Practice Room consisted of four featureless walls, colored yellow (North), red (East), blue (South), and green (West), a dark gray stone floor, and a featureless light gray ceiling. To define the arena space in the Practice Room, a tan marble wall 10 units high and 50 units in radius enclosed a portion of the Practice Room floor. Hence, when standing against and facing the arena wall, the arena wall filled the entire view of the monitor. When standing against and facing away from the arena wall, the monitor displayed a large portion of the arena, a portion of the Practice Room, and its floor and ceiling. The Practice Room separated the experimental trials and allowed the Ps to practice moving and looking.

The Experimental Room: The Experimental Room consisted of a computer-generated display of a 200 x 200 x 45 unit room, which housed textured tan marble circular arena wall 10

units high and 50 units in diameter. The ceiling of the Experimental Room was a light plain gray and the floor a dark textured gray. The light gray North wall contained a 28 x 25 unit icon of a black cat, a 20 x 40 unit door, and a 28 x 25 unit icon of a barrel cactus. Icons were centered, left to right respectively, and were separated by a space of 24 units. The striped dark gray and black East wall contained a centered 43 x 39 unit icon of a snow-capped mountain. The light gray South wall contained a 34 x 25 unit icon of a golden figure-head mask, a 40 x 27 unit icon of an Arizona sunset, and a 34 x 25 unit icon of a blooming cactus flower. These icons were centered, left to right respectively, and were separated by a space of 27 units. The textured gray West wall contained a 43 x 39 unit icon of a hoodoo rock formation.

Target: A 10 x 10 unit target, level with the arena floor, marked a specific place on the floor of the Experimental Room. When visible, the target was a featureless blue and, when facing it, could be seen from any location in the arena. When invisible, the target and the surrounding arena floor were identical in texture and color. See Figure 1 for a top-down illustration of the Experimental Room and Practice Room

Fig. 1 The CG-Arena Practice Room (left) and Experimental Room (right)



Quadrants: For descriptive and analytic convenience, and unbeknownst to the Ps, the CG - Arena was divided into four imaginary quadrants. Moving clockwise, the first was named Northwest (NW), the second Northeast (NE), the third Southeast (SE) and the fourth Southwest (SW). Lines delineating the quadrants were not a part of the P's display. The invisible target was located in the NW quadrant

Keyboard: Participants used the arrow keys on a computer keyboard to move in each room. The up arrow key moved the display forward 20 units/sec and the down arrow moved the view of the display backward at the same rate. The right and left arrow keys turned the display. Participants changed the display from the Practice to the Experimental Room by striking the space bar on the keyboard at any time. They changed the display from the Experimental Room to the Practice Room by striking the space bar while standing on the target in the Experimental Room.

Participants completed a short questionnaire packet after the consent phase. This included general demographics, an adapted Arizona Life History Battery short form (the Mini-K; Figueredo, 2007), the Ten Item Personality Inventory (TIPI) measuring Big-Five traits (Gosling et al. 2003), a Functional Spatial Abilities Questionnaire (Lili et al. 1996), and a Spatial Orientation Questionnaire (Skelton et al., 2000). (SEE APPENDIX 1)

Participants rated their anxiety levels four times throughout the procedures using the six-item short form of the state scale of the State-Trait Anxiety Inventory (STAI; Marteau & Bekker, 1992) (SEE APPENDIX 2). The first was meant as a baseline measure and was co-administered with demographics (STAI1), the second was administered immediately after the experimental manipulation (STAI2), the third was administered after participants successfully completed

encoding instructions (STAI3), and the fourth was administered after participants completed the CG-Arena task (STAI4).

Object Recognition Task

An Object Recognition Task (ORT) was used to measure the how well participants remembered and recognized distal icons in the Experimental Room of the CG-Arena. Participants were shown sixteen (16) icons, half of which were distractor icons, and asked to identify those that were in the CG-Arena space. Participants answered yes/no and indicated confidence on a -3 to +3 Likert scale (SEE APPENDIX 3).

Arena Reconstruction Task

The Arena Reconstruction Task (ART) was used to measure how well the participant could recreate the CG-Arena space. Participants were provided a top-down template of the Experimental Room with spaces allocated for the walls and four (4) possible locations of the invisible target. Participants were provided a small (1 cm x 1 cm) square representation of the target, four wall texture pieces, and eight (8) icons that represented the distal stimuli in the Experimental Room (SEE APPENDIX 4).

Experimental Manipulations

The role of stress is varied across different populations and, as a result, a variety of stressors have been developed and tested with different results (Duncko et al., 2007; Thomas et al., 2014). Two of the most common stressors, the Cold Pressor Test and the Trier Social Stress Test, have shown promising responses, but have shown variation in what stress systems are being activated. The CPT primarily activates physical responses to stress while the TSST employs a social element. Researchers (du Plooy, Thomas, Henry, Human, & Jacobs, 2014) have combined these procedures and have added a cognitively demanding arithmetic task in the effort

to create a stress manipulation with limited variation in response. This task, known as the Fear Factor Stress Test or FFST, shows no significant sex differences and shows sustained cortisol activation (as measured 35 minutes after manipulation) longer than the TSST or CPT. Within each group, participants were pseudo-randomly assigned to a stress condition or control.

In the FFST groups, participants were directed to imagine auditioning for the reality television show *Fear Factor*. Standard instructions read by the RA were used to inform participants what they would be expected to do in the audition. The first task included a 5-minute speech explaining why the participant should be a "contestant" on the show *Fear Factor*, the second was a 5-minute mental math exercise to evaluate their thinking under pressure, and a third being a test of pain resilience. Participants were told they would complete these tasks in from of two judges to determine their eligibility for the show.

For the first task, the RA provided participants with a blank sheet of paper and pencil upon which to prepare a speech. RAs stepped out to give participants 10-minutes to prepare their speech. At the end of this allotted time, the RA returned with a second RA of opposite sex. These RAs (one male, one female) acted as judges for the remainder of the FFST. Upon returning, RA1 (same sex as participant) and RA2 (opposite sex of participant) opened curtains to display the second half of the lab room (8' X 10'), a recording studio that contained a set of halogen lamps, a television, a video camera, a table and chairs for the RAs to sit, a two-way mirror, and a place-mark on the floor for the participants to stand while completing their tasks. RA2 turned on the lights, video camera, and television so participants could see themselves on screen and in the mirror during the entirety of the FFST. RA1 directed the participant to the place-mark in front of the table, closed the curtains, and took a seat located between the table and two-way mirror. RA2 took a seat next to RA1 and prompted participants to begin the speech, starting a stopwatch to

record their time. Participants were given 5-minutes to present the speech. Participants remained uninformed of their overall time and, if participants finished before the time limit, the judge of the opposite sex (RA2) asked standard prompting questions of, "You still have time left, please continue" and "What is your ultimate fear and how do you think you would be able to overcome it in front of a video camera?"

After the speech, RA2 directed participants to perform a 5-min mental arithmetic task. The mental arithmetic task included continuous subtractions by 17 beginning at the number 2043 (2043, 2026, 2011, etc.). If participants made an error, RA2 directed the participant to restart at 2043. At the end of 5-min, RA2 told them they had completed the task and they would move to the last task in the FFST

In the last task, a cold pressor test, RA1 placed a 5-gallon bucket on the table and directed participants to submerge their dominant arm, up to the elbow, in cold water (0° - 4° C) for as long as possible, for a maximum of two minutes. Once completed, RA1 handed participants a towel while RA2 shut off the television, video camera, and lights. Participants were then redirected by RA1 to the other half of the room for the remainder of the experiment. It was at this point that RA2 left the room and RA1 continued the rest of the experiment. Throughout the FFST, participants remained standing at the place-mark and judges (RA1 and RA2) watched from their seated positions.

The same room was used for the control stressor groups, however the curtains remained open throughout, the video camera pointed toward the floor, the television and lamps remained off, the chairs for RAs were not present, and the two-way mirror was covered. Control participants were provided with a blank sheet of paper and pencil and instructed to write a summary of their day. The RA stepped out to give participants 10-minutes to write their

summary. Upon returning, the RA instructed participants to stand and read aloud from a general interest magazine (*Arizona Highways)* for 5-minutes. Again, the RA left the room and permitted participants to read alone. After 5-minutes, the RA returned and instructed the participants to count aloud in multiples of 5s starting 0. The RA left the room for the participant to count aloud for 5-minutes. The RA returned once more, walked to the table, and retrieved a bucket of water previously hidden from the participants' view. The RA put this on the table and instructed the participant to submerge their dominant arm in warm water (34° - 38° C) for as long as possible up to a maximum of 2-minutes. For this task, the RA remained in the room to keep time with a stopwatch, but did not directly watch the participant. Once finished, the RA handed the participant a towel to dry off, placed the bucket back under the table, and directed the participant back to the other side of the room for the remainder of the experiment.

Procedure

Participants in Group 1, henceforth referred to as "normal/no stress" (NNS), were greeted directly outside the laboratory and were led to a well-lit room. The room was organized in accordance with the control condition. Participants took a seat at the open desk to read and sign the consent form. After a brief introduction to the experiment where participants were acquainted with the overall procedure, the RA handed the participant a demographics questionnaire (SEE APPENDIX A) that took about 10-15 minutes to complete. The last portion of the questionnaire, the STAI1, measured a baseline of subjective anxiety.

Experimental Manipulations

Upon completing the questionnaire, the participant began the control stressor condition summarized above. After completing the control procedure, an RA directed Ps from NNS to the

desk with the computer screen and, once seated, the RA handed the Ps. Participants were handed a second STAI (STAI2) immediately before receiving instructions. A standard set of instructions were used to explain the basic keyboard controls, what the participant would see in the arena, the rules of the CG-Arena space, the nature of the target, and the goal to be accomplished in the arena. These instructions outlined practice trials for the participants to become comfortable with the program. These instructions remained consistent for subsequent groups, but differed in their description of the location of the invisible target. In NNS, the location of the target in the Acquisition Trials was described as, "…located on the floor of the Experimental Room; remember, the invisible target will always be in the same place, so take a good look around the room when you find it." The location was mentioned again at the end of the instructions (SEE APPENDIX A).

When the RA read the instructions aloud and obtained verbal confirmation the participant understood, the participants completed a short comprehension quiz to confirm instructions were encoded. If participants did not answer all of the quiz questions correctly, the RA reread the directions aloud and administered a second comprehension quiz. This process continued until the participant achieved a 100% score whereupon a third STAI was administered.

CG-Arena

Practice Phase: After the instructions were encoded, the RA directed the participant to put on the headphones and press the space bar to begin. The first four (4) trials in the Experimental Room were practice trials designed to help participants become familiar with the program, controls, and task objectives. Participants used the Practice Room to practice moving and looking. Participants pressed the space bar to exit the Practice Room and enter the Experimental Room where the task was to locate and stand on a *visible* light blue target that

produced a clicking noise while standing over it. Participants pressed the space bar while on the target to return to the Practice Room. This process was repeated a second time to ensure the participant became familiar with looking, moving, and locating the place the target occupied. The location of the target was different for each of the practice trials. If participants failed to press the space bar to exit either room within 2-minutes (timed-out), the display automatically changed to that of the other room.

Acquisition Phase: Over the next seven (7) trials, the target was invisible until the participant found and stood directly on top of it. Throughout these Acquisition Trials, the location of the invisible blue target remained consistent, in the NW corner between an icon of a hoodoo and an icon of a black cat. Again, if the participants did not find the target and press the space bar in the allotted 2-minutes, the program timed-out and the display changed to that of the Practice Room. Participants entered the Experimental Room at the edge of the arena wall at four pseudo-randomly determined starting positions facing the center of the Arena.

Probe Phase: The seven (7) Acquisition Trials were followed by a 2-minute probe trial. This trial was identical to the Acquisition Trials except that, unknown to the participant, the target was not present in the arena. Consequently, the participant was forced to time-out to the Practice Room. The probe trial was designed to investigate search patterns in the absence of the target.

Final Phase: Immediately following the Probe Phase, a final trial began. This trial was identical to the Acquisition Trials: participants began at a pseudo-random position along the arena wall facing the center of the arena space and located an invisible target in the NW quadrant in a 2-minute time limit. Once participants either located target and pressed the space bar or timed out, the display changed to a final screen that thanked them for their participation. At this

point, the RA directed the participant to the other desk to complete the rest of the experiment.

Object Recognition and Arena Reconstruction Phase

The RAs then administered a final anxiety measure (STAI4). Once this was completed and filed, the RA began the Object Recognition Task (ORT).

ORT: Participants were given an ORT sheet (see Appendix 3) that illustrated sixteen (16) icons; half representing icons that appeared on the Experimental Room walls and the other half representing distractor icons, and were directed to indicate if they did or did not recognized each item as an icon on the Experimental Room walls Participants provided a yes or no answer and noted how confident their answer was on a -3 to +3 Likert scale.

ART: Participants were handed a blank, top-down, view of the Experimental Room (SEE APPENDIX 4). This illustration contained a circle representing a top-down view of the Arena, blank representations of the walls and four empty squares that represented possible locations of the target. The RA uncovered a hidden blue square icon that represented the target and directed the participant to place this in one of the arbitrary squares. Once the participant placed the representation of the target, the RA uncovered four icons that represented the textures of the walls of the Experimental Room. The RA instructed the participant to arrange these in the order they were represented in the Experimental Room. Once the participants finished placing the walls, the RA uncovered the eight (8) icons that were used as distal stimuli and told participants to arrange them in the order they appeared in the Experimental Room. After participants finished the ART, the RA carefully placed it out of the way and began the debriefing.

Participants in Group 2, henceforth referred to as “normal/stress” (NS) experienced identical procedures as NNS except for the manipulation of stress. Participants entered the room as described above for the FFST condition. The greeting phase, consent, introduction, and

demographics were identical to NNS. Upon completing the questionnaire, participants began the FFST condition summarized above. After completing the FFST procedure, participants continued identical procedures to NSS, receiving identical instructions, quizzes, CG-Arena parameters, ORT, and ART.

Participants in Group 3, henceforth referred to as "accurate/no stress" (ANS) experienced identical procedures as NNS except for the manipulation of instructions. Participants entered the room as described above for the control condition. The greeting phase, consent, introduction, and demographics were identical to NNS. After completing the questionnaire, participants began the control condition summarized above. After completing the control stressor, participants continued identical procedures to NNS, with the exception of provided instructions. In ANS, the location of the target in the Acquisition Trials was described as, "The invisible target will be located on the floor of the Experimental Room *between the picture of a hoodoo rock formation and the picture of the black cat*; remember, the invisible target will always be in the same place, so take a good look around the room when you find it." The location was mentioned a second time at the end of the instructions. (SEE APPENDIX A) The quiz for ANS reflected this change in instructions and was taken by the participant until they scored 100%. The remainder of the procedures were identical to NNS.

Participants in Group 4, henceforth referred to as "accurate/stress" (AS) experienced identical procedures as ANS except for the manipulation of stress. Participants entered the room as described for the FFST condition described above. The greeting phase, consent, introduction, and demographics were identical to NNS. After completing the questionnaire, participants began the FFST summarized above. The remainder of the procedures (instructions, quizzes, CG-Arena parameters, ORT, and ART) were identical to those of ANS.

Participants in Group 5, henceforth referred to as "random/no stress" (RNS) experienced identical procedures as NNS except for the manipulation of instructions. Participants entered the room as described above for the control condition. The greeting phase, consent, introduction, and demographics were identical to NNS. After completing the questionnaire, participants began the control condition summarized above. After completing the control stressor, participants continued identical procedures to NNS, with the exception of provided instructions. In RNS, the location of the target in the Acquisition Trials was described as, "The invisible target will be located on the floor of the Experimental Room *in a random place on every trial*; remember, the invisible target will always be in a random location." The location was mentioned a second time at the end of the instructions. (SEE APPENDIX A) The quiz for RNS reflected this change in instructions and was taken by the participant until they scored 100%. The remainder of the procedures were identical to NNS.

Participants in Group 6, henceforth referred to as "random/stress" (RS), experienced identical procedures as RNS except for the manipulation of stress. Participants entered the room as described for the FFST condition described above. The greeting phase, consent, introduction, and demographics were identical to NNS. After completing the questionnaire, participants began the FFST summarized above. The remainder of the procedures (instructions, quizzes, CG-Arena parameters, ORT, and ART) were identical to those of RNS.

Statistical Analysis

The data were analyzed using analysis of variance (ANOVA) techniques recommended by Rodger (1974, 1975). Rodger's method includes analyzing data from factorial designs in terms of a one-way design. Significant F scores are examined with linearly independent and

mutually orthogonal contrasts to reveal differences among conditions. Two estimates of effect size are then computed. Delameter, Derman & Harris (2017) describe the method, which provides an estimate of the non-centrality parameter of the non-central F distribution. In other words, this is a measure of the overall amount of variation among the population means comprising all conditions being analyzed.

The second measure of effects size consists of an estimate of population means, which are implied by the various decisions reached by the analysis conducted within the linearly independent sets of contrasts. The implied means are expressed in σ units. A difference between two implied means of, for example, 1σ unit reflects a rather large difference between the corresponding population means.

The method of analysis was chosen as it is the most comprehensive and powerful ANOVA technique for detecting true effects (Rodger & Roberts, 2013). Use of these methods can ensure that the expected rate of rejecting true null contrasts in error can be fixed by the experimenter as a critical value set. We set alpha at 0.05 for all statistical decisions (Delameter et al., 2017).

Results

Figure 2 illustrates the observed means obtained from Normal instruction/No Stress (NNS) and Normal instructions/Stress (NS) groups. It appears that, when the target was visible, the participants in both groups found it easily, efficiently, and quickly. When the target

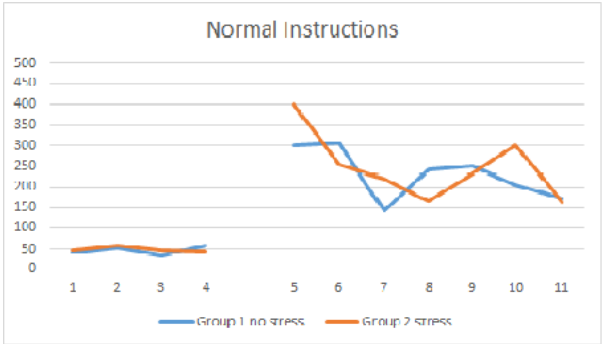


Figure 2

was invisible, however, it appears that the participants in both groups required at least two trials to locate the target, and did so, less easily, efficiently, or quickly.

Figure 3 illustrates the implied means derived from Rodger's Method, expressed in sigma units. The model is generally consistent with the impressions derived from the observed means (a correlation of .962 and .949 between the observed and implied means for groups NNS and NS, respectively). The model indicates, at best, a small difference between the latency required to locate the visible target on the first four trials for the non-stressed and stressed groups. The model also indicates that stress interfered with locating the invisible target on the first of the Acquisition Trials relative to the non-stressed group, but this relation reversed on the second of these trials. The model indicates the groups found the invisible target easily and equally on the remaining Acquisition trials.

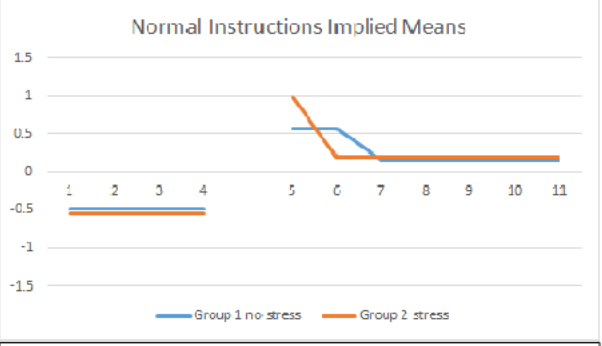


Figure 3

Figure 4 illustrates the observed means obtained from Accurate/No Stress (ANS) and Accurate/Stress (AS) groups. It appears that when the target was visible, both normal and stressed groups found the target easily, efficiently, and quickly. When the target was invisible, it appears that participants in both groups found the target equally on the first trial. The stress group (AS) experienced immediate reduction in latency on the next trial, whereas the no stress (ANS) group gradually found the target with less latency over time. By the fourth

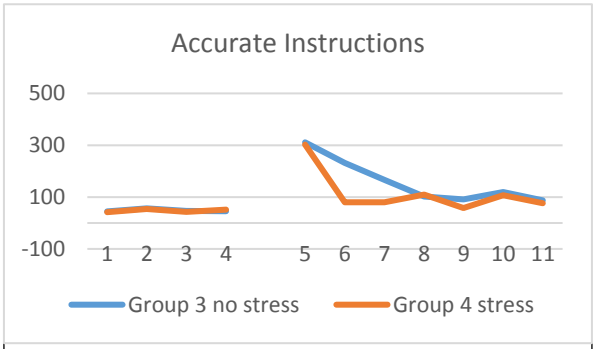


Figure 4

Acquisition Trial, the behavior of both groups were equivalent; participants in both groups found the invisible target easily, efficiently, and quickly.

Figure 5 illustrates the implied means derived from Rodger's Methods, expressed in sigma units. The model is generally consistent with the observed means (a correlation of .879 and .949 between the observed and implied means for groups ANS and AS, respectively). Again, the model indicates a small difference between the latency required to locate the visible target on the first four trials for the non-stressed and stressed groups. The model indicates a similar trend to the NNS and NS groups; the stress group (AS) had a faster reduction in time to acquire the target than the no stress group (ANS). The ANS group took two Acquisition trials, while the AS group took one Acquisition trial to acquire the location of the target. The model indicates the groups found the invisible target easily and equally on the remaining Acquisition trials.

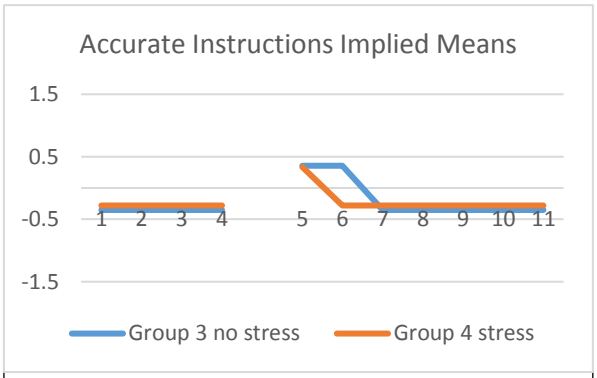


Figure 5

Figure 6 illustrates the observed means obtained from Random instructions/No Stress (RNS) and Random instructions/Stress (RS) groups. It appears that, when the target was visible, both the normal and stressed participants found it easily, efficiently, and quickly. When the target was invisible, it appears that the participants in the non-stress group (RNS) and the stress group (RS) had difficulty finding the target. A general trend of faster times

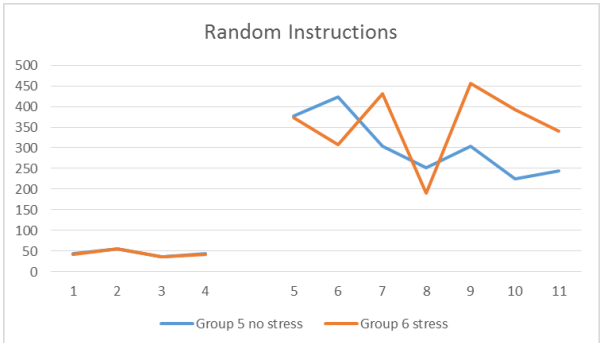


Figure 6

to find the target was observed in the non-stressed group (RNS) over time, but this trend was not detected in the stressed group (RS).

Figure 7 illustrates the implied means derived from Rodger's Method, expressed in sigma units. The model is mostly consistent with the impressions made by the observed means (a correlation of .984 and .971 between the observed and implied means for groups RNS and RS, respectively). The model indicates a difference between latency required to locate the visible target on the first four trials for the stressed (RS) and non-stressed (RNS) groups. In the visible target trials, the stressed group (RS) found the target a half standard deviation faster than the non-stressed (RNS) group. During the Acquisition Trials, the model indicates that the non-stressed group (RNS) took longer to locate the target than the stressed group (RS) for the first two trials, but that latency for RNS reduced during the third Acquisition Trial where the time remained consistent. Though there was a reduction in the implied mean, this value was still more than a half standard deviation from the mean compared to the accurate/non-stress group (ANS) indicating that participants had difficulty locating the target. The model indicates that the participants in the stressed group (RS) did not acquire the location of the target. There was an observed reduction in time at trial 8, but this reduction returns to the observed mean found in trials 5, 6, and 7 indicating that the stressed group (RS) did not acquire the location of the invisible target.

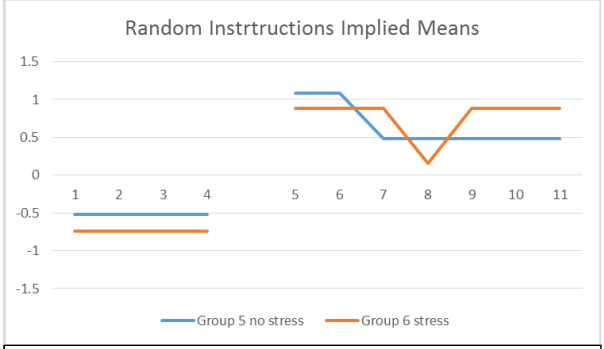


Figure 7

Figure 8 illustrates the observed means for the NNS and NS groups during the Probe Trial. The observed means indicate that participants searched the NW quadrant more than any of the other quadrants when the target was removed from the CG-Arena space. There appeared to be no difference between non-stressed (NNS) and stressed (NS) groups.

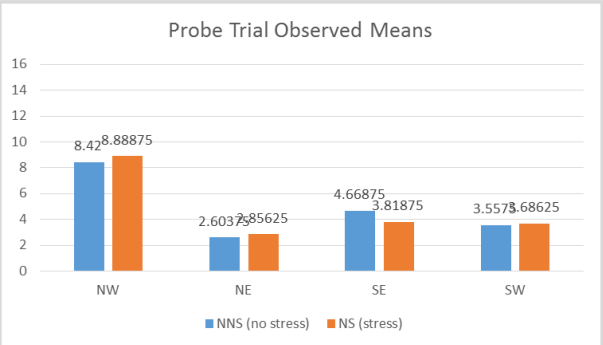


Figure 8

Figure 9 illustrates the implied means of derived from Rodgers's Method, expressed in sigma units. The implied means are generally consistent with the observed means with a correlation of .985; participants searched the NW quadrant significantly more than any other quadrant when the target was removed from the CG-Arena space. Implied means suggest, at best, a small differences between stress and non-stressed groups.

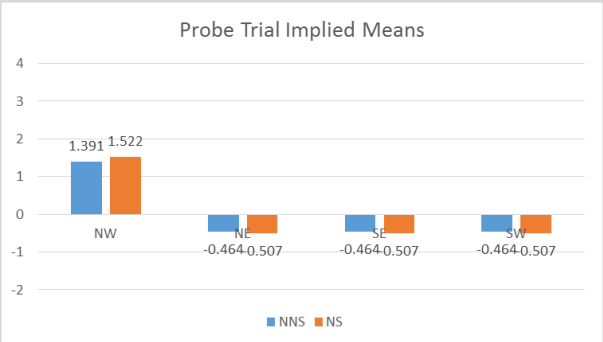


Figure 9

Figure 10 illustrates the observed means for the ANS and AS groups during the Probe Trial. The observed means indicate that participants overwhelmingly searched for the target in the NW quadrant when the target was removed. This observation indicates that participants had acquired the location of the invisible target and were convinced that it was still in the NW quadrant. Comparisons between groups NNS and NS with ANS and AS show that participants searched the NW quadrant more when the instructions explicitly stated the location of the target.

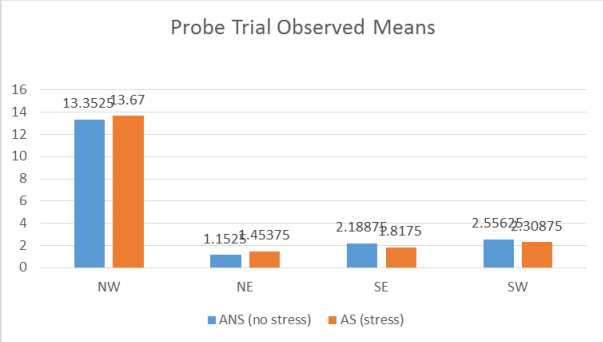


Figure 10

Figure 11 illustrates the implied means during the Probe Trial from the ANS and AS groups. Means were derived from Rodgers's Method, expressed in sigma units. The correlation between the observed means and implied means was .985, indicating an acceptable fit for the model.

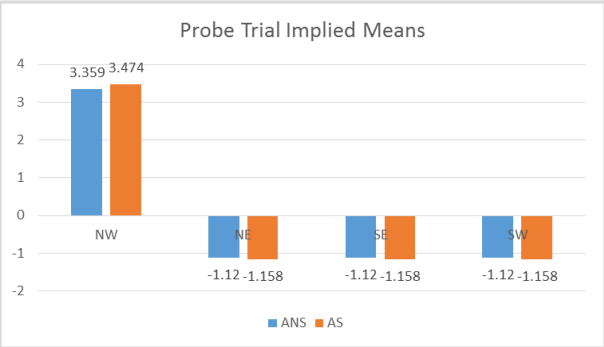


Figure 11

The implied means demonstrate a significant difference between the NNS/NS groups and ANS/AS groups in regards to the proportion of time spent in the NW quadrant. This indicates that participants in groups NNS/NS explored other quadrants when there was wasn't a target in the NW quadrant, but that participants in the ANS and AS groups did not

Figure 12 illustrates the observed means for the RNS and RS groups during the Probe Trial. The observed means indicate that participants did not prefer any quadrant over any other, indicating that participants did not acquire the location of the target, but rather adhered to the prescribed instructions. There appeared to be no difference between the non-stressed (RNS) and stressed (RS) groups.

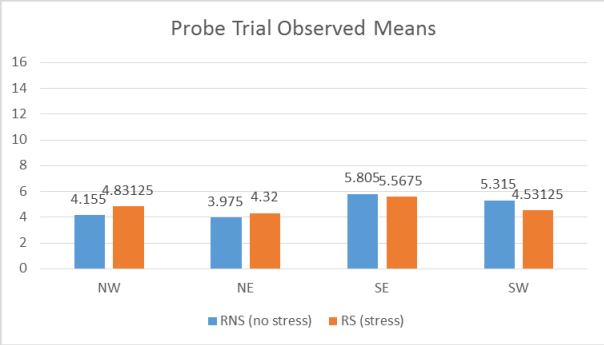


Figure 12

Figure 13 illustrates the implied means for the RNS and RS groups for the Probe Trial expressed in sigma units. There was no significant difference between any of the quadrants. The implied means correlate with the observed means at .985, indicating that participants did not prefer any quadrant. There was no difference between the non-stressed (RNS) and stressed (RS) groups. It appears

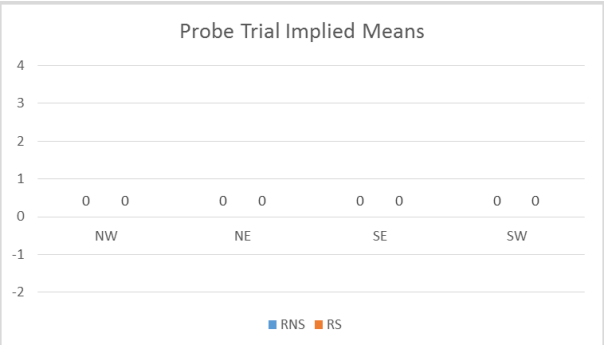


Figure 13

that participants in the RNS and RS groups never acquired the location of the invisible target, and preferred to follow the prescriptive instructions that the target would be in a random place on every trial.

Data acquired from the demographics, questionnaires, STAIs, ORTs, and ARTs were collected for post hoc analysis.

Discussion

The present results demonstrate that individuals adhere to prescriptive rules in a spatial navigation task and that stress increases adherence, regardless of rule accuracy. In Groups NNS and NS, where instructions were minimal, participants gradually acquired the location of the invisible target over 11 Acquisition Trials. These results conform to the literature examining cognitive mapping in rats and humans (Morris, 1981; Jacobs et al., 1997).

Participants in ANS and AS, where the rule and environmental contingencies corresponded, acquired the location of the invisible target on the first trial and performed well over the remaining 10 Acquisition trials. These results also conform to the existing literature (Jacobs et al., in preparation). Moreover, the participants in ANS and AS located the invisible target more quickly in both the stress and control conditions than the participants in NNS and NS, demonstrating that participants used the prescriptive rule to acquire the location of the target. As predicted, participants in RNS and RS, where the rule and environmental contingencies did not correspond, performed significantly slower than NNS, NS, ANS, and AS groups. Here, participants' adherence to the prescriptive rule and, as a result randomly, searched the CG-Arena. Though there was a decrease in time to the target in RNS over time, the latency to find the target was significantly longer that found in groups NNS, NS, ANS, and AS. Individual data for RNS, however, suggested that some participants acquired the location of the target. The participants in RS, however, showed consistent random search strategies suggesting that participants never acquired the location of the invisible target.

Data from the probe trial generally conforms to the observations made across groups. In NNS and NS, participants primarily searched the NW corner of the CG-Arena space, suggesting they acquired the spatial location of the target. This effect remained consistent in ANS and AS where the proportion was more dramatically skewed; participants focused almost entirely on the NW quadrant. Data from RNS and RS groups conforms to the data obtained during the Acquisition trials, participants searched in all quadrants about equally. Though individual data did show some difference in search strategies, the probe trial data suggests that participants in the RNS and RS groups did not acquire the location of the invisible target over the 11 Acquisition Trials; hence they randomly searched the CG-Arena, as the prescribed rule instructed them to do so.

Stress appeared to produce no effect in NNS and NS. There was, however, a significant difference between NNS and NS in regards to the latency to acquire the location of the target. On the first Acquisition Trial, those in the stress condition took longer to locate the target than those in the control condition, but located the target significantly faster on the second through the sixth trial. This effect disappeared after Trial 7. This pattern was also observed in ANS and AS; stress decreased the time to target on the second Acquisition Trial (Trial 6). In RNS and RS, stress had the opposite effect on time to target; those in the control condition, compared to those in the stress condition, located the target significantly faster across trials after the third acquisition trial (Trial 7). In ANS, AS, RNS, and RS groups, where the rule described prescriptive behavior, stress increased the likelihood to adhere to the rule; participants in ANS and AS looked in the described location and participants in RNS and RS randomly searched for the invisible target.

These data are consistent with the hypothesis that individuals habitually follow prescribed rules. The results are also consistent with the hypothesis that stressed individuals

adhere more strongly to these rules, even when the rule and environmental contingencies do not correspond. It is also appears that stress, in this goal-oriented task, increases rule-adherence, inhibiting strategies that counter the prescribed rule.

Anecdotally, the process of adhering to rules in stressful situations makes sense. Instructions, training, and advice are used to ensure that individuals behave in certain ways even when under pressure. The long history of reinforcing rule adherence through social contingencies make it a primary strategy when completing tasks. This is consistent with Schwabe and Wolf's (2011) demonstration that stress increases habitual behaviors and increases behavioral resistance to extinction.

The data presented here can be viewed within the frame of research investigating the effect of stress on performance. Yerkes and Dodson (1908) proposed an inverted-U-shaped function between arousal and performance; small and large levels of arousal lead to inaccurate performance, but moderate levels promote accurate performance in a variety of tasks. The present findings fit Yerkes Dodson in an interesting way: Accurate navigation did not increase, instead rule adherence increased.

Applying the principle that stimulus intensity determined arousal levels, Easterbrook (1959) hypothesized that an increase in arousal reduces the environmental cues that the individual uses. This interpretation fits the data observed in the present experiment; during stress, participants relied on prescriptive rules more than the actual environmental contingencies in the arena. Perhaps the Yerkes-Dodson law should be evaluated in light of cognitive systems that are taxed under stressful conditions. Though moderate arousal seems to increase performance in many tasks, the task at hand and strategies used to complete the task need to be taken into consideration.

Conclusions, Limitations and Future Directions

In conclusion, the results suggest that individuals follow prescriptive rules in a spatial navigation task. Individuals will follow these rules, even when the rule and the environmental contingencies do not match. Stress increased rule adherence, suggesting that stressed humans revert to the long reinforced habit of obeying rules.

There were some limitations in the current study. Participants were recruited through a homogenous pool of college students and future research could extend the findings to other populations. Sex differences to stressors have been documented in the literature, and though we used the FFST to mitigate this effect, including more males in each condition would have allowed differential statistical analysis to measure sex differences if they exist. Other hormonal factors such as steroid use, menstrual cycle, and birth control will be controlled in future studies.

In the present study, the condition with inaccurate instructions was not in direct opposition to the environmental contingencies. Though the rule was inaccurate, participants still found the invisible target but appeared to assume it was in a random place. In future research, a condition where the instructions direct participants to the wrong quadrant would illustrate if they are willing to abandon the rule and search in other places of the CG-Arena. In light of the current research, it would be predicted that participants would disproportionally search the incorrect location and that stress would reinforce this rule-adherence behavior.

References

Easterbrook, J. A. (1959). The effect of emotion on cue utilization and the organization of behavior. *Psychological Review*, *66*(3), 183–201.

Figueredo, A. J. (2007b). The Arizona Life History Battery [Electronic version]. Retrieved from http:// www.u.arizona.edu/~ajf/alhb.html

Gosling, S. D., Rentfrow, P. J., & Swann, W. B., Jr. (2003). A Very Brief Measure of the Big Five Personality Domains. Journal of Research in Personality, 37, 504-528.

Hayes, S. C., Brownstein, A. J., Zettle, R. D., Rosenfarb, I., & Korn, Z. (1986). Rule-governed behavior and sensitivity to changing consequences of responding. Journal of the Experimental Analysis of Behavior, 45, 237-256.

Jacobs, W.J., Laurance, H.E., & Thomas K., (1997) Place Learning in Virtual Space I: Acquisition, Overshadowing, and Transfer. L*earning and Motivation* 28, 521–541

Jacobs, W. J, Doll, B., & Thomas, K. (in preparation). Rule-governed obedience as an instrumental behavior: Acquisition, stimulus control, and context dependence. ……. (….)

Kaufman, A., Baron, A., & Kopp, R. E. (1966). Some effects of instructions on human operant behavior. *Psychonomic Monograph Supplements*, 1, 243–250.

Lee I, Solivan F (2008) The roles of the medial prefrontal cortex and hippocampus in a spatial paired-association task. *Learn Mem* 15:357–367.

Lili Liu, Gauthier, L., Gauthier, S. (1996). The Functional Spatial Abilitie Questionnaire for use with persons who are in the early stages of Alzheimer disease: Preliminary data on reliability and validity. Canadian Journal of Occupational Therapy, 63, 4, 224-233

Morris, R. G. M. (1981). Spatial localization does not require the presence of local cues. *Learning and Motivation*, **12,** 239–260.

Marteau, TM; Bekker, H (1992). "The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI)". Br J Clin Psychol. 31 (3): 301–6. doi:10.1111/j.2044-8260.1992.tb00997.x. PMID 1393159.

Park, J., Wood, J., Bondi, C., Del Arco, A., & Moghaddam, B. (2016) Anxiety Evokes Hypofrontality and Disrupts Rule-Relevant Encoding by Dorsomedial Prefrontal Cortex Neurons. *Journal of Neuroscience*, 36 (11): 3322-3335

du Plooy, C., Thomas, K.G., Henry, M., Human, R., & Jacobs, W.J. (2014) The fear-factor stress test: an ethical, non-invasive laboratory method that produces consistent and sustained cortisol responding in men and women. *Metab Brain Dis*. 2014 Jun;29(2):385-94. doi: 10.1007/s11011-014-9484-9.

Rips LJ (1999) Deductive reasoning. In: The MIT encyclopedia of the cognitive sciences (Wilson RA, Keil FC, eds), pp 225–226. Cambridge, MA:MIT.

Schwabe, L. & Wolf, O.T. (2011) Stress increases behavioral resistance to extinction. *Journal of Psychoneuroendocrinology, 36, 1287-1293*

Skelton RW, Bukach CM, Laurance HE, Thomas KGF, Jacobs WJ (2000) Humans with traumatic brain injuries show place-learning deficits in computer-generated virtual space. J Clin Exp Neuropsychol 22 (2): 157–175.

Skinner, B. F. (1969). Contingencies of reinforcement: A theoretical analysis. New York: Appleton-CenturyCrofts.

Szczepanski S. M., Knight R. T. (2014). Insights into human behavior from lesions to the prefrontal cortex. Neuron 83, 1002–1018. 10.1016/j.neuron.2014.08.01

Yerkes, R. M. & Dodson, J. D. (1908). The relationship of strength of stimulus to rapidity of habit formation. *Journal of Comparative Neurology and Psychology*, *18*, 459–482.

APPENDIX 1 DEMOGRAPHICS

Group #_____ Participant #_____

DEMOGRAPHICS QUESTIONNAIRE

1) What is your sex?
0. □ Male
1. □ Female

2) What is your date of birth? _____? (mm/dd/yy)

3) Do you consider yourself to be Hispanic or Latino?
1. □ YES
2. □ NO

4) What race do you consider yourself to be?
1. □ Black or African American
2. □ White
3. □ Asian
4. □ American Indian or Alaskan Native
5. □ Native Hawaiian or Other Pacific Islander
6. □ Some other race (please specify)_____

5) Were you born in the United States?
1. □ YES
2. □ NO
    a) If NO, where were you born?_____
    b) If NO, how long have you lived in the United States? _____ Years

6) What languages are spoken in your home?
1. □ English Only
2. □ Primarily English/Some Spanish
3. □ Primarily Spanish/Some English
4. □ Spanish Only
5. □ Other_____

7) What is the highest educational level **you** have achieved? _____

8) What is the highest educational level your mother (or the woman who was primarily responsible for taking care of you as a young child) achieved?
1. □ 10th Grade or less
2. □ 11th Grade
3. □ 12th Grade/ GED Diploma
4. □ Some college, but no college degree
5. □ Associate's Degree
6. □ Bachelor's or RN Degree
7. □ Some graduate or professional school, but no graduate degree
8. □ Graduate or Professional Degree

9) What is the highest educational level your father (or the man who was primarily responsible for taking care of you as a young child) achieved?
1. □ 10th Grade or less
2. □ 11th Grade
3. □ 12th Grade/ GED Diploma
4. □ Some college, but no college degree
5. □ Associate's Degree
6. □ Bachelor's or RN Degree
7. □ Some graduate or professional school, but no graduate degree
8. □ Graduate or Professional Degree

10) Which best characterizes your living arrangements during **childhood through the age of 16 years**? (choose one)
1. □ I lived with my mother, but not my father, most of the time.
2. □ I lived with my father, but not my mother, most of the time.
3. □ I lived with both of my parents most of the time.
4. □ I lived with extended family on my mother's side (grandparents, aunts, uncles, cousins) most of the time (not with my parents).
5. □ I lived with extended family on my father's side (grandparents, aunts, uncles, cousins) most of the time (not with my parents).
6. □ I was in foster care most of the time.
7. □ Other: _____

11) Have you ever experienced a head injury (e.g., being hit on the head with an object and losing consciousness as a result)?
1. □ YES
2. □ NO
   a.) If YES: How many times? _____
   b.) How old were you when this occurred? _____

12) Have you experienced a stressful event TODAY?
1. □ YES
2. □ NO
   a.) If YES: What was the event? _____

MINI K

Please indicate how strongly you agree or disagree with the following statements. Use the scale below and write your answers in the spaces provided. For any item that does not apply to you, please enter "0".

Disagree Strongly	Disagree Somewhat	Disagree Slightly	Don't Know / Not Applicable	Agree Slightly	Agree Somewhat	Agree Strongly
-3	-2	-1	0	+1	+2	+3

	1. I can often tell how things will turn out.
	2. I try to understand how I got into a situation to figure out how to handle it.
	3. I often find the bright side to a bad situation.
	4. I don't give up until I solve my problems.
	5. I often make plans in advance.
	6. I avoid taking risks.
	7. While growing up, I had a close and warm relationship with my biological mother.
	8. While growing up, I had a close and warm relationship with my biological father.
	9. I have a close and warm relationship with my own children.
	10. I have a close and warm romantic relationship with my sexual partner.
	11. I would rather have one than several sexual relationships at a time.
	12. I have to be closely attached to someone before I am comfortable having sex with them.
	13. I am often in social contact with my blood relatives.
	14. I often get emotional support and practical help from my blood relatives.
	15. I often give emotional support and practical help to my blood relatives.
	16. I am often in social contact with my friends.
	17. I often get emotional support and practical help from my friends.
	18. I often give emotional support and practical help to my friends.
	19. I am closely connected to and involved in my community.
	20. I am closely connected to and involved in my religion.

TIPI

Here are a number of personality traits that may or may not apply to you. Please write a number next to each statement to indicate the extent to which you agree or disagree with that statement. You should rate the extent to which **the pair of traits** applies to you, even if one characteristic applies more strongly than the other.

Disagree strongly	Disagree moderately	Disagree a little	Neither agree nor disagree	Agree a little	Agree moderately	Agree strongly
1	**2**	**3**	**4**	**5**	**6**	**7**

I see myself as:

1. _____ Extraverted, enthusiastic.
2. _____ Critical, quarrelsome.
3. _____ Dependable, self-disciplined.
4. _____ Anxious, easily upset.
5. _____ Open to new experiences, complex.
6. _____ Reserved, quiet.
7. _____ Sympathetic, warm.
8. _____ Disorganized, careless.
9. _____ Calm, emotionally stable.
10. _____ Conventional, uncreative.

FUNCTIONAL SPATIAL ABILITIES QUESTIONNAIRE

Please answer these questions by circling 1, 2, or 3.

YES (Y) (1)	NOT APPLICABLE (N/A) (2)	NO (N) (3)

	Y	N/A	N
1. I get lost in new or nonfamiliar environments when walking or driving.	1	2	3
2. I require supervision when traveling to a new environment.	1	2	3
3. I have difficulty following a map (e.g., subway map, city map).	1	2	3
4. I am uncomfortable when traveling alone.	1	2	3
5. I have difficulty remembering the destination when traveling.	1	2	3
6. I have difficulty returning home after an outing (e.g., take longer than is required, get off at wrong bus/subway, make a wrong turn).	1	2	3
7. My sense of direction has changed over time.	1	2	3
8. I get lost in previously familiar environments (e.g., homes of relatives/friends, shopping center).	1	2	3
9. I require supervision when traveling in the neighborhood.	1	2	3
10. I get lost in the home.	1	2	3
11. I am uncomfortable when I am alone at home.	1	2	3
12. I place objects in inappropriate locations in the home (e.g., put kitchen item in the bathroom).	1	2	3

SPATIAL ORIENTATION QUESTIONNAIRE

Based on your recent experience (the last month or so), circle the number on the line that best describes your experience.

1. Do you get lost in small familiar building (friend's house, corner store, etc.)?

1 2 3 4 5 6 7

Never Sometimes Every time

2. When you go into a large building you have been in before (malls, office building, hospitals) do you get lost?

1 2 3 4 5 6 7

Never Sometimes Every time

3. When you go into large buildings for the first time, do you get lost?

1 2 3 4 5 6 7

Never Sometimes Every time

4. When you are in familiar parts of town (like you own neighborhood), do you feel lost?

1 2 3 4 5 6 7

Never Sometimes All the time

5. When you are in unfamiliar parts of town, do you feel lost (or get lost)?

1 2 3 4 5 6 7

Never Sometimes All the time

6. Do you get people to take you over a route before you will go that way yourself?

1 2 3 4 5 6 7

Never Sometimes Every time

7. Do you stop and ask directions when you are on your way to someplace (or want to ask)?

1 2 3 4 5 6 7

Never Sometimes Every time

8. Do you make up shortcuts and figure out new routes from one place to another?

1 2 3 4 5 6 7

Never Sometimes Every time

9. Do you have trouble reading maps?

1 2 3 4 5 6 7

Never Sometimes Every time

10. Do you forget where you put things?

1 2 3 4 5 6 7

Never Sometimes Every time

11. Is it important to you that your clothes and food cupboards are arranged in a very specific way?

1 2 3 4 5 6 7

Not at all Somewhat Absolutely!

APPENDIX 2

Group #_____ Participant #_____

STAI [1]

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate **how you feel right now, at this moment.**

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

Group #_____ Participant #_____

	Not at all	Somewhat	Moderately	Very Much
1. I feel calm	1	2	3	4
2. I am tense	1	2	3	4
3. I feel upset	1	2	3	4
4. I am relaxed	1	2	3	4
5. I feel content	1	2	3	4
6. I am worried	1	2	3	4

STAI [2]

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate **how you feel right now, at this moment.**

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

Group #_____ Participant #_____

	Not at all	Somewhat	Moderately	Very Much
1. I am tense	1	2	3	4
2. I am relaxed	1	2	3	4
3. I feel content	1	2	3	4
4. I am worried	1	2	3	4
5. I feel calm	1	2	3	4
6. I feel upset	1	2	3	4

STAI [3]

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate **how you feel right now, at this moment.**

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

Group #_____ Participant #_____

	Not at all	Somewhat	Moderately	Very Much
1. I feel calm	1	2	3	4
2. I feel content	1	2	3	4
3. I am relaxed	1	2	3	4
4. I feel upset	1	2	3	4
5. I am worried	1	2	3	4
6. I am tense	1	2	3	4

STAI [4]

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate **how you feel right now, at this moment.**

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	Not at all	Somewhat	Moderately	Very Much
1. I am relaxed	1	2	3	4
2. I feel upset	1	2	3	4
3. I feel content	1	2	3	4
4. I am tense	1	2	3	4
5. I feel calm	1	2	3	4
6. I am worried	1	2	3	4

APPENDIX 3

OBJECT RECOGNITION TASK

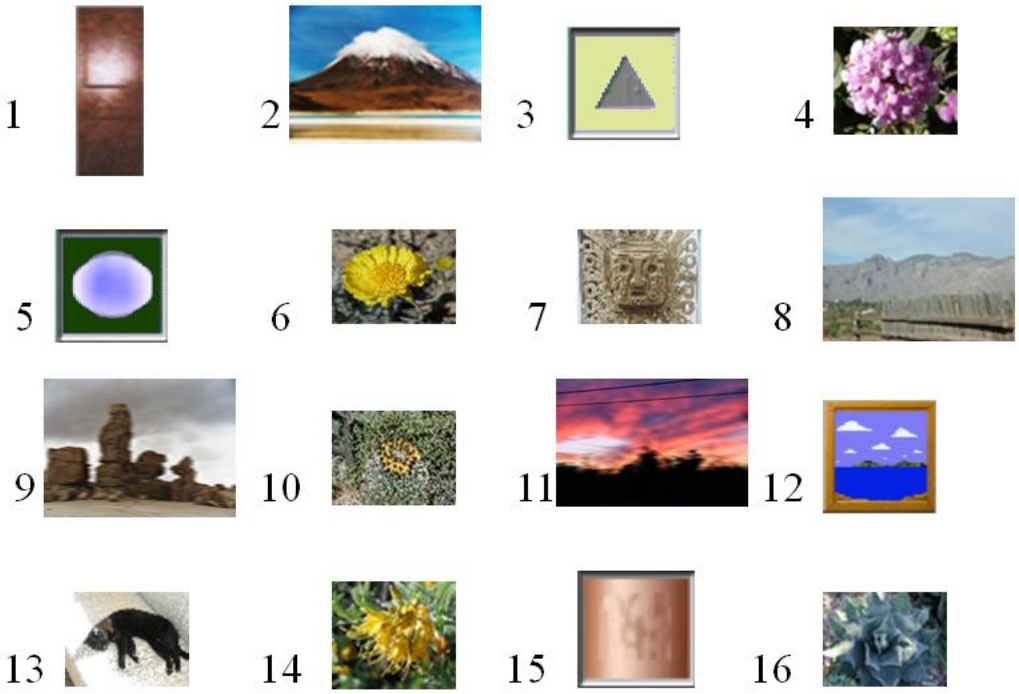
Answer Sheet

Circle "yes" if the item **was** in the experimental room. Circle "no" if the item **was not** in the experimental room.

Next to each answer, circle the number corresponding to how confident you are of your answer (-3 = not at all confident, +3 = very confident).

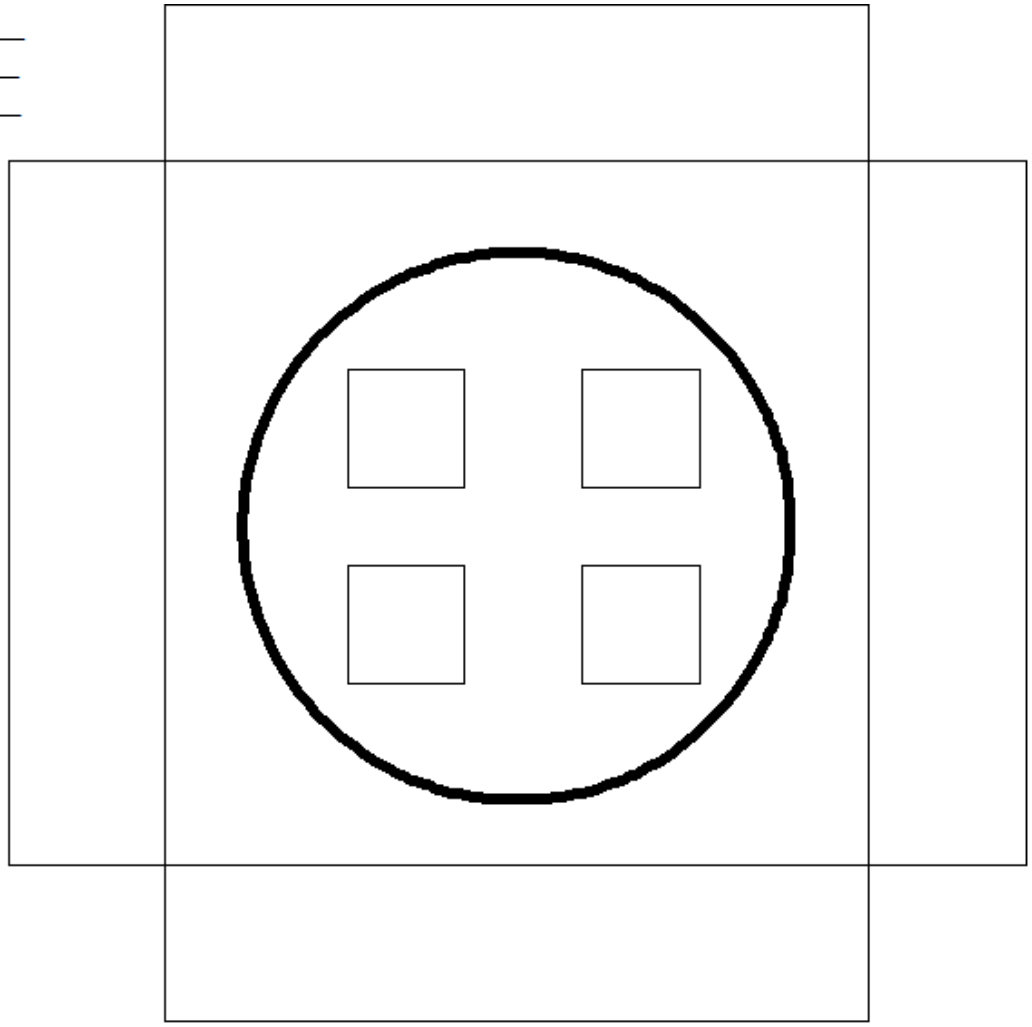
Item Number			Confidence Rating						
1.	Yes	No	-3	-2	-1	0	+1	+2	+3
2.	Yes	No	-3	-2	-1	0	+1	+2	+3
3.	Yes	No	-3	-2	-1	0	+1	+2	+3
4.	Yes	No	-3	-2	-1	0	+1	+2	+3
5.	Yes	No	-3	-2	-1	0	+1	+2	+3
6.	Yes	No	-3	-2	-1	0	+1	+2	+3
7.	Yes	No	-3	-2	-1	0	+1	+2	+3
8.	Yes	No	-3	-2	-1	0	+1	+2	+3
9.	Yes	No	-3	-2	-1	0	+1	+2	+3
10.	Yes	No	-3	-2	-1	0	+1	+2	+3
11.	Yes	No	-3	-2	-1	0	+1	+2	+3
12.	Yes	No	-3	-2	-1	0	+1	+2	+3
13.	Yes	No	-3	-2	-1	0	+1	+2	+3
14.	Yes	No	-3	-2	-1	0	+1	+2	+3
15.	Yes	No	-3	-2	-1	0	+1	+2	+3
16.	Yes	No	-3	-2	-1	0	+1	+2	+3

OBJECT RECOGNITION TASK



APPENDIX 4

Subject #_____
Group # _____
Exp # _____



APPENDIX A

INSTRUCTIONS FOR THE C-G ARENA:

(To be read verbatim to participants.)

In this part of the experiment, your task is to find a target on the floor of a computer-generated room. You will see two different computer-generated rooms, a waiting room and an experimental room.

You will start in the waiting room. It has brightly colored walls, a gray ceiling, a marble arena wall, and a gray floor. In this room, all you need to do is practice moving around using the joystick.

Moving and looking:

To go forward, press the up arrow key.

To go backward, press the down arrow key.

To turn to the right, press the right arrow key.

To turn to the left, press the left arrow key.

Remember: Pressing the left or right arrow key will turn you in the corresponding direction, but will not move you sideways.

When you have mastered moving and looking, press the space bar on the keyboard and the display will change to the experimental room.

In the experimental room, your task is to search for, find, and stand on a large blue target. On the first four trials, you'll be able to see the target. It will appear in different places on each trial. Just go stand on it and, when you are ready, press the space bar. That will change the display back to the waiting room.

On the next nine trials, the target will be invisible until you stand on it. You'll know you are on the target when you hear a clicking sound and see the large blue square appear on the floor of the room.

The trick here is that (INSERT 1a, 2a, 3a)

Each time you find and stand on the invisible target, press the space bar to go back to the waiting room. If you don't find the target in a minute or so, you will be automatically transported back to the waiting room.

The most important thing to remember is that: while the visible target in the first four trials is in different places, the invisible target in the other trials will always be (INSERT 1b, 2b, 3b).

Do you have any questions? ***[Tell participant(s) to put on headphones.]***

APPENDIX A

INSTRUCTION MANIPULATIONS

Experiment 1

1a The invisible target is *always located on the floor in the same place of the Experimental Room*; remember, the invisible target will *always be in the same place*, so take a good look around the room when you find it.

1b in the same place

Experiment 2

2a The invisible target is located on the floor of the Experimental Room *between the picture of a hoodoo rock formation and the picture of the black cat*; remember, the invisible target will always be in the same place, so take a good look around the room when you find it.

2b between the picture of a hoodoo rock formation and the picture of the black cat.

Experiment 3

3a The invisible target will be located on the floor of the Experimental Room *in a random place on every trial*; remember, the invisible target will always be in a random location on every test trial.

3b in a random location on every trial

APPENDIX A QUIZZES

NNS/NS

CG Arena Rule Comprehension EXP 1

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. How many different rooms will you see on the computer screen during this task?
   a. One
   b. Two
   c. Three
   d. Four

____ 2. In the practice room, all you should do is:
   a. Find the visible target and stand on it
   b. Find the invisible target and stand on it
   c. Practice using the arrow keys to move and look around the room
   d. Stand in one spot and don't move

____ 3. In the experimental room, your task is to:
   a. Find the target and stand on it
   b. Practice using the joystick to move and look around the room
   c. Stand in one spot and don't move
   d. Stand as close to the arena wall as possible

____ 4. The target is a _____ on the _____ of the experimental room.
   a. large blue square; floor
   b. small red circle; floor
   c. large blue square; ceiling
   d. small red circle; ceiling

____ 5. How many experimental rooms are there?
   a. One
   b. Two
   c. Three
   d. Four

____ 6. To go from an experimental room to the practice room, you should:
   a. Hit the space bar at any time
   b. Stand on the target
   c. Hit the space bar while standing on the target
   d. None of the above--you can't escape from the test room

____ 7. The invisible target in the experimental room:
   a. will always be in the same place
   b. flashes
   c. will become visible after one minute
   d. Both a and c

____ 8. In the experimental room, you have _____ amount of time to find the target.
   a. an unlimited
   b. a limited

____ 9. You will know you've found the invisible target when:
   a. The experimenter lets you know you've found it
   b. The computer screen goes blank
   c. You hear a bell and see a small red circle appear on the ceiling
   d. You hear a sound and see a large blue square appear on the floor

ANS/AS

CG Arena Rule Comprehension EXP 2

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. How many different rooms will you see on the computer screen during this task?
   a. One
   b. Two
   c. Three
   d. Four

____ 2. In the practice room, all you should do is:
   a. Find the visible target and stand on it
   b. Find the invisible target and stand on it
   c. Practice using the arrow keys to move and look around the room
   d. Stand in one spot and don't move

____ 3. In the experimental room, your task is to:
   a. Find the target and stand on it
   b. Practice using the joystick to move and look around the room
   c. Stand in one spot and don't move
   d. Stand as close to the arena wall as possible

____ 4. The target is a _____ on the _____ of the experimental room.
   a. large blue square; floor
   b. small red circle; floor
   c. large blue square; ceiling
   d. small red circle; ceiling

____ 5. How many experimental rooms are there?
   a. One
   b. Two
   c. Three
   d. Four

____ 6. To go from an experimental room to the practice room, you should:
   a. Hit the space bar at any time
   b. Stand on the target
   c. Hit the space bar while standing on the target
   d. None of the above--you can't escape from the test room

____ 7. The invisible target in the experimental room:
   a. is between the picture of the hoodoo rock formation and the black cat
   b. flashes
   c. will become visible after one minute
   d. Both a and c

____ 8. In the experimental room, you have _____ amount of time to find the target.
   a. an unlimited
   b. a limited

____ 9. You will know you've found the invisible target when:
   a. The experimenter lets you know you've found it
   b. The computer screen goes blank
   c. You hear a bell and see a small red circle appear on the ceiling
   d. You hear a sound and see a large blue square appear on the floor

RNS/RS

CG Arena Rule Comprehension EXP 3

Identify the letter of the choice that best completes the statement or answers the question.

____ 1. How many different rooms will you see on the computer screen during this task?
   a. One
   b. Two
   c. Three
   d. Four

____ 2. In the practice room, all you should do is:
   a. Find the visible target and stand on it
   b. Find the invisible target and stand on it
   c. Practice using the arrow keys to move and look around the room
   d. Stand in one spot and don't move

____ 3. In the experimental room, your task is to:
   a. Find the target and stand on it
   b. Practice using the joystick to move and look around the room
   c. Stand in one spot and don't move
   d. Stand as close to the arena wall as possible

____ 4. The target is a _____ on the _____ of the experimental room.
   a. large blue square; floor
   b. small red circle; floor
   c. large blue square; ceiling
   d. small red circle; ceiling

____ 5. How many experimental rooms are there?
   a. One
   b. Two
   c. Three
   d. Four

____ 6. To go from an experimental room to the practice room, you should:
   a. Hit the space bar at any time
   b. Stand on the target
   c. Hit the space bar while standing on the target
   d. None of the above--you can't escape from the test room

____ 7. The invisible target in the experimental room:
   a. will always be in a random place
   b. flashes
   c. will become visible after one minute
   d. Both a and c

____ 8. In the experimental room, you have _____ amount of time to find the target.
   a. an unlimited
   b. a limited

____ 9. You will know you've found the invisible target when:
   a. The experimenter lets you know you've found it
   b. The computer screen goes blank
   c. You hear a bell and see a small red circle appear on the ceiling
   d. You hear a sound and see a large blue square appear on the floor