Suppressing Visual Memories Through Executive Control

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Abstract

Forgetting is often perceived as the challenge one must overcome to have a good memory, when in fact, forgetting is actually an important component in maintaining a good memory. If people remembered everything from their daily lives they would become overloaded with unimportant thoughts, making it difficult to recognize relevant information. For example, if one remembered every parking place one's car had ever occupied it would become difficult to bring to mind only the current parking place. Irrelevant or intrusive thoughts can also be distracting and unpleasant. For these reasons the ability to push information out of mind can be a useful skill. For instance, if one's favorite restaurant changed location, one would benefit from pushing the memory of the old location from mind, so that one can more easily recall the new location. Being able to selectively forget is a useful component of memory that allows people to focus on, and thereby, facilitate retrieval of contextually relevant information from their surroundings. The current study, using the Think/No-Think (TNT) paradigm, attempted to determine how actively avoiding thought for a visual image would affect a person's ability to later recognize that item. The stimuli used were neutral words paired with complex visual-spatial pictures of faces or nature scenes. The results indicate that, relative to baseline memory performance, there is an overall inhibition of memory for items that were actively not thought about. These findings validate the hypothesis that actively avoiding thought of a picture leads to impaired recognition of that picture at a later time. Subjects' were less confident in their ability to recognize which word-picture pairs they had seen earlier. Actively thinking of a picture in some cases facilitated memory of that word-picture pair, but this was not consistent across all stimuli. These findings support the

everyday use of memory inhibition by indicating that humans are able to exert executive control over what they think or don't think about, which later influences what they remember. Choosing to avoid thinking about a picture, even when presented with its cue, leads to inhibition of that memory, making it harder to recognize at a later time.

Research suggests that humans have an inhibitory mechanism that can be recruited to help them suppress unwanted information. Through executive control humans can choose what they want to bring into consciousness, and remember, or push from consciousness, and later forget (Bjork et. al. 1998). Did you forget to take out the trash again? Maybe you didn't actually forget, but after repeatedly ignoring the undesirable task, your brain inhibited the thought so that you would not have to think about it. Memory suppression occurs in everyday life. We have to forget where we parked our car yesterday, and remember where we parked it today. If a person actively tried to remember everything that happened in their life their brain would be overloaded with information. Top-down modulation explains the human ability to selectively attend to important stimuli while ignoring irrelevant stimuli. The objective, in this study, is to determine what the effect of actively avoiding thought for a picture will have on a person's ability to later recognize that picture. In a further study, we hope to determine how and where in the brain top-down modulation affects memory for visual stimuli. Isolating brain regions responsible for attending, or suppressing unwanted visual memories may aid those suffering from Attention Deficit Disorder (ADD), Post Traumatic Stress Disorder (PTSD) or Depression.

In an experiment conducted by Michael Anderson and Collin Green (2001), at the University of Oregon, the ability to recall a word after it has been actively suppressed was studied. The Go/No-Go paradigm, which in past studies has shown that humans have executive control over their motor abilities (Casey et. al. 1997), was adapted in Anderson and Green's study to see if the same inhibitory mechanism could be utilized for retrieval of memories. Termed the Think/No-Think paradigm (TNT), subjects first

would learn pairs of words. Next, during the TNT phase, subjects would be instructed to concentrate on some word pairs intensively while suppressing other pairs. Baseline pairs were previously learned word pairs that were not presented during the TNT phase. Even though subjects were maintaining visual focus on the cue for the suppressed words, they were asked to try not to let the associated word enter consciousness at all. In the Final Test of Memory Ability a word was presented from one of the previously learned pairs, and the subject was asked to respond with the correct associated word. The results indicated that, relative to baseline memory performance, retrieving the word increased a subject's ability to correctly respond in the final test, which supported the hypothesis that actively retrieving an item would facilitate its later recall. The critical result, however, was that suppressed pairs showed the opposite effect: actively avoiding thought for the word decreased a subject's ability to recall that word at a later time, relative to baseline memory performance.

The results from Anderson and Green's (2001) study indicate that people are able to suppress word pairs through the use of executive control. To further confirm this theory they conducted a follow-up study to demonstrate that suppression of the target was in fact taking place, rather than unlearning the cue-target pair, or creating other diversionary associations to the old cue. This was tested by presenting the subjects with a new independent cue that was from a category semantically associated to the target word. If an inhibitory mechanism was being used to reduce the ability to retrieve the target word, then no matter what cue was given, the retrieval of the target should be impaired. The results indicated that even when presented with the independent cue, subjects' ability

to recall the target was still consistently below baseline. This helps to confirm that the target word was in fact being suppressed.

When subjects participated in the TNT paradigm task while their brains were being scanned using a Functional Magnetic Resonance Imaging device (fMRI), it was found that recruiting inhibitory mechanisms resulted in increased dorsolateral prefrontal cortex (DLPFC) activation, and reduced hippocamapal activation (Anderson et. al. 2004). The magnitude of forgetting of the word pairs could be predicted both by the prefrontal cortical and right hippocamapal activations. The localized neurological activations provide further support for the existence of an inhibitory mechanism that humans can recruit to induce forgetting. The conclusion from the Anderson et. al. (2004) study was that when people are presented with a cue to an unwanted memory, they are able to recruit an inhibitory mechanism that allows them to suppress the item. This indicates that humans have executive control of their memory. Humans are able to choose what they allow into consciousness, and therefore, what they remember at a later time.

Another related experiment conducted by Adam Gazzaley and colleagues (2005) at the University of California, Berkeley explored the effect top-down modulation has on the magnitude and speed of neural activity. Top-down modulation explains the human ability to selectively attend to relevant stimuli, while ignoring other distracting stimuli. This study focused on the brain mechanisms that allow for the increase in ability to recall attended items compared to ignored items. Pictures of faces and scenes were used, with an instruction to Ignore, Remember, or Remember Both (remember all stimuli presented). Gazzaley used fMRI and Event-Related Potentials (ERP) devices to capitalize on temporal and spatial resolution. The regions of interest in the fMRI analyses were the

Fusiform Face Area (FFA) and the Parahippocampal Place Area (PPA), which are regions in the brain that are active when coding for faces and scenes respectively. The first hypothesis stated that when instructed to remember specific stimuli there would be a modulation in the magnitude and speed of cortical processing in the area responsible for processing that type of stimulus. The results from the ERP showed a peak latency shift of 10 msec slower for faces that the subject was instructed to ignore compared to faces they were supposed to remember. This slightly longer time interval needed to retrieve ignored items indicates that the speed of cortical processing is affected by attention. To conclude, support for this hypothesis showed that both the magnitude and speed of cortical processing are affected by top-down modulation.

Gazzaley's second hypothesis investigated the existence of a modulation above (enhanced) or below (suppressed) baseline brain activity, dependent on the instruction given to the subject. In analysis of fMRI data nearly all subjects showed increased activity in the FFA and PPA for Remember Faces and Remember Scenes respectively, compared to Ignore Faces and Ignore Scenes. This indicates that top-down processing modulates the magnitude of activity in the FFA and PPA. In support of Gazzaley's second hypothesis it was found that relative to a perceptual baseline there was enhancement for Remember stimuli, and suppression for Ignore stimuli.

The third hypothesis was concerned with the idea that top-down modulation has a limited capacity, and enhancement would be compromised when the limit is exceeded. When asked to Remember Both sets of stimuli there was no significant difference between Passive View and Remember Both, which supports the third hypothesis, indicating that top-down modulation is resource limited. When asked to Remember

Both, humans are able to perceptually process all the information, but there is a lack of storage to remember everything that is presented to them due to competition from other items.

This current research study is a combination of Anderson's and Gazzaley's work. Anderson found significance for the executive control of memory by pairing words together (2001), and Gazzaley (2005) showed top-down modulation was used with pictures of faces and scenes. In the current study, the TNT paradigm was adapted by using a word paired with a picture of either a face or scene, in an attempt to see if humans were able to suppress visual memories through executive control when presented with a neutral word cue.

The expected results for this study were that when presented with a cue word, avoiding thought for the associated picture would decrease the person's ability to later recognize that picture, relative to baseline memory performance. In contrast, actively thinking of a picture would facilitate the person's ability to recognize that picture later. These results would further support the idea that humans have executive control over their memory, and would aid in the extension of this theory to now include executive control over visual memory when presented with word cues.

The ability to suppress words (Anderson, 2001) and pictures (Gazzaley 2005) has extended our knowledge about how the human mind is able to control what it remembers. A current study, conducted by Rhiannon Hart (2006), at Hampshire College, applied the TNT paradigm to emotionally infused visual stimuli. Hart conducted a two-part study including: non-neutral cue words, paired with neutral pictures of faces, and neutral words paired with non-neutral faces. Hart's results indicated that people were able to suppress

pictures of neutral faces and emotional faces. Subjects were especially able to recruit executive control when the cue word or the face had a negative connotation compared to a neutral connotation. These results suggest an important practical function, when, for example, a person has had a bad experience with another person, and a certain word makes them recall the face of the person. It would be beneficial to avoid the distracting or unpleasant face from coming to mind when presented with the cue word, and eventually reduce the chance that the cue would later bring the face into consciousness.

In another similar study conducted by Brendan Depue and colleagues (2006) at the University of Colorado at Boulder, the TNT paradigm was again adapted to be used with pictures of faces that were paired with emotionally valenced words. This study was an inverse of Hart's study, testing the recall of declarative word memories that had been paired with pictures. The results of Depue's study again showed that people have an executive control over what they remember, with further findings showing that these mechanisms were stronger for negative compared to neutral information.

Hart's and Depue's results help support the main focus of the present hypothesis that executive control for unwanted memories can be extended to include visual stimuli paired with words. The goal of the current study is to determine how the TNT paradigm could be utilized when subjects were presented with neutral cue words and pictures. There is often no real motivation outside the laboratory to avoid thinking about neutral items, so this study would give a more general view as to if or how people are able to recruit inhibitory mechanism to aid in their forgetting when presented with neutral information.

Method

Participants

The participants (n= 24) in this study were all native English-speaking students at the University of Oregon who participated in exchange for course credit. The age of the participants ranged from 18 to 21 with 6 males and 18 females. The experiment also required that subjects learn and remember 60 word-picture pairs, and then pay close attention for the entirety of the TNT phase, which lasted 39 minutes with only five 45 second breaks. There was consequently a study restriction against subjects with learning disabilities (ex. ADHD), or subjects who had any previous brain damage, including concussions, that could possibly compromise their ability to attend. The subject, also, could not be red-green colorblind, as words were colored in green and red, and differing responses were required with respect to the word's color. Subjects were excluded if they had less than five hours of sleep the night before their participation in the study, since this could affect their ability to attend to the stimuli.

Materials

The effect of top-down modulation was tested using a set of word-picture pairs. There were 24 experimental word-face pairs and 24 experimental word-place pairs, with 12 filler pairs as distracters. The words were 3-8 letters long, and were generated with respect to the Nelson Norms (1998) to make sure there was no confound of associated words. The pictures were photographs acquired from a study done by Gazzaley at University of California, Berkeley. They were grayscale images of neutral faces and natural places. The faces were blurred along the contours to reduce variability, and there were equal numbers of male and female faces. The pictures of nature scenes included an

equal number of mountains, water, trees or plains as the main focus. The seated subject was initially presented with 240 word-picture pairs, to familiarize them with all the words and pictures that they would be seeing throughout the study. During the learning phase, they were presented with 60 critical word-picture pairs on a computer in a quiet room. To test the subjects' ability to recognize the picture that was paired with the word for the Initial and Final Attention Tests, a computer keyboard were used. Once the testing on the computer had been completed, the subjects were given a questionnaire concerning their ability to complete the instructions requested of them. At the conclusion of the experiment, the subjects were given a debriefing form.

Procedure

Participants were recruited from the University of Oregon through the Department of Psychology online Human Subject Pool. When the subjects arrived for their scheduled study time, they were escorted to a room in Straub Hall and seated at a computer. They filled out a consent form, and the study was explained to them using a written script. This experiment was a two by three, between subjects experimental design: with the targets being a face or scene, and the conditions being baseline, suppress and respond. Each participant was presented with all the word-picture pairs, but the order in which the pairs were presented were randomized in blocks. There were eight blocks with six pairs in each, containing a baseline face pair, baseline place pair, suppress face pair, suppress place pair, respond face pair, and respond place pair. The exception to the blocked randomization was that at the beginning and end of the pair presentation task there were two filler pairs, to control for primacy and recency effects.

The first task subjects were asked to complete was a localizer task, so that when subjects in a later study were run in the MRI their baseline activation in the FFA when presented with pictures of faces, and PPA when presented scenes could be determined. This localizer task was also used to familiarize the subjects with all the words and pictures they would be seeing throughout the study. This familiarization was utilized so that later when testing the subjects' ability to recall the critical pairs, familiar pictures could be presented, that had already been paired previously with a word, as distracters to the correct associate. During the localizer the participants were instructed to carefully observe each of the 240 word-picture pairs, that were presented for two seconds each, and make a rating using the keyboard as to how difficult, moderate, or easy it was for them to make an association between the word and picture. The reason for having the subjects make a rating was to make sure subjects had their full attention focused on the screen during the nine minute long localizer presentation. After being presented with all the word-picture pairs, the subjects were then presented with the shorter, critical 60 word-picture pair list. Subjects were asked to study these pairs for the four-second period that each was presented, so that later when presented with the word, they could generate and bring to mind the picture that went with it. The next procedure was the drop-off phase, in which the subject was presented with the word for an unlimited time. They were asked to try to generate and bring to mind the picture that went with the word (testing their recall memory for that pair). If they were able to bring the correct picture to mind, when only being presented with the word, they would press the "yes" button on the computer keyboard. If they were unable to bring the correct picture to mind, when presented with the word, they would push the “no” button on the keyboard. After a recall decision had

been made, four picture options would appear on the computer screen for up to 4 seconds and subjects were asked to choose the correct associate picture as quickly as they could. They used the computer keyboard to push the key corresponding to the correct picture. If subjects said "yes" they could recall the picture and then chose the correct picture from the options presented, the pair would be removed from the list, however, if they said "no" they couldn't recall it, or chose the incorrect picture, it would remain on the list to be studied, and would be presented repeatedly until the subject was able to recall the picture from just seeing the word and choose the correct picture from the options presented. After the subject chose a picture from the options presented, the correct picture would be shown to the subject for a brief period to help reinforce their knowledge of the word-picture pair. After being able to bring the picture to mind and choosing the correct picture from the options provided for all 60 critical word-picture pairs, the subjects would move on to the Think-No-Think (TNT) phase.

During the TNT phase, only the words were presented; half of the words were green, and half were red. Baseline pairs were not presented during this phase. For the green words the subjects were asked to think about the previously learned associated picture the entire time the word was on the screen. For the red words the subject was asked to avoid thinking about the associated picture at all. They were asked to keep looking at and paying attention to the word on the screen the entire time, regardless of the color of the cue, but for red words they were not to think at all of the picture that was associated with it. If the associated picture did come to mind when looking at a red word, they were instructed to actively push the picture from their mind, and keep it out of mind. This phase lasted 39 minutes, with only five 45-second breaks for them to relax and rest

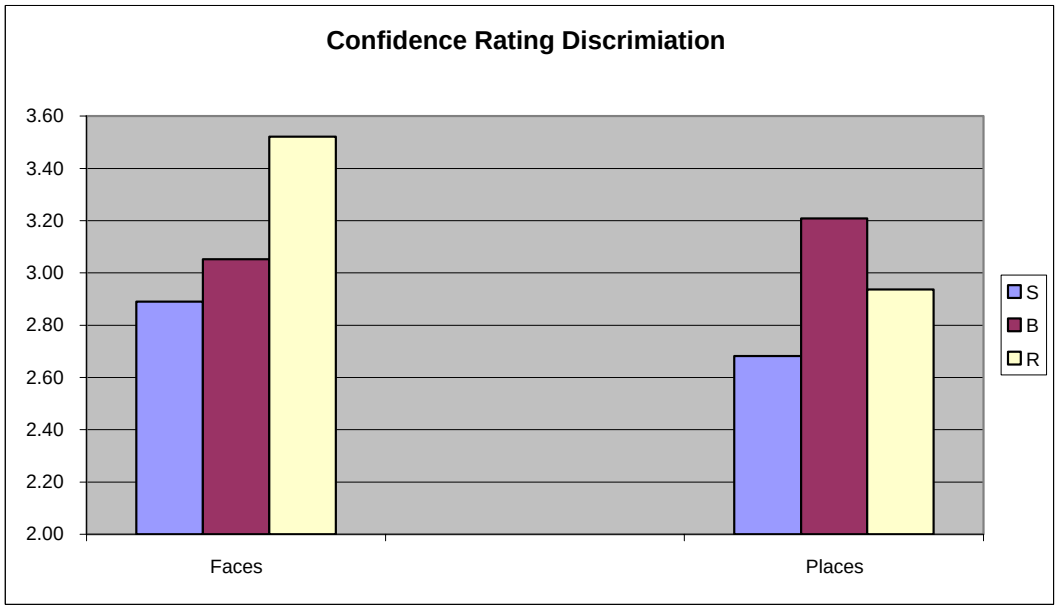
their mind. During the Final Recognition Test, following the TNT phase, word-picture pairs were presented. All of the words and pictures presented had been seen before, but some were pairs they had studied together before, and others had not been seen paired together previously. The subjects were instructed to make a rating on a 6-point Likert Scale as to their confidence that they had studied the exact pair together before, or if it was a newly arranged pair. They were to press the number key 6 on the keyboard if they were confident they had studied that exact pair before, that is, it was an old pair, 5 if they thought it was an old word-picture pair, but were less sure, and 4 if they thought they had seen the pair together, but were very unsure. They were to press 1 if they were sure they hadn't seen it as a word-picture pair, that is, it was a "new" pair, 2 if they thought they hadn't seen it as a pair, but were less sure, and 3 if they thought they hadn't seen it, but were very unsure. The data was analyzed to determine if there was a significant modulation above (enhancement) or below (suppression) the baseline for word-picture pairs.

Results

The analysis of the Faces and Places TNT Data Set was completed using an Analysis of Variance (ANOVA). The test was run using all three between-subjects factors: test order counterbalancing (two halves of final test), item counterbalancing (faces vs. places), and cue counterbalancing (word-face or word-place), and two within-subjects factors: stimuli type (faces/places), and condition type (suppression/baseline/ respond). The subjects' confidence for a pair was computed by averaging the ratings over all the items in a condition. When analyzing the confidence ratings, a correction was used for guessing: hits minus false alarms. A hit in this case was when subjects correctly

answered new or old for the respective pairs. The false alarms were when a subject rated a pair as old, or one they had previously studied, when it was in fact a new pair. The ratings were averaged to determine subjects' overall confidence in the final test pairs.

This confidence analysis showed a significant interaction between the stimuli presented (faces and places) and the condition type (suppress/baseline/respond), $F(2.24)=4.37$, $p=.02$. This significant interaction does not support the predicted hypothesis, indicating that the stimulus types are different depending on the condition types. The marginal means for suppress faces (M=2.89) was lower than the baseline faces (M=3.06), which was much lower than respond faces (M=3.52). Similarly suppress places (M=2.68) was much lower than baseline places (M=3.21), however, respond places (M=2.94) was also slightly lower than baseline places, which was an unexpected result. This is represented graphically in Graph 1.



Graph 1: Represented here are the corrected for guessing confidence-rating scores for each stimulus type separated into each condition type. (Legend- S: Suppression/No-Think Items, B: Baseline, R: Respond/Think Items).

There was no significant main effect for faces compared to places, $F(1,12)=1.95$, $p=.19$, with faces ($M=3.16$) being only slightly better recognized than places ($M=2.95$), indicating that there was no overall difference between the two stimulus sets. There was, however, a significant main effect for the within-subjects factor of condition type, $F(2,24)=9.49$, $p=<.001$, with suppress items ($M=2.79$), being much lower than baseline items ($M=3.13$), which was lower than respond items ($M=3.23$).

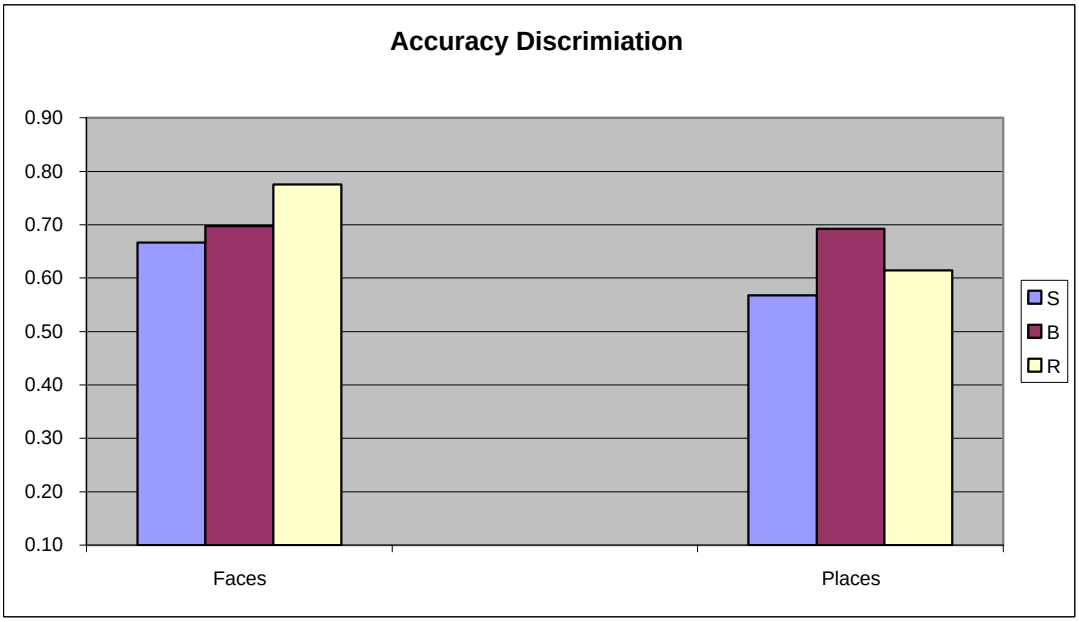
In support of the hypothesis, there was a significant difference between the ability to recognize suppress items when compared to baseline items when collapsed over both stimulus types, $F(1,12)=11.35$, $p<.001$. This indicates that actively trying to avoid thought for an item leads to impaired recognition of the item at a later time, when compared to baseline items. However, there was no overall facilitation, meaning that actively thinking of an image does not later facilitate one's ability to recognize that image, when baseline items were compared to respond items, $F(1,12)=.94$, $p=.35$. This does not support the idea that actively thinking about an item facilitates the person's ability to later recognize that item. When examining the suppression effect across stimulus type there was no significant interaction, $F(1,12)=1.45$, $p=.25$, indicating that inhibition does not vary with stimulus type, supporting the hypothesis that both types of visual stimuli can be suppressed. There was, however, a significant difference between faces and places for the facilitation of respond pairs above baseline, indicating a significant interaction, $F(1,12)=16.07$, $p=.002$. This suggests that the amount of facilitation varied significantly across the faces and places stimuli, showing that faces benefited from actively thinking about the face, while places did not show this facilitation effect.

When analyzing the data separately for each stimulus type, it was found that there was no significant inhibition for face stimuli, $F(1,12)=1.53$, $p=.24$, however, there was a highly significant facilitation above baseline for faces, $F(1,12)=23.20$, $p<.001$. The places showed the opposite effect, with a significant inhibition, $F(1,12)=5.56$, $p=.04$, but no significant facilitation for places, $F(1,12)=2.62$, $p=.13$. While this could be due to the variance in the baseline levels for each stimulus type, there was no significant difference between the baselines for faces compared to places, $F(1,12)=.65$, $p=.44$.

Another analysis of variance was conducted with the Faces and Places Data Set. The confidence ratings were converted into accuracy scores for this analysis that were corrected for guessing. If the subject rated a word-picture pair between 1-3 on the Likert Scale it indicated they thought the pair was new, or a rearranged pair, and was scored as a 0. If they rated the word-picture pair between 4-6 they thought the pair was old, or a pair they had seen and studied together before, and was scored with a 1. This measure provides an estimate of the percentage of the items that subjects correctly recognize. Overall, the accuracy score data looks similar to the confidence rating data with a few changes.

The findings with the confidence rating data showed a significant difference between faces and places for facilitation, which was unexpected; analysis of the accuracy scores showed less of a difference between stimulus classes, $F(1,18)=9.5$, $p=.01$, although still significant. The suppress faces ($M=.67$) was lower than the baseline faces ($M=.70$) which was much lower than the respond faces ($M=.78$). The suppress places ($M=.57$) was much lower than the baseline places ($M=.69$), but the respond places ($M=.62$) was

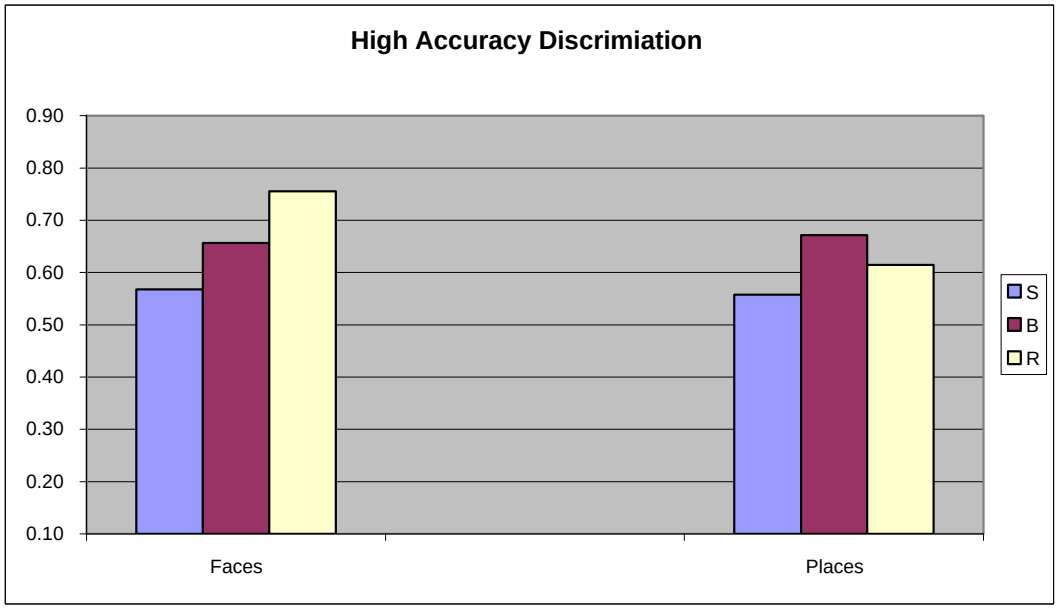
also lower. Using the analysis of accuracy scores the unexpected difference between the baseline and the respond condition for places shows a 7% difference.



Graph 2: Represented here is the percentage accuracy of subjects to correctly recognize pairs (corrected for guessing). (Legend- S: Suppression/No-Think Items, B: Baseline, R: Respond/Think Items).

The accuracy score data was analyzed further to exclude subjects' ratings of 3 and 4 on the final recognition Likert Scale. These middle ratings were to be chosen if the subject was "very unsure" about the word-picture pair, in a sense they were guessing whether the pair was new or old. When this exclusion was taken into account the analysis of the data showed that the suppress faces (M=.57) condition was now much lower than baseline faces (M=.66), which was much lower than respond faces (M=.76), indicating a very clear difference as a function of control. The suppress places (M=.56) was much lower than the baseline places (M=.67), which was still slightly higher than respond faces (M=.62). The interesting finding here was that by excluding the subjects'

"very uncertain" responses the suppression effect was now highly significant for faces, F(1,18)=8.93, P<.01, with a 9% difference between the suppress faces and baseline faces. By excluding the items on which the subjects were assumed to be guessing, both the suppression and facilitation effect was present for faces. Another interesting finding was that the respond places was getting closer to the baseline, indicated by a non-significant difference between the two, F(1,18)=1.65, p=.21, with only a 5% difference between baseline places and respond places. This result suggests that by excluding the low confidence scores, the strength of the unexpected lower respond for places is diminished.



Graph 3: Represented here is the high percentage accuracy score data, which excluded the "very unsure" subject ratings. (Legend- S: Suppression/No-Think Items, B: Baseline, R: Respond/Think Items). By removing the "very unsure" ratings from the accuracy score data, and only looking at the high confidence accuracy scores, there appears a significant suppression for faces below baseline, F(1,18)=8.93, P<.01. The unexpected lower respond places was less significant, F(1,18)=1.65, p=.21, indicating that by

excluding the low confidence scores the unexpected lower respond for places moves closer to what was expected.

Discussion

The results of this study indicate that people do have the ability through top-down modulation to recruit an inhibitory cognitive mechanism to help suppress visual images. This study confirmed the predicted hypothesis that actively suppressing a picture will inhibit a person's ability to later recognize that item. These results indicate that the TNT paradigm, developed by Anderson and Green (2001) with the use of word-word pairs, does in fact generalize to visual stimuli using word-picture pairs. In addition to being able to generalize the TNT paradigm to visual stimuli, this paradigm can also be applied to visual recognition. Anderson and Green (2001) used a cued-recall test in their initial TNT study, showing that suppression of words was possible when subjects were asked to recall the target word presented with the cue word. In the current study subjects were actually presented with the word-picture pair they had studied, and they were still less able to later recognize the pairs that they had actively suppressed. This finding indicates that inhibitory mechanisms generalize not only for reduced recall memory, but also in suppressing recognition memory.

The results of this study indicate a strong main effect for condition type, indicating that the three conditions: suppression, baseline and respond were not equal for recognition ratings. The results show a strong suppression effect for "no think" items over both classes of stimuli. Suppress items were consistently recognized less often for both faces and places relative to the baseline pairs. There was also a very strong facilitation for the "think" faces, indicating that actively trying to retrieve the face that

was paired with the cue word led to better recognition at a later time. Unexpectedly, the facilitation effect was not significant for places, with results showing that the places pictures were later recognized slightly less compared to baseline. This could have been because the baseline levels for faces and places, while not significantly different, did differ slightly. Overall, it seemed pictures of places were initially more memorable than faces, which was indicated by its slightly higher baseline level. The lowered baseline level for faces could have also led to the slightly lower suppression effect observed for faces. The lower memorability of faces was confirmed by the fact that removing the "very unsure" ratings that subjects gave in the final recognition test, and using only the scores for the ratings subjects were confident about, led to a very strong suppression effect for pictures of faces. This finding indicates that subjects were able to recruit inhibitory mechanisms for the word-face pairs that they initially learned successfully. Also, with the removal of the "very unsure" ratings, and using only high confidence accuracy data, the unexpected results were reduced in strength for the "think" places to only a 5% difference.

A follow up study to this behavioral pilot will be to run subjects in the University of Oregon's fMRI scanning device to determine the level of activation and location in areas of the brain that are recruited during memory suppression of visual stimuli. The activation levels will be compared to the passive localizer task that has already been designed into this study. The value of using pictures of faces and places is that there have already been many studies conducted that have localized the areas of the brain active when people view pictures of faces (Tong et. al. 2000) and places (Epstein et. al. 1998). The areas of importance in the brain for faces and places are the Fusiform face area

(FFA) and the Parahippocampal place area (PPA) respectively. Anderson and colleagues (2004) found that the magnitude of forgetting when subjects were presented with word pairs could be predicted both by the prefrontal cortical and right hippocamapal activations. If subjects are presented with pictures of faces and places it is expected that there will be modulated activation in the FFA and PPA respectively, in addition to the already localized neurological markers for forgetting.

Overall, it is quite intriguing that humans have executive control over what they choose to think about, and what they subsequently remember. Anderson and Green (2001) found that with the use of the TNT paradigm people could inhibit words, when paired with other words. Gazzaley and colleagues (2005) determined that with top-down modulation subjects could enhance or suppress pictures of faces and scenes. Hart (2006) and Depue (2006) generalized the TNT paradigm to include emotionally charged word and picture pairs. Finally, the current study has further generalized the TNT paradigm's effectiveness to include neutral word-picture pairs with recognition memory.

In the last five years there have been major advances in the way we understand the behavioral ability of humans to have executive control over retrieval of memories. To determine neurologically how and where this suppression of visual information occurs within the human brain could serve as an important step in understanding, and subsequent remediation of problems associated with visual memories. Determining the location in the brain where potential strengths and/or limitations in attending or suppressing visual stimuli exist could ultimately lead to assistance for those suffering from problems with Attention Deficit Disorder (ADD), Post Traumatic Stress Disorder (PTSD), Depression or Anxiety Disorders.

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