INTRODUCTION

• Multivoxel Pattern Analysis (MVPA) can quantify the specificity with which stimuli held in memory are represented in distributed patterns of brain activity.
• Despite its potential to characterize memory representation, however, MVPA has seldom been used in populations with memory disorders, and never in cases of amnesia.
• With the current study, we used MVPA to assess memory representation in N.C., an individual with developmental amnesia caused by a thalamic stroke he suffered in infancy.
• We tested N.C. and 19 age-matched controls on an fMRI paradigm for which they repeatedly viewed and recalled a set of 11 audio-visual film clips with diverse content. During recall, participants mentally replayed the cued video.
• First, we trained and tested a pattern classifier to identify videos from the stimulus set during perception trials. We predicted that N.C. and controls should not differ and used this measure as a baseline to validate our approach.
• Then, we assessed cortical reinstatement by training a classifier on perception trials and testing it on recall trials. We anticipated that NC’s classification would be reduced as a consequence of his poor memory.
• Finally, we trained and tested a classifier to identify videos during recall trials. Again, we anticipated poor classification in N.C., but we also investigated the possibility of compensatory patterns of representation in his brain activity.
• Our results validate MVPA as a tool that can characterize memory disorders, and provide novel markers of amnesia based on distributed patterns of stimulus representation.

METHODS

IN-SCAN TASK:
• N.C. and 19 control participants (5 M/14 F) alternated between viewing and recalling 11 short videos cued by a title.
• Viewing and recall trials were intermixed pseudo-randomly, and each clip was viewed and recalled 21 times in total.
• During recall, participants performed a “mental replay” of the cued video. Then, they rated the vividness of their mental replay on a 1-4 scale.
• Post-scanning, participants verbally recalled visual and auditory features about each video and then answered true-false questions about their content.
• N.C. is a 20 year old male who suffered a thalamic stroke at 10 days old. He has damage to the mediodorsal thalamic nucleus bilaterally (right > left) and to the right anterior thalamic nuclei. His right fornix is atrophied and his mammillary bodies are reduced in volume.

RESULTS

• We trained classifiers using Shrinkage Discriminant Analysis, a form of Linear Discriminant Analysis that relies on James-Stein type shrinkage estimators.
• The Perception Classifier was trained and tested on activity from perception trials. Unexpectedly, N.C.’s classification was superior to classification in controls.
• The Recall Classifier was trained and tested on activity from recall trials. N.C.’s classification was indistinguishable from classification in controls.
• The Cross-Condition Classifier was trained on perception trials and tested on recall trials. N.C.’s classification was inferior to classification in controls.
• To localize video-specific activity, we conducted searchlight analyses to compute classification accuracy within an 8mm sphere moved across the brain for each of the three classifiers (perception, recall and cross-condition).
• We contrasted searchlight classification maps between N.C. and the controls using an adapted t-test developed to contrast single cases to groups of controls.

RESULTS CONT’D

• To identify regions with video-specific signal that was not reinstated from perception, we subtracted the Cross-Condition searchlight map from the Recall searchlight map (Recall minus Cross).
• We identified such regions in N.C., but not in controls. A modified t-test identified several regions where the difference between recall and cross classification accuracy was superior in N.C. than in controls.

CONCLUSIONS

• Item-specific classification accuracy during repeated viewing was superior in N.C., an individual with developmental amnesia, compared to a group of healthy controls.
• This enhanced consistency for distributed neural signal at perception could reflect a lack of encoding, a lack of repetition suppression, or even possibly a lack of boredom with repeating stimuli.
• Accuracy for the cross-condition classifier trained on perception and tested on recall was a true measure of cortical reinstatement, the phenomenon by which activity elicited at perception is reactivated during retrieval.
• Cross-condition classifier accuracy was significantly reduced in N.C., a finding consistent with his impoverished memory content. However, the searchlight analysis did not localize this deficit in specific brain regions, possibly due to a floor effect and/or because N.C.’s reduced representation was better captured at the whole-brain level.
• Interestingly, classification based on whole-brain activity during recall was indistinguishable between N.C. and the controls. However, a searchlight analysis identified regions with significantly greater classification in N.C. than in controls.
• In N.C.—but not in controls—these regions contributed disproportionately to recall when compared to cross-condition classification, suggesting a compensatory pattern of representation that was not modeled on perception.

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