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HUMAN MEMORY: PERFORMANCE LINKED TO CHANGES IN BRAIN STRUCTURE AND FUNCTION

Findings explore complexities of how the brain learns, stores, and recalls information

WASHINGTON — New research released today provides insight into one of neuroscience's most intriguing mysteries: how the human brain learns and remembers. These studies — involving topics as diverse as musical memory, "change blindness," and attention deficit hyperactivity disorder (ADHD) — illustrate the profound influence that specific changes in either the brain's structure, function, or both, can have on human behavior.

The research findings were presented at Neuroscience 2011, the Society for Neuroscience's annual meeting and the world's largest source of emerging news about brain science and health.

Specifically, the studies released today show that:

- Two brain regions associated with personal recollections and obsessive compulsive disorder are larger in individuals with highly superior autobiographical memory, a rare condition that allows people to remember nearly every event of their lives (Aurora Leport, abstract 603.04, see attached summary).
- A German cellist with severe amnesia not only performs normally on a standardized test for musical memory, he is also able to acquire new musical information. The finding suggests musical memories are stored differently than other memories in the brain (Carsten Finke, MD, abstract 287.17, see attached summary).
- The phenomenon of "change blindness," the common inability to notice changes that occur right before our eyes, may result from a failure to consciously compare consecutive scenes, according to new research using a 100-year-old card trick (Luis Martinez, PhD, abstract 93.09, see attached summary).
- A key cognitive control area of the brain functions abnormally in children with ADHD — a factor that may make it more difficult for these children to perform in school (Tudor Puiu, abstract 93.13, see attached summary).
- The brains of postmenopausal, middle-aged women with cognitive complaints work harder when performing a working memory task than the brains of women without such complaints — a difference that may help identify those at risk for dementia (Julie Dumas, PhD, abstract 645.11, see attached summary).

"This research is helping us better understand the extraordinary complexity of what goes on in the brain as we're absorbing, and later recalling, information of all kinds," said press conference moderator Howard Eichenbaum, PhD, of Boston University, an expert on memory formation. "Such research will also help us develop more effective interventions and treatments for brain diseases and conditions that interfere with — and sometimes even destroy — our ability to learn and remember."

This research was supported by national funding agencies, such as the National Institutes of Health, as well as private and philanthropic organizations.

Related Presentation:

Nanosymposium: **Human Memory: Multivariate and Connectivity Studies**
Monday, Nov. 14, 8–10:45 a.m., Room 206

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Abstract 603.04 Summary

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Structural Differences Found in Brains of Individuals Who Remember Most Days of Life

Findings may deepen understanding of autobiographical memories

Imagine being able to remember, with great detail and accuracy, the days of your life. New research shows that individuals who possess this rare ability — called highly superior autobiographical memory (HSAM) — have differences in brain regions associated with autobiographical memory and obsessive compulsive disorder (OCD): the middle temporal gyrus and the basal ganglia. The findings were presented at Neuroscience 2011, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

"Our findings may help explain the extraordinary ability of some people to recall vast amounts of personally relevant information — details that span across most of their lifetime — without the aid of any mnemonic trick or technique," said lead author Aurora Leport of the University of California, Irvine. These findings may also explain why individuals with HSAM tend to express some OCD-like behaviors, such as germ-avoidance and hoarding. "Their obsession about their life memories and their need to organize those memories by the dates on which they occurred suggest that their superior memory ability and obsessive behavior may have some common neurobiological bases," Leport said.

The study used magnetic resonance imaging (MRI) to compare the brains of 11 people with HSAM with those of a group of control participants with average memory, revealing significant differences in the shape and size of brain regions that may contribute to participants' memory abilities.

"Those results suggest that the brain structures shown to be structurally different are probably contributing to our HSAM participants' phenomenal autobiographical memory abilities," said Leport. "The next step is to use functional magnetic resonance imaging to obtain a deeper understanding of how the brains of these individuals are functioning to form and retrieve autobiographical memories."

Research was supported with funds from the University of California, Irvine.

Scientific Presentation: Tuesday, Nov. 15, 11–12 p.m., Halls A–C

603.04, Highly Superior Autobiographical Memory (HSAM): An investigation of the behavioral and neuroanatomical components
A. K. LEPORT, H. ANSON, C. STARK, J. MCGAUGH, L. CAHILL; Neurobio. and Behavior, Univ. of California Irvine, Irvine, CA

TECHNICAL ABSTRACT: The study of memory operating at a superior level stands to enrich our understanding of its' dynamic nature. There are few investigations on superior memory leaving much to be explored about the neuropsychological functions underlying long-lasting vivid memories. A.J. is the first of twenty participants to characterize the phenomenon HSAM. She exhibits the ability to accurately recall vast amounts of autobiographical information spanning her lifetime, without the use of practiced mnemonics (Parker et al., 2006). The characteristics of the seemingly indelible nature of this populations' memory has been assessed by a comprehensive behavioral and neuroanatomical investigation. A cognitive battery, including both autobiographical as well as non-autobiographical memory tests, has been administered to compare behavioral differences between the HSAM population and controls, matched by age and sex. Results indicate that HSAMs perform significantly better at recalling personal autobiographical as well as public events and the days and dates these events occurred. However, they perform at an indistinguishable level on most short term, non-autobiographical laboratory memory tests. To explore the substrates supporting this ability we conducted a whole-brain morphological analysis comparing structural differences between the HSAM population and their controls. Neuroanatomical results indicate the left temporoparietal junction and left posterior insula, areas that appear to correspond with autobiographical memory, as being significantly larger. The insights into memory formation and retrieval afforded by this study could contribute to our understanding of the brain and how it supports autobiographical memory.

Abstract 287.17 Summary

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Cellist with Severe Amnesia Retains Memory for Music

Case study suggests musical memory may be stored differently than other types of memory

A case study involving a professional cellist who experienced catastrophic, permanent amnesia after an illness suggests that musical memory is stored in different areas of the brain than memories for facts and autobiographical information. The study was presented at Neuroscience 2011, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

"Despite severe amnesia, the patient's memory for music was remarkably intact," said senior author Carsten Finke, MD, of the Charité University Medicine Berlin. "Our findings suggest that the acquisition, long-term retention, and retrieval of semantic musical information is possible even in certain cases of severe amnesia."

The 68-year-old cellist, called P.M., had performed with a major German orchestra before herpes encephalitis destroyed parts of his medial temporal lobes in 2005. Those areas of the brain are crucial for the normal, healthy functioning of episodic and semantic memory. After the illness, P.M. could live only "in the moment," unable to recall facts or other information that had just been told to him. He was also unable to recall his own biographical details, and could not remember anyone other than his brother and full-time caregiver. However, when tested on basic musical skills, researchers found the cellist was able to identify the intervals, scales, rhythms, and metrics of various musical pieces. Most remarkably, he performed normally on a standardized test for musical memory. Further tests revealed he could also acquire new musical information.

"Musical memory seems to be stored independent — at least partially — of other types of memory," said Finke. "In addition, our observations in this case study suggest that music may provide a means of improving the neurological rehabilitation and quality of life of patients with severe amnesia, including patients with Alzheimer's disease."

Research was supported by Deutsche Forschungsgemeinschaft.

Scientific Presentation: Sunday, Nov. 13, 1–2 p.m., Halls A–C

287.17, Player with a single string - Preserved semantic musical memory in an amnesic professional cellist
N. E. ESFAHANI, *C. J. PLONER, U. A. KOPP, **C. FINKE**; Charité, Berlin, Germany

TECHNICAL ABSTRACT: We report the case of a 68 year-old professional cellist with dense amnesia but relatively spared semantic musical memory. Patient P.M. became amnesic following herpes encephalitis in 2005. Cerebral imaging showed extensive bilateral lesions mainly involving the left temporal lobe, the left orbitofrontal cortex and the right medial temporal lobe. Standard neuropsychological testing revealed a severe retro- and anterograde amnesia with scores of three to five standard deviations below average on most subtests of the Wechsler Memory Scale. General episodic and semantic memory seemed to be almost absent. For example, P.M. was unable to name any German river, federal state or historic event. In addition his ability to recall professional knowledge or events was severely compromised. He was unable to name composers, famous cello players or personal professional events. However, when we tested his perceptual musical abilities by means of the Montreal Battery of Evaluation of Amusia (MBEA), his ability to discriminate melodic and temporal variations was within normal range. Most remarkably, he also performed normally in the incidental musical memory test of the MBEA. To further investigate his semantic musical memory, we devised two additional memory tasks. In a first task, P.M. was asked to discriminate famous instrumental music composed before 2005, i.e. before the onset of his amnesia, from pieces of instrumental music composed after 2005. The pieces of music were closely matched for musical character and instrumental line-up. In a second task, we tested his ability to acquire new musical information. P.M. was presented excerpts of instrumental music composed after 2005, i.e. music that he supposedly had never played or listened to. P.M. was asked to evaluate the emotional character of the excerpts. Several hours later, these excerpts had to be discriminated from matched new excerpts. P.M. performed well above chance level in both tasks (correct recognition in task 1: 93%; task 2: 77%). Taken together, preservation of retrograde and anterograde semantic musical memory in patient P.M. suggests that acquisition, long-term retention and retrieval of semantic musical information is possible even in severe amnesia following temporal lobe damage. This case provides evidence that the neural networks sub-serving semantic musical memory are at least partially segregated from the neural correlates of semantic memory in other modalities.

Abstract 93.09 Summary

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Card Trick Reveals New Information about "Change Blindness"

Findings suggest visual short-term memory is highly volatile

Using a modern variation of a century-old card trick, researchers have uncovered new information about "change blindness," a normal brain phenomenon that obscures changes that occur right before our eyes. The findings were presented at Neuroscience 2011, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

From past research, it was unclear if change blindness results from a failure to create viable images of a scene's details or from a failure to compare two consecutive representations of a scene. The current study uses a method inspired by the classic "Princess Card Trick" devised by Henry Hardin in 1905. It found that items — cards or human faces — that lie outside our focus of attention are created, albeit passively, in visual short-term memory (VSTM). Change blindness, the findings suggest, results from a failure to consciously compare consecutive scenes.

The study also found this passive form of visual short-term memory to be very volatile. "The casual chitchat used by magicians to distract audiences can effectively interfere with and even completely abolish these short-term memories," said lead author Luis M. Martinez, PhD, of the Instituto de Neurosciencias de Alicante.

These findinsg suggest there might be a central element of VSTM that is shared by our other senses, acting as a "bottleneck" of sorts when we are trying to observe all the dynamics of a scene playing out visually before us.

Change blindness is helpful — most of the time. "It allows us to stay focused on important tasks while ignoring other things that might not be relevant to our current activity," explained Martinez. "Only when these 'other things' are really important is change blindness a safety risk: people being given the wrong medications at busy hospitals, say, or traffic accidents caused by overtaxed cab drivers."

Research was supported by the European Regional Development Fund and the Spanish Ministry of Education and Science.

Scientific Presentation: Saturday, Nov. 12, 1–2 p.m., Halls A–C

93.09, The fate of visual short-term memory during the time course of a magic trick
L. M. MARTINEZ, D. ALONSO-PABLOS, C. PONS; CSIC-Univ Miguel Hernandez, Sant Joan d'Alacant, Spain

TECHNICAL ABSTRACT: We are consciously aware of far less of our visual word than we think. Continuity errors, for instance, are common in movies. These types of mistakes often go unnoticed by audiences because of our poor ability to detect changes across successive visual displays; a phenomenon known as change blindness. In principle, change blindness could occur from a failure to form and maintain a viable representation of the objects in a scene or from a failure to compare the existing representation to the post-change image. Therefore, its study has important implications for our understanding of the mechanisms of attention, awareness, visual short-term memory (VSTM) and perception. Thus far, change blindness has been studied using variations of two alternative methods: either in laboratory experiments using protocols that allow control of attention but usually involve associated cognitive loads and many repeats, being therefore predictable and not very natural; or under more ecological conditions, outside the laboratory, which, in turn, make it more difficult to control for viewing, e.g. attended versus unattended, conditions. Here we introduce a new change detection paradigm, inspired by a modern variation of the classical "Princess Card Trick" devised by Henry Hardin in 1905, to study the interaction between attention and VSTM. Our results show that items, cards or human faces, which lie outside the focus of attention, are still stored in VSTM. Moreover, this passive representation of a visual scene is rather rich and, even though it does not give rise to conscious perception, it can be unconsciously retrieved and used in a forced-choice paradigm as efficiently as the previously attended objects. Thus, change blindness can result from the failure to consciously compare between two consecutive representations of a scene. On the other hand, this "passive" VSTM is rather labile and we show that patter, the casual chitchat used by magicians to distract audiences, can effectively interfere with, and even completely abolish, its contents. These results suggest that there might be a central element of VSTM that is amodal and that acts as the bottleneck of our capacity to represent visual scenes dynamically.

Abstract 93.13 Summary

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Brain's Key "Control" Area Functions Less Efficiently in Children with ADHD

Findings may lead to more effective learning strategies and therapies

An area of the brain that controls regions important in cognition functions abnormally in children with attention deficit hyperactivity disorder (ADHD), suggesting that their brains function inefficiently. The research was presented at Neuroscience 2011, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

For the study, researchers used functional magnetic resonance imaging (fMRI) to scan the brains of 19 children with ADHD and 23 children without it. The children, ages 7 to 14, performed a simple memory task that involved remembering letter sequences. An analysis of the data showed that the dorsal anterior cingulate cortex worked harder to control other brain regions in children with ADHD. Previous studies had shown this brain region to be abnormally structured in this population.

"Our findings suggest that the function as well as the structure of this brain area is different in children with ADHD," said study author Tudor Puiu, of Wayne State University. "We specifically found that this area must work harder to influence other brain regions during brief memory tasks. This need for greater control, even for simple tasks, suggests that the ADHD brain is inefficiently organized, and that these inefficiencies in turn may make it more difficult for affected children to perform in school."

The findings also suggest that learning strategies or therapies that enhance efficiency in this brain area may prove helpful to children with ADHD, Puiu added.

Research was supported by the National Institute of Mental Health.

Scientific Presentation: Saturday, Nov. 12, 1–2 p.m., Halls A–C

93.13, Disordered control by the dorsal anterior cingulate cortex during working memory in ADHD
T. PUIU[1], V. DIWADKAR[2], J. STANLEY[2], R. WHITE[2]; [1]Sterling Heights, MI; [2]Wayne State Univ., Detroit, MI

TECHNICAL ABSTRACT: Introduction: Attention Deficit Hyperactivity Disorder (ADHD) is a common disorder among children and adolescents (Qiu et al., 2010) affecting executive function, working memory and inhibitory control (Hale et al., 2007). Here we investigated control mechanisms in working memory by examining dorsal anterior cingulate cortex(ACC) modulation of corticostriatal networks in children and adolescents with ADHD and controls during the n-back. Methods: The experiment used 23 healthy control (HC) and 19 ADHD subjects. Conditions (0 or 1 back) were blocked in 30 s epochs interspersed with pure rest epochs (30s). The fMRI was conducted on a 3T Siemens Verio system using a 12-channel volume head coil (TR: 2.6s, TE: 29ms, FOV: 256mm2, acquisition matrix: 128x128, 36 axial slices, pixel dimension: 2x2x3mm3). EPI images were analyzed using standard methods in SPM8. Dorsal ACC modulation was assessed using psycho-physiological interaction (PPI; Friston et al., 1997). Results: During 1-back epochs, ADHD subjects showed decreased modulation in the superior parietal ($x=-24$, $y=-46$, $z=40$; $p<0.001$, $t=3.08$) and inferior temporal regions ($x=58$, $y=-30$, $z=-21$; $p<0.001$, $t=3.36$) by the dorsal ACC when compared to healthy controls. Conclusion: This evidence of disordered modulation by the brain's principal control region, the dACC in ADHD suggests reduced integrity of network interactions. Reduced control may reflect an inability of the ADHD brain to manage resources in the context of tasks with non-trivial demands.

Abstract 645.11 Summary

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Increased Brain Activity Found Among Middle-aged Women with Cognitive Complaints

Findings may lead to the earlier identification of people at risk for dementia

Middle-aged women who complain of cognitive difficulties after menopause use more brain areas to successfully complete a working memory test, compared with similarly aged women without cognitive complaints. This new finding was presented at Neuroscience 2011, the annual meeting of the Society for Neuroscience and the world's largest source of emerging news about brain science and health.

Researchers, led by Julie Dumas, PhD, of the University of Vermont, compared postmenopausal women with and without cognitive complaints. The women performed similarly on a working memory task. Those with cognitive complaints, however, had greater activation in two areas of the brain's frontal lobe that are involved in performing attention and memory tasks: the dorsolateral prefrontal cortex and the anterior cingulate cortex. Both of these areas are also affected by aging.

"This finding suggests that the women with cognitive complaints were recruiting additional brain regions in order to perform the memory tasks as successfully as the non-complainers," said Dumas.

For the current study, 22 postmenopausal women ages 50 to 60 completed a series of questionnaires about memory and other cognitive complaints. Data from those questionnaires identified 12 of the women as "cognitive complainers." All the women were then given a working memory test while their brains were scanned using functional magnetic resonance (fMRI).

"We believe our data show that women with cognitive complaints have brains that function like an older group of people," said Dumas. "This finding is important because other research involving older groups of participants has suggested that the presence of cognitive complaints may be a risk factor for developing dementia. If we can identify these people at a younger age, perhaps Alzheimer's disease prevention measures will be more effective," she said.

Research was supported by the National Institutes of Health and Department of Energy.

Scientific Presentation: Tuesday, Nov. 15, 3:30–3:45 p.m., Room 201

645.11, Increased frontal activation during working memory performance in postmenopausal women with cognitive complaints
J. A. DUMAS[1], A. M. KUTZ[1], A. PFAFF[1], M. NAYLOR[1], P. CASSON[2], P. NEWHOUSE[1]; [1]Psychiatry, [2]Obstetrics and Gynecology, Univ. Vermont, BURLINGTON, VT

TECHNICAL ABSTRACT: Cognitive aging research has begun to focus on cognitive changes in middle age in an effort to identify adults who are at a higher risk of developing cognitive deficits. One group of subjects who are at increased risk for pathological aging are those who report subjective cognitive complaints but perform normally on neuropsychological tests. Prior studies have shown older adults with cognitive complaints have morphological and functional changes relative to older adults with no complaints (Rodda et al. 2010; Saykin et al. 2006). No study has thus far examined the presence and functional consequences of cognitive complaints in a middle aged sample of subjects. Twenty two postmenopausal women aged 50-60 completed a cognitive complaint battery of questionnaires (Saykin et al., 2006). Twelve women were categorized as cognitive complainers because then endorsed more than 20% of the items on the cognitive complaint battery and ten were non-complainers. All subjects then took part in a functional MRI scanning session during which they completed a visual verbal N-back test of working memory. Results showed no differences in working memory performance between complainers and non-complainers. However, complainers had greater activation ($p < .01$) in the dorsolateral prefrontal cortex (BA 9) as well as in the anterior cingulate cortex (BA 32) relative to the non-complainers. We interpret this increased activation as compensation in the complainer group such that they recruited additional brain regions to perform the task at the same level as the non-complainers. This is the first study to show functional activity changes in cognitive complainers in a middle aged group of women.