Synopsis of "Preserved Neural Correlates of Priming in Old Age and Dementia" by Cindy Lustig and Randy L. Buckner (2004)

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Introduction. The most devastating aspect of Alzheimer's disease and other forms of dementia is the tell-tale destruction of explicit memory. It eats away at our stories, our independence, and the very things we take solace in after senescence has invaded. And while there is no cure, implicit memory may be a viable loophole that allows us to find alternatives, more effective treatments, and therapies to help older individuals reclaim their lives. Lustig and Buckner's 2004 paper, *Preserved Neural Correlates of Priming in Old Age and Dementia*, is one of the most important papers that examines this specific possibility.

Lustig and Buckner presented youth, older adults, and individuals with dementia with word lists. They asked them to make semantic judgements (of novel and repeated words) while performing fMRI scans to examine B6, 44, 45, and 47. They found implicit priming was strong in all three groups despite dementia subjects demonstrating a significant decline in explicit recognition. In addition, they found older adults had great activation in B45 and 47 and B44 and 6 along the left frontal gyrus, suggesting older groups compensate with visual processing areas and bilateral recruitment. In short, their study provided evidence that, despite significant confusion and debate in the field, implicit therapeutic and care methods could be viable options for older individuals with dementia.

Background. Behavioural repetition priming is considered an indicator of incremental learning, but what does that all mean? Memory and learning are believed to be mediated by many neural systems (Gotts, 2016). Medial temporal lobe structures like the hippocampus are thought to be vital in episodic memory, but the neocortex holds conceptual knowledge stored as perceptual representations, which are organized in conceptual categories. The various memory systems then work in tandem to access and adjust these representations to improve task performance. This is where incremental learning becomes important. Each time you have an experience, incremental learning refines the neural representation of that experience and its associated knowledge through synaptic plasticity. It is believed that these small variations make the representations richer, stronger, and more accurate, as well as prevent knowledge base

degradation and interference with other representations that it may overlap with.

Repetition priming is an automatic process that makes completing tasks faster and more accurate with repetition (Gotts, 2016). It occurs with many sensory modalities, is long-lasting, requires few repetitions to begin, and is accurate even when the task is poorly recollected explicitly or the tasks are completed with small variations in stimuli or examples. And previous studies on the topic have found evidence that it involves long-term memory and learning to some degree, as well as perceptual and conceptual knowledge. Curiously, however, neural activity declines once priming begins.

Researchers are not sure why or how neural activity declines with priming (Gotts, 2016). Called repetition suppression, there are five theories behind the phenomenon:

- Facilitation Model - Repetition causes neural responses to begin and end earlier.
- Synchrony Model - Repetition allows the cells to fire synchronously.
- Perceptual Model - The firing rates of the cells involved become more finely tuned, relying less on sensory systems.
- Predictive Coding Model - Priming improves the feedback loop, which uses sensory information as "evidence" and "predictions" from higher cognitive processes, resulting in more accurate predictions.

As mentioned previously, dementia and diseases like Alzheimer's attack an individual's explicit memory, but implicit processes remain intact, at least in the earlier stages of the disease. We didn't always believe this, however. Early studies in this area showed evidence that both processes were impaired (Fleischman & Gabrieli, 1998). As research continued, however, evidence began to show mixed results. Why? Power, participant characteristics, and the tasks they chose.

In many instances, researchers failed to have enough participants or failed to include young individuals or amnesia patients who have their implicit processes in place. The nature of the disease also means it's difficult to get a group of participants with consistent cognitive decline. Lastly, the nature of the tasks chosen was also historically problematic (Fleischman, 2007). In many instances, tasks that outwardly appear to rely on intrinsic processes actually made use of extrinsic processes at some points during testing or were the result of inadequate initial-stimulus

processing (Backman, Almkvist, Nyberg, & Andersson, 2000). Once these errors were addressed, however, it became clear that implicit processes in dementia patients were equivalent, or at least similar, to older individuals without the disease.

Research Questions and Hypothesis. Lustig and Buckner (2004) had one hypothesis: Do the effects of repetition and priming persist into old age and the early stages of dementia-like diseases? And if so, are these techniques worth exploring regarding cognitive training, therapies, and rehabilitation? To answer this hypothesis, Lustig and Buckner asked a series of questions:

- Are repetition-related response time priming and activity reductions preserved in old age and with dementia?
- Do early visual and motor regions show group differences in overall activation?
- Do reductions in the left prefrontal cortex activation correlate with reductions in behavioural response time?

Methods. To find answers to their many questions, Lustig and Buckner divided 91 participants into three groups: university students, older adults, and older adults diagnosed with dementia. Then, structural imaging was completed, followed by two block-design runs of a semantic classification task on novel words. Next, participants were given a recognition test for previously studied words, a twelve-item semantic classification task, and two rapid event-related runs, which included a study phase where words were presented and asked to determine if they were living or nonliving things. The event-related fMRI run was a semantic judgement task comprising new and previously used words.

Results. Lustig and Buckner found that all groups could classify words above chance. They all showed significant repetition effects regarding time and activation in controlled verbal processing areas (Broadmann's areas 45 and 47 and Broadmann's 44 and 6). When it came to recognition, the dementia group struggled compared to the old and young groups, as expected, proving that implicit priming effects were robust despite having inhibited explicit processes.

Next, they compared neural activity for new and repeated words in all three groups. Older adults showed greater activation, which the researchers believed was associated with slower response times. However, activity in B 45/47 was not significantly different across groups. B

45/47 and B 44/6 both showed strong repetition effects. As mentioned in the study, older adults often show increased activation in the right prefrontal regions on verbal tasks compared to young adults. And indeed, the study found group differences in the right B 44/6 similar to those found on the left. They found activation increased with the old and dementia groups, but this increase was only significant when compared to the young group, suggesting the increase is an effect associated with normal aging.

The comparison of the right and left B 44/6 regions provided evidence for increased activity and bilateral recruitment in older adults, with the increased recruitment of the right hemisphere proportionate to the increase on the left by older adults. Analysis of the visual cortex, B 17/18 and motor cortex found no real repetition effects, which is typical. Finally, when looking for reductions in left prefrontal cortex activation, the researchers found the activity and behavioural response times were similar across all three groups. The relationship between neural and behavioural repetition effects was preserved.

In summary, individuals with dementia still demonstrated strong implicit memory and priming effects similar to that of younger adults, which was backed up by decreases in left frontal cortex activity. Older adults had significant frontal activation for repeated words, while young adults did not. Each group showed strong priming and repetition effects, showing high-level, controlled processes can benefit from learning in old agefrontal activity correlated with repetition-related changes in response time. To provide further evidence, individual differences in behavioural benefits of repetition were linked to individual differences in brain activity modulation.

Conclusion. Lustig and Buckner showed that older individuals and those with dementia still demonstrate repetition-related effects in terms of response time but were also able to tie these benefits back to specific frontal cortex regions. They found these benefits were associated with increased activity in these regions. Visual and motor regions showed no significant increase in activation, so they could conclude that the benefits they were seeing were not a result of modality or sensory processing. Lastly, via evidence collected regarding frontal-mediated controlled processes and neural patterns, the authors found that older adults and those with dementia were still able to learn.

These findings have three important implications. First, the authors noted priming deficits in older groups when processing tasks changed from the study to the test phase. This deficit increased when the test task required changes in controlled, strategic processing. This is important to note for future studies of this sort and when creating aids, therapies, and other supports for older individuals.

Secondly, this study not only showed that priming effects remained for dementia and older adults in terms of response times but was able to correlate those improvements with specific frontal brain regions. The authors mention that these effects could result from compensatory recruitment since older adults have greater activation in the frontal cortex than younger study participants. In addition to providing a small insight into how the brain's plasticity may play a role in compensating for damage to these systems, it also provides hope to individuals with frontal lobe damage, particularly regarding treatment or alternative learning options.

Lastly, the findings presented in the Lustig and Buckner paper have significant implications for treating and caring for older individuals, dementia patients, and those living with frontal damage. They note that environments, aids, therapies, and other supports that can reduce the reliance on controlled processing by focusing on the task structure have the potential to be the most effective. The researchers noted that the improvements associated with high-level cognitive processing occur regardless of whether the words were seen or heard. This provides individuals seeking to provide care, guidance, therapies, and aids to older individuals and dementia patients with the ability to do so using different methods without worrying about reducing the priming effect and inhibiting learning. Perhaps most important of all, the study showed that dementia and older adults continue to have at least some plasticity and an ability to learn, provided the tasks help them to compensate for higher-level and explicit processes. And that, at least, is a little bit of hope.

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