Processing of novelty and familiarity in the aging brain

VI.8. Impact Paragraph

The ability to respond to distinct, unusual, or new stimuli is an instinct that drives the unconscious sensory-based and continuous exploration. Thus, from an evolutionary perspective identifying something as new is essential for learning, adapting to changes, and survival. According to research, newborns show an orienting response, as they automatically direct their attention to stimulus novelty. However, evidence also shows that infants do not always favor new over old things. Such old-new shifts remain as we get older and wiser. For example, we are naturally drawn to anything outside the status quo. Also, we often fancy the new at the expense of the old. Other times, we stick to old run-in routines, which offer convenience and stability. Despite decades of research, it remains unknown and highly debated which type of information, old or new, is preferentially processed by the brain. This is especially true for stimuli that have likely not been seen outside an experimental context.

Considering the above, the main objective in the current work was to investigate the behavioral and electrophysiological processes underlying old/new recognition of pre-experimentally unfamiliar abstract figures and non-words in a set of five experiments. Specifically, the goal was to examine the role of memory strength and age in such processing. Memory and novelty detection have both previously been shown to rely on the cholinergic system of the brain. The cholinergic system comprises nerve cells, such as muscarinic and nicotinic receptors, that use the neurotransmitter acetylcholine when communicating with each other. Aging is associated with deficits in cholinergic neurotransmission. Thus, we also tested whether cholinergic modulation with the muscarinic type 1 receptor antagonist drug, biperiden, could pharmacologically model the memory impairment of healthy elderly. To find out the answers to these questions, we used a memory paradigm with abstract figures and non-words. First, the

participants were asked to redraw the abstract figures and mention existing rhyming words for the non-words. Afterward, they had to memorize the presented items without any additional tasks. Here, the items from the first phase were repeated and mixed with some new ones. Finally, they were shown the before seen, old items mixed with some previously not presented ones. Their task was to decide if the presented stimulus was familiar (old) or not (new). Repetition and the drawing/rhyming task created strong memories, while simply memorizing the items led to weak memory formation. This way, we could manipulate the strength of the different item memories. Both healthy young and old adults performed the tests.

Every experiment has shown that people were better at recognizing something as 'new' than 'old'. However, this was only true when the familiar items relied on weak memories. In contrast, when the familiar stimuli were memorized via drawing or rhyming words, they could be recognized as 'old' just as good as the new items were identified as 'new'. These findings were consistent in the young, elderly, and when we used a pharmacological manipulation. It also did not matter whether the items were pre-experimentally familiar words and figures or were utterly new and likely never before seen abstract figures and non-words. Therefore, we concluded that a particular memory's strength plays a vital role in how well one can distinguish new from old. Furthermore, the behavior and the brain activity were different for the different stimuli. For example, when the brain distinguishes between the new and the weakly embedded abstract figures, the event-related potentials associated with familiarity (FN400) and recollection (P600) are missing for the weak memories. On the other hand, when the brain accurately recognized the strongly embedded non-words, there was an increase in the memory-related P600 component compared to the studied and new items.

Concerning the impact of healthy aging, we found that the seniors were impaired in identifying the new stimuli correctly and had difficulties with discriminating the old abstract figures. However, age did not affect the processing of the non-words. Thus, these findings indicate that processing problems in aging can differ for visual and verbal stimuli. In contrast to the expectations, the biperiden-induced effects showed the opposite pattern. Namely, the drug impaired old item recognition while leaving correct identification of the new stimuli unaffected. Thus, it can be said that biperiden could not adequately mimic the memory deficits of the healthy elderly.

The presented results clarify the dispute on how the brain discriminates old information from new and how aging affects such processing. These findings extend current knowledge on how we process and respond to pre-experimentally unfamiliar abstract figures and non-words. Abstract figures and non-words hardly involve semantics, thus verbalizing what we see or experience. Therefore, knowing how the brain processes these items can improve our understanding of visual, lexical, and orthographic memory processing and contribute to establishing relevant aging models. Furthermore, the current findings are useful for addressing how novel and familiar information can be effectively presented in recognition memory paradigms. The presented findings can also explain why, in some situations, old information is less accurately processed than new. The stakeholders for this aspect are a broad spectrum of clinical and non-clinical psychologists.

Moreover, the effects of aging on new item identification show a possible direction for developing new drugs that could improve somebody's cognitive performance. It seems wise to consider other drugs that, for instance, target the brain's dopamine system to improve our ability to react to new information. Such assumptions make sense in light of findings showing that stimulus novelty engages the brain's dopamine-mediated reward centers. Nevertheless, this bears

future research. It could also benefit patients with brain disorders such as schizophrenia, dementia, or Alzheimer's disease. Namely, in these conditions, next to the fact that memory is impaired, both the cholinergic and the dopaminergic brain systems play an essential role. Thus, the results could shed better light on the cognitive impairments these patients face, which could ultimately provide improved means for adequate diagnosis and treatment options. It is noteworthy mentioning that life quality is a crucial factor in general and psychological well-being, especially with increasing age. Also, the number of demented patients is expected to increase substantially in the coming decades, putting much pressure on the healthcare system and the caregivers.