Psychophysical investigations of perceptual learning and attention

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Knowledge Valorization
Relevance

Learning and memory are a fundamental part of human life. Lesion-induced memory impairments, such as those of Henry Molaison, more commonly known in the scientific world as H.M., impressively illustrate how big a part they actually play. Importantly though, lesions have also contributed to the insight that there is not just a single memory type. Instead, a distinction is made between explicit and implicit memory. Each type is again subdivided into several subtypes, and for implicit memory one of these is procedural memory, which involves the acquisition of skills. Skills can be related to different domains or combinations of them, namely cognitive, motor, and perceptual. Perceptual learning, in turn can relate to any of the five senses, visual olfactory, somatosensory, and gustatory. In the present thesis we focused on visual perceptual learning and attention. Given the above classification of memory, it becomes obvious that visual perceptual learning is just one small fraction of the memory concept. This is not to say that perceptual learning is unimportant though. As almost any leisurely, educational or professional activity one performs relies on one or more skills (see General Introduction), it is important to acquire more knowledge about visual perceptual learning but also skill learning in general. A considerable part of education at school (languages, mathematics, sciences) relies heavily on skill learning which in itself makes skill learning a very important and relevant domain of cognitive neuroscience.

To whom are the research results of interest?

The empirical work presented here first and foremost was aimed to acquire fundamental knowledge about visual perceptual learning, the nature of underlying neural networks and processes, as well as the relationship between attention and microsaccades. Therefore, the findings presented here are mostly of interest for researchers in the field of skill learning, memory, and attention. The results might, for example, inspire further empirical work regarding computational modeling of the visual system.

Besides, our findings might also be of interest for policy makers in education. Findings about specificity/generalization (Chapters 2 and 3) and interference (Chapters 4 and 5) in the domain of visual perceptual learning might have general
relevance for the organization of teaching in schools and universities, and for professional training in professions requiring specific skills. We have shown that interference occurs even for strictly sequential training (*Chapter 4*) and with unattended/unperceived stimulation (*Chapter 5*). In essence, our data show that a re-activated memory trace under some conditions can be erased by additional learning (interference), whereas in other conditions additional training strengthens or refines the memory trace. In the laboratory situations we used, and using simple tasks, we managed to control when strengthening vs. erasure occurred. It is therefore an interesting question in real-life learning tasks in schools or professional environments which conditions need to be created to strengthen learning, and which conditions should be avoided to avoid interference. That question is however very challenging as the number of relevant factors in complex environments and complex learning tasks increases by orders of magnitude. It will be necessary to gradually build up the complexity of skill learning tasks to approach real-life tasks to achieve a better understanding of learning conditions that could either enhance or interfere with real-life learning.

Our findings may also have clinical relevance. It has been suggested that some visual deficits can be counteracted by training. In the visual domain, it has been suggested that visual perceptual learning might be used in the treatment of amblyopia (e.g., Chen, Chen, Fu, Chien, & Lu, 2008; Fronius, Cirina, Cordey, & Ohrloff, 2005; Levi & Polat, 1996; Li, Provost, & Levi, 2007; Zhou et al., 2006), a developmental abnormality that is caused by physiological alterations in the visual cortex (Kiorpes & McKeet, 1999). This condition can be ameliorated by training in human children and adults (Kandel, Schwartz, Jessell, Siegelbaum, & Hudspeth, 2012). As research has shown that visual perceptual learning results in performance improvements that have been reported to remain stable for years (Karni & Sagi, 1993), it is at least worth to investigate further in how far perceptual learning can be used to aid/speed up conventional amblyopia treatment such as patching the good eye (for a critical review see, Levi & Li, 2009). The idea of training has been demonstrated to be useful as well in recovering from stroke (e.g., to overcome partial paralysis or impairment of language) (Meinzer, Elbert, Djundja, Taub, & Rockstroh, 2006; Taub, Uswatte, & Pidikiti, 1999), and in preventing maladaptive
topographic remapping after amputations (Chan et al., 2007; Ramachandran & Altschuler, 2009). Although far removed from the experiments performed in the thesis, the theoretical idea of reactivating memory traces and then deleting them by imposing interference (either behaviorally or pharmacologically) has been used successfully in combating phobia’s and psychological trauma (Kindt, Soeter, & Vervliet, 2009; Soeter & Kindt, 2011). One might speculate whether such approaches might also be useful in combating maladaptive or pathological habits (such as neurotic behaviors or addictions). Given the fact that basal ganglia/striatum have been implicated both in habit learning and addictions this idea is not too far-fetched, but as indicated in the previous section, much fundamental research is required before applications will come in sight.

**What can result from the research findings?**

As emphasized above, the studies in this thesis were conducted to obtain more knowledge about perceptual learning and attention, and did not anticipate any concrete products, services, processes, activities or commercial activities. The field of perceptual learning is a rather small niche in the field of cognitive neuroscience. Our research aims at learning about perceptual learning - simply because we want to understand how it works. If, as is the case with amblyopia, treatment opportunities arise from such research that is marvelous. But one should not be ignorant about the fact that most of the time fundamental science comes before applied science, and that the ways in which fundamental science leads to applications are almost always complex, dependent on convergent insights from uncountable studies, and simply unpredictable. This is why the across-the-board requirement to write a valorization chapter by Maastricht University is hard to understand – it suggests that the leadership of our university understands neither the value of fundamental science nor its complex relationship with societal and economical applications. Fundamental science constitutes one of the noblest human endeavors – the curiosity to gain deep understanding into all that surrounds us including other humans - and as such is highly intrinsically valuable. Whether or not there is a potential for material or monetary gain or any type of societal impact should be irrelevant. The better universities defend this academic view of science against various political pressures,
the richer science will be and the better chances will be for beneficial applications. Writing a ‘valorization chapter’ and treating fundamental science as something that it is not, as Maastricht University now requires from its PhD students, certainly is not creating applied value. It is just a waste of valuable time.

References


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