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# Development and training of higher order cognitive functions and their interrelations

**AKADEMISK AVHANDLING**

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av

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# ABSTRACT

Inhibitory functions (IFs) and working memory (WM) are essential for higher order cognitive functions such as non-verbal reasoning (NVR). WM is the ability to temporarily store and process information. IFs involve resisting automatic, inappropriate responses and limiting the interference of information held in WM. Deficits in them are associated with learning difficulties and Attention Deficit Hyperactivity Disorder. The behavioral link between IF and WM has been well established, whereas the neural correlates have not. Studies have shown that it is possible to train WM in school-aged children and adults and that effects can transfer to measures of IFs and NVR. Training efforts on IFs have been sparse, with no improvements on WM demonstrated. NVR training has mostly involved strategy learning and has not been reported in preschool children. The aims of the thesis were to study: the relation between WM and IFs (**Study I & II**), the effects of targeted cognitive training of either: WM (**Study II & IV**), IFs (**Study II**), NVR, or both WM and NVR (**Study IV**) on preschoolers and finally, the effects of musical practice on WM and NVR (**Study V**).

**Study I** reports that IFs and WM rely partly on activation of the same brain areas. Results showed an overlap in the right inferior frontal and, at a lower threshold, the right middle frontal gyrus and right parietal regions. **Study II** aimed to investigate whether training either IFs or WM would lead to improvements on the functions themselves and one another. This was studied in preschoolers, where individuals practiced either IFs or WM tasks 5 days/week for 5 weeks. The visuospatial WM training led to improvements on a verbal WM task and measures of sustained attention, whereas IF training led to improvements on trained tasks only. **Study III** aimed to increase the precision in which WM can be measured in low capacity individuals. This was done by testing 4- and 6-year-olds on multiple items of a WM span task, extracting the item difficulties, explaining their difficulty with logistic regression, and finally arranging selected items into sub-levels, thus increasing the possibility for further differentiation between abilities. **Study IV**, explored if WM and NVR could be trained respectively and elicit transfer effects to the other function, and whether training them together would result in benefits exceeding those expected. WM training increased WM capacity and NVR training improved fluid intelligence as well as a measure of WM. Training both functions improved both domains, but only at the expected level. **Study V** investigated the link between playing a musical instrument and cognitive benefits in a longitudinal design on individuals aged 6 to 25. Results showed that music practicing individuals showed a steeper development of visuospatial WM and NVR ability, and that this development was associated either with the type of instrument practiced (for NVR) or the number of hours per week they practiced (for WM).

These results illustrate that even though relations between cognitive functions are established, training or development of one does not automatically generalize to the others. Task requirements and appropriate load may be key differentiators between successful and non-successful interventions. Overall, this thesis presents evidence of early susceptibility to cognitive interventions and illustrates the complexity in the interrelations between higher order cognitive functions.