Chapter 1
General Introduction
Worldwide, more than 11 million people are currently imprisoned, resulting in an estimated world prison population rate of 144 per 100 000 individuals.¹ For many centuries, imprisonment has been used to sanction offenders, and most of the research and discussion revolving around imprisonment takes place within the fields of criminology and law. However, imprisonment can also be considered a stressful life-event which can impact psychological- and brain functioning. This thesis therefore aims to study imprisonment from a neuropsychological point of view. The readership of this thesis may be a mixed assemblage of both individuals with a background in neuropsychology, as well as individuals with a background in criminology or forensic practice. What follows is a general introduction to the neuropsychological constructs used in this thesis – such as self-regulation and executive functions – as well as an introduction to the influence of the environment on brain structure and function. Next, a brief overview of research on the neuropsychological functioning of the prison population is provided. We conclude with a description of the prison environment and the relationship with aforementioned constructs, followed by the outline of this thesis.

**Neuropsychology, self-regulation and executive functions**

In the field of neuropsychology, behavior and cognition are studied in relation to developmental- or acquired deficits in brain structure and function. Broadly, this relationship can be studied on three levels. First, on the level of brain structure and function, second, on the level of cognitive functions, and third, on the behavioral level. Methodologically, studying brain structure and function may entail the use of electroencephalography (EEG) or brain imaging techniques such as magnetic resonance imaging (MRI). These techniques can be used for instance to study prefrontal functioning in patients with low self-control. A more indirect method of assessing brain function is the use of neuropsychological tests that measure cognitive functions. Advantages of this method are that it is less invasive than imaging techniques, and the results are more closely related to the behavioral level. In this thesis, we indirectly assess prefrontal functioning of the brain by measuring executive functions.

“Executive functions” is an umbrella-term for top-down cognitive processes that are crucial for goal-directed and adaptive behavior and self-regulation,² such as initiative-taking, attention, planning, set-shifting, working memory, and
In other words, functions that are needed to organize important elements of an independent and legitimate life, such as income and housing, which make an individual self-supporting and enable self-regulation. These functions are also essential upon re-entry into society after a period of imprisonment. Executive functions are mostly regulated through top-down and bottom-up inhibition, by brain regions such as the dorsolateral and ventromedial prefrontal cortex, the orbitofrontal cortex, and the anterior cingulate cortex; collectively identified as the prefrontal cortex.\(^3\)

Top-down inhibition refers to a neuronal network with functional connectivity between the prefrontal cortex and, for example, subcortical areas and nuclei such as the limbic system, a collection of brain areas important in motivation, emotions, and learning.\(^5\) The medial prefrontal cortex in particular controls (or inhibits), through top-down processes, the activity of the amygdala, which is part of the limbic system and known for its sensitivity for fear. The prefrontal cortex may also exert inhibitory influence through bottom-up processes, which we illustrate in the following example. Impulsive risk-taking might occur when a person gets excited as a result of overvaluing an external stimulus, such as money, which is a bottom-up process. Strong excitation through this bottom-up process may result in a lack of proper reflection on the possible consequences of a choice – a top-down process – and, subsequently, result in making an impulsive high-risk choice.\(^6\) Bottom-up inhibition entails the activation of subcortical areas by the prefrontal cortex that favor a more appropriate, beneficial, or “safe” response. In other words, bottom-up inhibition occurs by means of influencing the competition between subcortical areas, in favor of those areas that support a more appropriate response.

Executive functions and prefrontal functioning are positively related to environmental enrichment, which is the enrichment of ones environment by means of increased physical activity, cognitive stimulation (e.g. an education or job that is challenging to an individual), and social interaction.\(^7\) An increase in physical activity, for example, improves executive functions in all age groups,\(^8-10\) particularly in those who are sedentary.\(^11\) Experimental animal studies show that physical activity may stimulate the dorsal raphe nucleus (a nucleus located in the brainstem, projecting serotonin to the prefrontal cortex),\(^12\) which increases prefrontal activity and, consequently, improves inhibition. An impoverished environment on the other hand, may negatively influence executive functions and...
self-control. Experimental animal studies show a negative effect of an impoverished environment on the prefrontal cortex,\textsuperscript{13-16} while human studies, with for instance elderly, show a negative relationship between an impoverished environment and self-regulation.\textsuperscript{17} An impoverished environment may also \textit{indirectly} lead to reduced prefrontal functioning through inducing stress. Stress causes various neurochemical events, such as the release of high levels of glucocorticoids (e.g. cortisol) and monoamines (e.g. dopamine and noradrenaline), which lead to reduced prefrontal activity and increased activity in the amygdala and other subcortical regions – regions important for more conditioned primitive and emotional responses.\textsuperscript{18} Lastly, an impoverished environment may also lead to sleep disturbances, for instance due to a disturbance in the sleep-wake rhythm. Nocturnal restlessness is particularly related to reduced self-control,\textsuperscript{19, 20} and can even be considered a risk factor for aggression and violent behavior.\textsuperscript{20}

\textbf{A prefrontal deficit in offenders, and other vulnerabilities}

Considering that executive functions are crucial for self-regulation, it would not be surprising that criminal offending – in which an individual fails to adhere to the generally accepted rules of a society – can be related to a prefrontal deficit. In antisocial and criminal populations, imaging studies show reduced structure and function in the right orbitofrontal cortex, right anterior cingulate cortex, and left dorsolateral prefrontal cortex.\textsuperscript{21} Concurrently, a recent meta-analysis found a robust association between criminal behavior and executive function deficits\textsuperscript{22}, with larger differences found in studies involving prisoners. Some studies even suggest a relationship between executive dysfunction and reoffending,\textsuperscript{23-25} though it should be noted that all studies were retrospective.

Besides a prefrontal deficit, a higher prevalence of other mental health problems can also be found in the prison population. Prisoners frequently suffer from psychiatric disorders such as depression, psychotic disorders, and post-traumatic stress disorder, from alcohol- and drug addiction, intellectual disabilities, traumatic brain injury, and personality disorders.\textsuperscript{26, 27} In sum, prisoners can be considered a “vulnerable” population, in the sense that they often suffer from psychiatric disorders and, as recent studies show, reduced prefrontal functioning, which may contribute to their behavioral problems and difficulties adhering to the law.
The prison environment

Before we look into the prison environment, let us consider the goals of punishment under criminal law. In the Netherlands – as well as in many other countries – these goals are retribution, restoration of the legal order, incapacitation, and general and specific prevention. General prevention means that the punishment should serve as a deterrent, i.e., the potential gain of committing a crime should not be worth taking the risk of receiving the associated punishment. Specific prevention refers to the fact that while in prison, it is most probably harder to commit certain crimes. It also refers to the concept of rehabilitation: the punishment should lead to a change in one’s future behavior and reduce the risk of reoffending. One of the means to achieve aforementioned goals is imprisonment (alongside community service or a monetary penalty). Therefore, ideally, imprisonment in itself should also serve these goals; not only should such a drastic measure function as a deterrent and provide retribution and temporary safety by removing the offender from society, it should also provide more sustainable safety for society through rehabilitation of the offender.

Completely opposite to the specific rehabilitative function, spending a significant amount of time in an impoverished environment may lead to a further functional decline of the prefrontal cortex. Nevertheless, prison is a typical example of an impoverished environment. Imprisonment inherently leads to reduced autonomous decision making and a lack of cognitive challenges, but studies also show that many prisoners lead a sedentary lifestyle that revolves, for a large part, around their beds and television. Physical inactivity appears to be a hallmark of prison life in various countries; few prisoners meet the generally accepted guideline of 30 minutes of moderate physical activity per day. Prisoners in a UK prison were found to sit or lie 9.36 hours per day on their bed, in addition to the hours they spent sleeping. Moreover, many prisoners experience sleep disturbances and chronic stress (of which the negative effects on prefrontal functioning have been described in the second paragraph), for example due to constant feelings of unsafety, a severe lack of autonomy, or improper sleep hygiene as a result of imposing a daily regime in which prisoners spend a large amount of time in their “bedrooms”.

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Aim and outline of the current thesis

In this thesis, we aim to expand fundamental knowledge on the neuropsychological functioning of prisoners, and to study the influence of the prison environment on executive functions and self-control.

In our review of the literature in chapter 2, which focuses on studies regarding regular prisoners (i.e. those imprisoned on regular wards, as opposed to psychiatric wards), we showed that deficits in specific executive functions can be found in this group. It remains unclear, however, whether these executive function deficits are already present upon imprisonment, whether these deficits originate in prison, or both.

Another related question is whether executive functions, in particular inhibition, vary between different subgroups of offenders. The prefrontal cortex is crucial for executive functions, and disturbances in the prefrontal cortex, especially the orbitofrontal cortex, are associated with impaired self-control and uncontrolled aggressive- and inappropriate behavior. While such disturbances may be detected in brain lesion patients or imaging studies, we examined in chapter 3 possible differences in executive functioning between violent and non-violent offenders.

Sleep disturbances are frequently observed in prisoners and are considered to be impairing. They are related to comorbid conditions as well as the prison environment itself. We examined the sleep-wake rhythm and its relationship with aggressive behavior (an expression of reduced self-control) in prisoners with a psychotic illness residing in the Penitentiary Psychiatric Center of Amsterdam (see chapter 4).

A clinically, as well as societally relevant question, is whether self-control and executive functions decline, or further decline, during imprisonment. In other words, does the impoverished prison environment (further) reduce the, in many cases already vulnerable, executive functions in prisoners? We studied this question in remand prisoners in Penitentiary Institution Amsterdam Over-Amstel, of whom we assessed executive functions within the first week of their arrival, and reassessed executive functions after three months of imprisonment (see chapter 5).

Understanding whether executive function deficits arise or worsen in prison would be valuable knowledge to prison policy, as they may call for the
development of methods to improve executive functions in prisoners. However, some prisons already employ interventions such as Running Therapy, which may directly improve executive functions by means of increased physical activity, and indirectly through improved sleep. A study protocol on studying the influence of Running Therapy on executive functions in prisoners is presented in chapter 6.

A summary of this thesis, a discussion of the implications and limitations, as well as recommendations for future research are presented in chapter 7.
REFERENCES


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