Chapter 7

General Discussion
Purpose of the dissertation

The main purpose of this dissertation was to investigate the relationship between neurobiological factors and prisoners’ response to a cognitive skills training program. Two research questions were formulated. The first question was as follows: *What is the predictive value of neurobiological factors in relation to the outcome of a cognitive skills program for adult prisoners?* Investigation of this relationship might provide more insight into who is able to benefit from therapy and who is not. The second question was the following: *Do prisoners’ neurobiological factors change in response to a cognitive skills training program?* Studying this issue might provide more insight into why intervention is effective in reducing antisocial behavior. In addition, knowledge retrieved from investigating these two questions was used to reflect on how neurobiological measures might have an added value in the field of criminology in general.

First, this final chapter provides a heuristic model in which the central questions of the dissertation will be presented. Second, the main findings per chapter will be briefly described, after which results from the empirical studies will be discussed with respect to the proposed heuristic model and existing literature. Finally, this chapter discusses study limitations, implications for correctional rehabilitation and suggestions for future research.
Theoretical Framework

Worldwide, few researchers have attempted to capture the relationship between neurobiological factors and antisocial behavior in a theoretical framework. Adrian Raine (2002b) was one of the first to develop a heuristic model on the key influences of genes and environment and how these factors give rise to social and biological risk factors for the development of antisocial behavior. In addition, Ward and Beech (2006) proposed an integrated model on the influences of biological functioning and social learning on the development of sexual offending. In 2007, Van Goozen and colleagues developed a more extended theoretical model on the direct and indirect pathways through which family factors (including early childhood adversity and genetic factors) affect biological, cognitive, and emotional mechanisms, which predispose an individual to the development of antisocial behavior problems. Furthermore, Vaske and colleagues (2011) proposed a biosocial theory of offender rehabilitation. Until today, their publication is the first, and in all probability the only one that has attempted to capture the relationship between effective offender rehabilitation and the structure and functioning of the brain in a heuristic model.

Currently, existing models on the relationship between neurobiological factors and criminal behavior are fairly general and highly explorative. This suggests that the field would benefit from high quality empirical verification of present models to develop comprehensive frameworks. To address the research questions in this dissertation, we focus on the model as proposed by Vaske and colleagues on the relationship between neural substrates and offender rehabilitation.

According to Vaske et al. (2011), cognitive behavioral therapy (CBT) is effective in reducing problem behavior, including crime, because the intervention indirectly affects specific areas of the brain. To illustrate, there is strong meta-analytic evidence for the relationship between low empathic skills and antisocial behavior (Jolliffe & Farrington, 2004; Van Langen, Wissink, Van Vugt, Van der Stouwe, & Stams, 2014), and therefore cognitive aspects of empathy are one of the central concepts in correctional intervention. In addition, brain imaging studies have revealed that cognitive empathy is consistently associated with activation of specific brain areas, including medial prefrontal cortex, cingulate cortex, posterior superior temporal sulcus, temporo-parietal junction, and the temporal poles (e.g., Amodio & Frith, 2006; Lieberman, 2007; Singer, 2006). As stated by Vaske et al. (2011), effective CBT will ultimately lead to a change in cognitive aspects of empathic functioning, which in turn affects both functional and structural aspects of the underlying brain areas. These cognitive and neural changes together will eventually
lead to a reduction in criminal behavior. Their idea has been captured as follows: CBT → changes in cognition ↔ changes in brain functioning → changes in behavior.

Evidence for changes in brain functioning after CBT is supported by various studies including patients with different psychiatric disorders (including panic disorder and obsessive compulsive disorder; for reviews on this subject see Karlsson, 2011; Linden, 2006; Porto et al., 2009). Based on this initial empirical evidence, Vaske et al. (2011) seem to have proposed a plausible model on the relationship between correctional treatment and changes in brain functioning and structure among individuals with antisocial behavior. Nevertheless, there are important aspects that the authors have not fully considered yet. First, their model only focuses on brain structure/functioning while specific regions of the brain also control autonomic nervous system activities, including respiration rate and heart rate, and endocrine system activities (e.g., Critchley, 2005; Damasio, 1996; Smith & Vale, 2006). From the literature it is known that impairments in these biological activities are also frequently related to antisocial behavior problems (e.g., Beauchaine, Hong, & Marsh, 2008; De Kogel, 2008; Lorber, 2004; Ogilvie, Stewart, Chan, & Shum, 2011; Wilson & Scarpa, 2012; Yang & Raine, 2009). However, Vaske et al. (2011) do not discuss whether neurobiological factors related to antisocial behavior other than brain functioning may change in response to CBT. Furthermore, at the very end of their article, Vaske et al. (2011) stated that, “...it is very likely though that there are reciprocal relationships between CBT effectiveness and brain functioning (CBT ↔ brain functioning)” (page 96). Although the authors are aware of a possible reciprocal relationship between brain functioning and CBT effectiveness, this is currently not captured in their proposed model.

Here we would like to advocate an extended version of Vaske et al.’s (2011) model by suggesting the following additional relationships: (1) not only brain functioning/structure, but also other neurobiological factors, such as heart rate and hormone levels, might change in response to CBT; (2) neurobiological factors do not only change in response to CBT, but they may also have a predictive value in relation to CBT outcome; and (3) Vaske and colleagues suggest that there is a sequential effect of CBT on first cognitive functioning followed by neurobiological changes. In our extended version of the model we choose to leave out a chronological effect and suggest that after effective CBT, cognitive improvement and neurobiological changes go hand in hand with the possibility that either cognitive or neurobiological improvement occur first. Figure 1 shows our heuristic model on the relationship between neurobiological factors and correctional cognitive behavioral therapy based on the initial model as proposed by Vaske and colleagues.
As shown in Figure 1, we did not examine the interplay between neurobiological factors and cognitive skills before treatment. This would address different research issues, such as treatment readiness or the general underlying characteristics of individuals selected for correctional intervention. In addition, we were not able to investigate the effects of correctional CBT on criminal recidivism rates via neurobiological and cognitive factors due to the duration of the project. Nevertheless, there is empirical evidence that specific neurobiological factors, including brain areas involved in error-related learning and heart rate reactivity, are related to reoffending rates (e.g., Aharoni et al., 2013; De Vries-Bouw et al., 2011). Therefore, it is essential that future research focus on how neurobiological and cognitive changes after CBT together account for a reduction in criminal recidivism.

**Hypotheses.** Based on the proposed model, we started our research with two general hypotheses: (1) neurobiological factors are predictive of treatment outcome and (2) along with cognitive improvement, neurobiological factors, particularly brain functioning, change in response to cognitive behavioral therapy. However, based on the model we were unable to hypothesize which neurobiological factors would have a predictive value and in what direction neurobiological characteristics might change. To get a better idea of what to expect in our empirical study, which included adult prisoners selected for a cognitive skills training program, two literature reviews were performed.
Summary of the main results

The literature review described in Chapter 2 revealed that research on the predictive value of neurobiological factors in relation to treatment outcome of individuals with antisocial behavior is scarce. Only ten relevant studies were found in which the majority included child and adolescent samples. Two studies investigated the predictive value of neurocognitive measures in relation to adult prisoners’ treatment outcome. At first glance, the results of these two studies seemed to be conflictive. However, various methodological differences, including selected neurocognitive tasks and treatment outcome measures, hampered an adequate comparison of the results from the two studies. The findings of the remaining eight studies revealed one consistent finding. It appeared that indices of low physiological arousal (especially low cortisol levels) were related to poor treatment outcome. This suggests that individuals with antisocial behavior characterized by low physiological arousal before treatment may benefit less from intervention compared to individuals with normal to high physiological arousal.

Results of our empirical study on the predictive value of neurobiological factors in relation to prisoners’ treatment outcome are described in Chapter 3. In total, 121 Dutch adult prisoners who were selected for a cognitive skills training program by Probation Service officers, participated in the study. It appeared that, the D2 Cancellation Task, a neurocognitive test that assesses concentration/attention skills, had a modest predictive power for treatment dropout. This result suggests that offenders with low concentration/attention skills are less likely to complete treatment. Although the predictive power of this simple test was modest, it was found to be superior to, for instance, a ‘conscious’ self-report assessment of treatment motivation as administered by the offenders. On the other hand, most of the neurobiological assessments that we performed in this study, including heart rate assessment, were not found to be ‘predictive’ of treatment outcome.

The second literature review, described in Chapter 4, revealed eleven relevant studies that examined neurobiological changes after behavioral intervention for individuals with antisocial behavior. In general, the values of specific neurobiological risk factors, particularly of basal cortisol, became less abnormal following behavioral intervention. However, this process of ‘normalization’ was only found in child and adolescent samples. In contrast, the only study consisting of adult offenders, did not find any change in neurocognitive functioning following different behavioral intervention programs. Furthermore, four studies reported an association between neurobiological and behavioral changes in response to intervention whereas few other studies did not find a relationship. All in all, no definite conclusions could be
drawn about the relationship between neurobiological and behavioral changes in response to intervention.

Chapter 5 presented the results of our empirical study comprising 84 Dutch adult male prisoners who completed neurocognitive tasks, a heart rate activity assessment, and behavioral measures before and after a cognitive skills training program. In addition, 64 waitlist-control group participants were included to investigate treatment effect on neurobiological changes. In general, no significant changes in neurocognitive functioning and heart rate activity were detected in favor of prisoners who completed the intervention. Furthermore, mixed results were found with regard to behavioral outcome measures.

Finally, in Chapter 6, it is argued that with the ongoing increase in knowledge on neurobiological characteristics related to criminal behavior, it is worthwhile to explore how neurobiological research methods could play a more significant role in the field of criminology. Initial empirical research has shown that even relative simple neurobiological measurements, such as resting heart rate assessment and a spatial span task, are able to predict the presence of antisocial behavior net of control for more traditional criminological measurements, such as the Self-Control Scale questionnaire (Armstrong, Keller, Franklin, & MacMillan, 2009; Cauffman, Steinberg, & Piquero, 2005). In addition, our empirical study indicated that a simple concentration test might be able to differentiate between those who will complete intervention and those who will not. Overall, in Chapter 6 we emphasize that especially a multidimensional approach, including psychological, social and neurobiological methods, is what will eventually help to better understand, prevent, and treat criminal behavior. For an overview of the main results per chapter, see Table 1.
Main results of the dissertation per chapter.

<table>
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<tr>
<th>Problem statement</th>
<th>Research question</th>
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<tr>
<td>What is the predictive value of neurobiological factors in relation to the outcome of a cognitive skills program for adult prisoners?</td>
<td>What previous research has been conducted that has investigated the predictive value of neurobiological factors in relation to treatment outcome of individuals with antisocial behavior?</td>
<td>Literature review</td>
<td>2</td>
<td>Neurobiological indicators of low physiological arousal are related to less benefit from correctional behavioral intervention program for individuals with antisocial behavior.</td>
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<tr>
<td>Are neurocognitive skills and heart rate activity predictive of male adult prisoners’ response to a cognitive skills training program?</td>
<td>Literature review</td>
<td>3</td>
<td>Concentration level, assessed with a neurocognitive task, predicts prisoners’ treatment dropout above and beyond traditional measures. However, most other neurobiological factors did not predict treatment outcome.</td>
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<tr>
<td>Do prisoners’ neurobiological factors change in response to a cognitive skills training program?</td>
<td>What previous research has been conducted that has investigated the change in neurobiological factors after treatment for individuals with antisocial behavior?</td>
<td>Literature review</td>
<td>4</td>
<td>Neurobiological values can change toward ‘less abnormal’ values in response to correctional intervention programs.</td>
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<tr>
<td>Does neurocognitive functioning and heart rate activity change in male adult prisoners following treatment and is this related to behavioral improvement?</td>
<td>Literature review</td>
<td>5</td>
<td>No significant changes in neurocognitive functioning and heart rate activity were detected in favor of prisoners who completed intervention.</td>
<td></td>
</tr>
<tr>
<td>In what way could neurobiological knowledge contribute to the field of criminology?</td>
<td>How can ‘basic’ neurobiological measurements benefit criminological research and practice?</td>
<td>State of the Art review</td>
<td>6</td>
<td>Basic neurobiological measures are relatively easy to use and to implement. Using these measures could improve our understanding, prediction, and prevention of criminal behavior.</td>
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Discussion of the results

This section discusses the following issues: (1) whether the results of the literature reviews show support for the general hypotheses based on our heuristic model; (2) which specific hypotheses resulted from the literature reviews; and (3) to what extent our empirical findings support the heuristic model and the more specific hypotheses based on initial literature.

Neurobiological ‘predictors’. The first general hypothesis based on the proposed model was the idea that neurobiological factors are able to predict correctional treatment outcome. Results from the literature review provided support for this relationship and showed that among children and adolescents with antisocial behavior problems, there
is a consistent relationship between neurobiological indicators of low physiological arousal and poor treatment outcome. Based on these results, we hypothesized that low heart rate activity in our adult prisoner sample would be predictive of poor treatment response. There are different potential explanations for the association between low physiological arousal and poor treatment outcome. One possible clarification comes from Van Goozen and colleagues (2007). They suggest that children with severe disruptive behavior, who show reduced physiological arousal levels, have a deficient response to risky or stressful situations. Due to their disrupted physiological arousal system, these children are physiologically not responsive to stressful situations, resulting in no activation of a warning signal in the behavioral ‘withdrawal’ system of the brain. In other words, due to their physiological deficits, these children are at risk of acting inappropriately or antisocially in situations where ‘normal’ individuals would remove themselves. In addition, these children also display reduced social learning skills, hampering them to learn from the negative consequences that others might experience after immoral behavior. Overall, reduced sensitivity to negative cues might decrease the learning potential of these children since negative feedback is often an educational component central to behavioral interventions.

The findings from our empirical research also provided some, albeit limited, evidence for the proposed heuristic model. The results indicated that a specific neurocognitive task assessing concentration/attention skills might be predictive of prisoners’ completion of the intervention. Although the predictive power of this test was limited, the task better predicted treatment dropout above and beyond cognitive characteristics (e.g., self-reported motivation and moral reasoning) and background characteristics (e.g., age and IQ). The positive relationship between concentration/attention skills and treatment completion, may be explained by the fact that in order to focus on learning processes, including treatment instructions and supportive material, an individual needs to ignore distractors, such as their own distress or other prisoners’ murmurs. A reduced ability to concentrate might lead to a loss in motivation and eventually could increase the chances to resign from treatment.

The positive relationship between concentration/attention level and treatment completion found in our empirical study seems to be in line with a previous study conducted by Fishbein et al. (2009). This study was included in the literature review and concerned 224 prisoners who were selected for correctional CBT. The results of Fishbein et al. (2009) indicated that prisoners who completed intervention were less impulsive and showed longer reaction times in risky decision-making processes (both measured with neurocognitive tasks) than those who dropped out. More generally, they found that deficits
in inhibition skills significantly predicted less benefit from intervention, and more so than background, psychological, or behavioral variables. Together with our empirical findings, this suggests that specific neurocognitive factors, including concentration/attention, sensitivity to rewards versus penalties and impulsivity, might have the potential to better predict treatment completion and gain, above and beyond traditional background and psychological characteristics.

On the other hand, the results from our empirical study did not provide support for the hypothesis based on the literature review that indicated a positive relationship between physiological arousal and treatment benefit. In fact, the physiological measures central to our empirical study, including heart rate assessment during rest and stressful phase, showed no predictive value in relation to treatment outcome. There are different possible explanations for why the empirical study did not provide support for the low physiological arousal – poor treatment outcome relationship. First, the literature review mainly included child and adolescent samples, which could hamper the generalizability of the results to adult samples. In addition, cortisol levels in particular appeared to be predictive of treatment outcome among studies included in the literature review. However, we experienced that asking prisoners for endogenous substance (i.e., saliva samples to assess cortisol levels) made them suspicious and less willing to participate. In addition, the composed assessment procedure, including various neurocognitive tasks, questionnaires and heart rate assessment, already took prisoners an average of three hours to complete. Therefore, it was decided that assessing hormone levels would be too much of a burden on participants. Nevertheless, Fishbein et al. (2009) succeeded to assess cortisol levels during rest and a stressful situation in their adult prisoner sample. Interestingly, the results showed that ‘cortisol reactivity’, which refers to the change in cortisol level during baseline to stressful situation, was more pronounced in prisoners who viewed themselves as more treatment ready compared to those who reported less readiness. However, self-reported treatment readiness appeared not to be predictive of actual treatment performance indicators. It remains unclear what underlies the positive relationship between cortisol reactivity and self-reported treatment readiness, yet overall the results indicated that cortisol reactivity was not predictive of treatment outcome.

In sum, both the literature review, and our empirical study provided some evidence for the proposed heuristic model, in that both studies indicated a predictive value of specific neurobiological factors in relation to treatment outcome of individuals with antisocial behavior. However, both studies seem to reveal two different neurobiological constructs, namely physiological arousal and concentration/attention skills. While the studies provide insight into which neurobiological factors are related to poor treatment outcome, the fact
that the results seem not to be in line with each other makes it difficult to conclude who will benefit less from intervention from a neurobiological perspective. In the following paragraph, we will attempt to integrate the findings from both the literature and the empirical study by exploring one potential overarching neural mechanism: the right-hemisphere of the brain.

**Arousal and attention.** The right-hemisphere of the brain is responsible for various processes. For instance, it controls autonomic functions, such as respiration and heart rate (Raine, 2002a), but it also appears to be involved in the ‘withdrawal system’, a system that promotes escape from aversive and dangerous situations (Davidson, 1998; Davidson, Saron, Senulis, Ekman, & Friesen, 1990). Reduced functioning of the right-hemisphere might therefore explain the relationship between low physiological arousal and the increased vulnerability to show law-breaking behavior (Baker et al., 2009; Raine, 2002a). Besides the control of autonomic functioning, there is also empirical support, especially from patients with brain lesions, that the right-hemisphere controls specific attention processes, such as selective attention (Shulman et al., 2010; Kastner, 2000). Overall, this indicates that from a neurobiological perspective, the findings from the literature and the empirical research are perhaps much more intertwined (via the right-hemisphere) than they initially seemed to be. Whether reduced right-hemisphere functioning also underlies other neurocognitive deficits related to poor treatment outcome, as shown by Fishbein et al. (2009), and thus serves as a key mechanism that can explain why some individuals benefit less from behavioral intervention, is something that requires further research with help of more advanced methods, such as brain imaging techniques.

**Neurobiological changes after intervention.** The second general hypothesis based on our heuristic model was captured as follows: along with cognitive improvement, neurobiological factors (particularly brain functioning) change in response to cognitive behavioral therapy. Results from the second literature review supported this hypothesis and showed that brain functioning, but especially basal cortisol levels, become ‘less abnormal’ following behavioral intervention. On the other hand, the literature review showed mixed evidence for the relationship between cognitive improvement and neurobiological ‘normalization’, but the balance of evidence favors an association between neurobiological normalization and cognitive improvement.

The finding that neurobiological factors show normalization in response to cognitive behavioral intervention in individuals with antisocial behavior is not surprising given the strong empirical evidence for normalization of neural patterns after CBT in patients with various psychiatric disorders (as described earlier). According to Kandel (1998), long-
lasting changes in behavior due to psychotherapies (including CBT) are supported by changes in gene expressions which in turn modify the strength of synaptic connections in the brain. In addition, there are multiple studies that show the positive effects of psychosocial intervention programs on normalization of cortisol levels (both in baseline and stress conditions) among various groups of individuals, including maltreated infants, children in foster care, as well as healthy adults (e.g., Cicchetti, Rogosch, Toth, & Sturge-Apple, 2011; Fisher, Stoolmiller, Gunnar, & Burraaston, 2007; Hammerfald et al., 2006; Mommersteeg, Keijsers, Heijnen, Verbraak, & van Doornen, 2006).

Despite the accepted idea that CBT leads to normalization of neurobiological values, results from our empirical study did not indicate a change in neurobiological factors in response to cognitive skills training in adult prisoners. With regard to brain functioning, the absence of change in neurocognitive functioning after intervention was unexpected, but appeared to be in line with the results from a previous dissertation by Ross (2012). In this dissertation, 69 adult prisoners completed behavioral intervention programs and 50 prisoners served as a control group. According to Ross (2012), the fact that neurocognitive skills did not improve in favor of the intervention group was probably due to prisoners’ relative normal level of neurocognitive functioning at pre-test. This might have limited prisoners’ learning potential. In contrast, post-hoc analysis revealed that our sample was characterized by specific neurocognitive impairments before treatment, in particular by reduced verbal fluency skills, suggesting that there was potential for improvement after intervention.

Moreover, based on the literature review we expected to find normalization in heart rate activity in our adult prisoner sample following intervention, but the results of the empirical study did not provide evidence for this. It is unclear what might have hampered a change in neurobiological factors in response to intervention, but one potential clarification could be adopted from the behavioral measures that were central to our study.

**Effective intervention?** Although our study was not designed to evaluate the effectiveness of the cognitive skills training program (called ‘CoVa’), the behavioral results are thought provoking. To begin, mentors did not report a significant decrease in prisoners’ aggressive behavior on the ward following intervention. Furthermore, the majority of prisoners stated that although they felt that the content of the CoVa intervention was satisfactory, they did not experience a change in the way they thought or behaved after intervention. Only trainers reported a significant change in prisoners’ cognitive functioning after intervention. Despite some methodological issues with regard to our behavioral measures, the balance of evidence seems to suggest that the effectiveness of the CoVa training
program is uncertain. However, if the effectiveness of the treatment program itself is questionable, then this raises the question of whether or not we could have expected a change in neurobiological functioning in our empirical study.

Evidence for the potentially limited effectiveness of the CoVa training is supported by initial literature. In 2005, the CoVa training was implemented in the Dutch correctional service system as a new intervention program based on the English Enhanced Thinking Skills (ETS) training. We now know that research evaluations of the ETS program have shown limited to no success in reducing reoffending rates (for an overview, see Gobbett & Sellen, 2014). For this reason, the ETS program is currently not part of the correctional rehabilitation system anymore in Wales and England. In the Netherlands, evaluation studies on the CoVa training are basically non-existent. Only one study has been performed recently, but the lack of a control group in this particular study makes it difficult to draw definite conclusions about the effectiveness of the training program (Buysse & Loef, 2012). The study, consisting of more than 1,400 prisoners, showed that after intervention, prisoners themselves reported a small significant improvement in interpersonal problem-solving, self-control, and social perspective-taking skills, but no significant improvement in critical and moral reasoning skills. The same study also revealed that 32% of the inmates did not fully meet the CoVa inclusion criteria and that one third of the CoVa training programs that were provided between 2008 and 2012 did not meet the treatment integrity criteria.

These results imply that a wide variety in treatment success might not only be related to prisoners’ characteristics, but also by the quality of existing intervention programs. Furthermore, it highlights the need to improve the current intervention program to effectively decrease prisoners’ criminal behavior. Very recently, the Dutch Probation Service has implemented adaptations to the original CoVa training program based on new insights (called ‘CoVa 2.0’). The program now includes individualized sessions and focuses more on prisoners’ personal needs. Unfortunately, it is too early to conclude whether CoVa 2.0 has more potential to improve offenders’ behavior than the original version of the training. All in all, it is possible that various treatment characteristics of the original CoVa, for instance the quality of the content and treatment integrity, underlie the absence of cognitive, behavioral as well as neurobiological improvement.

**Into perspective.** Another potential mechanism that might explain the absence of neurobiological normalization in our empirical study is related to background characteristics of the included sample. We examined an adult prisoner sample, of which most prisoners had been detained for at least several months before taking part in the study. In addition, almost all of the participating prisoners had a history of previous
imprisonments. For this reason, applying the hypotheses on changes in neurobiological functioning based on child and adolescent samples, as included in the literature review, to our adult prisoner sample might be inappropriate.

The fact that our sample was on average thirty years old and had been familiar with imprisonment for a significant period of time, could have limited the ability to change both in a behavioral way as well as in a neurobiological way for several reasons. First, it is possible that children and adolescents are in general more responsive to behavioral intervention when compared to adults. In fact, it has been suggested that there is a substantial decrease in the ability to change complex behavior in adults with antisocial behavior because the increased antisocial behavior problems over time makes it hard to reverse (Gezondheidsraad, 2006; Raine, 2002b). Second, from a neurobiological perspective, there is evidence that the plasticity of the brain is reduced when growing older (Mahncke, Bronstone, & Merzenich, 2006). Finally, it has been suggested that the impoverished and sedentary environment of prisons itself has a negative effect on prefrontal brain functioning, leading to reduced neurocognitive skills (Melendez, Gregory, Bardo, & Kalivas, 2004; Mendes et al., 2013; Volkers & Scherder, 2011). If the impoverished nature of prison environments has a negative impact on neurocognitive functioning then this might counteract the potential positive effects of cognitive skills training.

Interestingly, these arguments may place the effectiveness of the CoVa training in a different perspective. Here, we would like to argue that the content of the CoVa training program might be theoretically successful in affecting criminogenic needs. But as long as the intervention is not tailored more towards the negative effects of the prison setting itself and towards the potentially reduced ability of adult prisoners to change their ingrained antisocial behavior patterns and underlying neurobiological deficits, the effectiveness of the intervention program may remain limited. Before we suggest how to improve the current intervention program, a reflection on the proposed heuristic model is made.

**Modeling the model.** This final chapter started with a proposed heuristic model with the aim to investigate the relationship between neurobiological factors and correctional intervention in a constructive way. Both literature and empirical research have been employed resulting in three important findings: (1) specific neurobiological deficits, including indicators of low physiological arousal and attention deficits, appear to be predictive of correctional treatment outcome. Yet we are not able to give a comprehensive answer to the question of who is less able to respond to intervention from a neurobiological perspective. In addition, there are potentially other neurobiological factors that require future investigation; (2) there is initial evidence that neurobiological factors normalize in
response to behavioral intervention among children and adolescents, but the relationship between neurobiological normalization and cognitive improvement is not yet unraveled. In order to shed more light on the mechanism of effective CBT on both cognitive improvement and neurobiological changes, future research should include multiple cognitive and neurobiological measurement points during intervention. Overall, it is too early to conclude why intervention is effective for some but not all offenders. In addition, neurobiological normalization might be age and/or setting dependent; finally, (3) our studies have indicated the potential value of neurobiological factors to better understand prisoners’ treatment outcome, but at the same time our results emphasize that research on the relationship between neurobiological factors and behavioral interventions aimed to reduce antisocial behavior is highly explorative and mixed results have been found. The proposed heuristic framework served as a starting point to create a comprehensive model on the relationship between neurobiological knowledge and correctional intervention, yet high quality empirical research, including sufficient participants, valid instruments and an effective treatment program is required to increase insight into the relationship between neurobiological factors and correctional intervention programs.

**Implications for practice and future research**

As described throughout this dissertation, psychological and sociological perspectives dominate the field of criminology. But those who are familiar with the history of criminology know that criminology and biological theories were practically synonymous until the early 20th century (Fijnaut, 2014; Rafter, 2008). However, by the end of World War II, ideas on the link between biology and criminal behavior were firmly rejected due to what the Nazis had done in the name of biology (Rafter, 2008). Since then, sociological and also psychological perspectives have become more dominant and to this day these approaches influence the way we think about crime, risk assessment, and correctional intervention programs.

In this dissertation, we draw from a more modern, 21st century-based neurobiological approach to examine criminological practice. This approach has important differences from early biological perspectives in the field of criminology. For example, the interaction between social circumstances and biological factors is much more recognized now and most researchers in the field of ‘biocriminology’ reject biological determinism (Rafter, 2008). In addition, multiple disciplines, including neuroscience, psychology, and genetics are combined in the study of biology and crime and it is argued that this multiple approach in particular is what could increase our understanding of crime and the treatment of
antisocial behavior. Results of this dissertation indicate that within the field of correctional rehabilitation and neurobiology, only a few explorative studies have been conducted. For this reason, provisional suggestions can be made for practical implications that may become more concrete and directed with future research. In this section we argue that neurobiological insights can potentially shed more light on: (1) treatment selection procedure; (2) format and content of intervention programs; and (3) treatment outcome assessment.

First, the results from Chapter 3 suggest the potential added value of the D2 Cancellation Task. This task appears to predict treatment attrition above and beyond traditional selection factors, such as self-reported motivation level and background characteristics. The D2 Cancellation Task could be added to the current treatment selection procedure for early detection of individuals who are at risk of dropping out of treatment. This knowledge might then be used to provide these individuals extra guidance throughout the intervention. The advantage of the D2 task is that it is a relative simple test and it takes less than five minutes to complete (Brickenkamp, 2007). However, before implementing the D2 task, more research is necessary to confirm our empirical results and to ‘individualize’ the results by determining which exact scores are predictive of treatment dropout.

Results from the empirical studies also showed a relative low verbal intelligence level in the empirical research sample. As research has shown the importance of verbal intelligence in relation to treatment outcome (Andrews & Dowden, 2007; Dowden & Serin, 2001), another implication based on this dissertation is to include a reliable verbal intelligence test in the current treatment selection procedure. This would help practitioners to better allocate prisoners to the regular CoVa training program or to the CoVa-plus training program, which is specially developed for individuals with reduced intellectual abilities. Given that the official inclusion criteria of the CoVa training program request an intelligence level above 90 and the average intelligence level of the current research sample was 80, implementing a reliable intelligence test could increase adherence to the treatment inclusion criteria and may improve treatment efficacy.

On the other hand, it is probably too early to state that physiological measures, such as hormone assessment, should be incorporated into the current treatment selection procedure. Although the relationship between low physiological arousal and poor treatment outcome has been established in various initial studies, our empirical research did not indicate support for it. Moreover, the low arousal – poor treatment outcome relationship is limited to group level studies making it difficult to conclude which specific neurobiological values (e.g., how many heart beats per minute) are related to poor treatment outcome. As
long as normative data are lacking, neurobiological measures cannot play a significant role in the treatment assessment procedure.

Second, based on the results of this dissertation, suggestions on how to improve the effectiveness of the current intervention program might be proposed. For example, it has been suggested that the negative effects of prolonged imprisonment(s) on brain functioning may prevent the current intervention to be effective. This raises the question whether the CoVa training might be more effective if extended from a 10-week course to an intervention program that spans multiple months in order to structurally improve cognitive functioning and reverse underlying neurobiological deficits. Moreover, could enriching the prison setting itself, for example, by providing prisoners with more control over daily activities and more social challenges, have a positive effect on prisoners’ learning potential during intervention? Future research should examine whether considering issues such as these may help to successfully improve neurocognitive functioning and, eventually, reduce criminal behavior (Meijers, Harte, Jonker, & Meynen, 2015).

Furthermore, neurobiological insights could be used to improve the content of cognitive behavioral intervention programs. For example, individuals with low attention skills might not only benefit from extra guidance throughout the intervention, but a preparatory or additional treatment module aimed to increase attention skills might also reduce dropout rates and improve neurocognitive functioning. The meta-analysis by Ogilvie et al. (2011) can

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Model partly derived from Van Goozen et al. (2007) to illustrate that traditional correctional treatment focuses on cognitive and emotional problems, while neurobiological deficits might be an alternative site of intervention to reduce antisocial behavior problems.
inform which additional neurocognitive deficits are strongly related to antisocial behavior, such as working memory impairments, and might be added to the current intervention programs to effectively reduce criminal behavior.

In addition, traditional correctional intervention programs merely focus on cognitive and emotional problems despite the increased knowledge on neurobiological deficits associated with antisocial behavior problems (e.g., Beauchaine et al., 2008; De Kogel, 2008; Lorber, 2004; Ogilvie et al., 2011; Wilson & Scarpa, 2012; Yang & Raine, 2009). Part of Van Goozen and colleagues’ biosocial model is shown in Figure 2 highlighting the importance of neurobiological deficits as an alternative site of intervention. Currently, only a few researchers around the world are investigating the effects of neurobiological intervention methods to reduce antisocial behavior problems. Examples of innovative intervention methods are transcranial magnetic stimulation, neurofeedback, and hormone treatment. Another avenue of interest is related to nutrition. There is growing evidence for an interesting effect that poor nutrition may have on brain development which in turn could predispose to risk factors for antisocial behavior problems (Liu, 2011; Raine, 2008). There is empirical evidence showing that nutritional components, including omega-3, can produce reductions in antisocial behavior problems (Raine, Portnoy, Lui, Mahoomed, & Hibbeln, 2014; Zaalberg, Nijman, Bulten, Stroosma, & van der Staak, 2010). Exploring alternative, neurobiological treatment options could increase the range of available correctional treatment programs and can lead to a better connection between individual needs and relevant treatment options.

Third, the initial model as proposed by Vaske and colleagues (2011), together with the findings from the literature review suggest that neurobiological factors may function as additional treatment outcome measurements. In 2006, Popma and Raine already suggested that neurobiological tools might serve as parameters that could inform practitioners concerning treatment efficacy. However, important knowledge gaps remain that preclude further advances. For instance, existing literature does not provide consensus. Some studies indicated normalization of neurobiological factors after intervention while others did not. In addition, it is unclear what ‘normalization’ actually implies. Again, only group level research has examined neurobiological normalization, meaning little is known about individual-level processes. This is especially relevant for physiological data, since norm scores are often available for specific neurocognitive measures. At this moment, the absence of normative data indicating to what level a physiological characteristic should normalize in response to intervention, impedes the usage of physiological measurements to determine individual treatment efficacy.
Methodological limitations. This dissertation has a unique character since it investigated both the predictive value as well as changes of neurobiological factors in one and the same relatively large adult prisoner sample selected for correctional CBT. Nevertheless, there are several methodological limitations that need to be addressed.

First, our sample should not be viewed as a ‘regular’ adult prisoner sample, because these prisoners were selected by the Probation Service for CoVa participation based on their level of cognitive deficits and language understanding. These characteristics might hamper the generalizability of our results to other prisoner samples. Furthermore, we were not able to prevent control group subjects from participating in different training programs between pre- and post-test assessment. The completion of training programs by the control group might have reduced the potential to find group differences in neurobiological and behavioral functioning at post-test assessment. In addition, ideally we would have preferred to include a community-residing control group to verify whether both the intervention and the control group participants were characterized by ‘abnormal’ neurobiological functioning before treatment. This is especially relevant since several neurobiological measures employed in this study lacked normative data. However, due to limited time and research resources we were unable to include a community-residing control group. Future research should consider doing so in order to provide more insight into the neurobiological deficits of prisoners selected for correctional intervention.

Second, although the employed measurements in the empirical studies were selected with care, there are several considerations. We might have overlooked the importance of other neurocognitive measures that are potentially strongly related to treatment outcome. For example, we did not include similar neurocognitive measures as used by Fishbein et al. (2009) who found a predictive effect of impulsivity and risk taking behavior in relation to treatment dropout and treatment gain. In addition, the meta-analysis by Ogilvie et al. (2011) indicated that measures of working memory are highly correlated with antisocial behavior. Working memory can be described as an overarching skill to monitor cognition and self-regulatory behavior (e.g., Burgess, Dumontheil, & Gilbert, 2007; Endres, Rickert, Bogg, Lucas, & Finn, 2011; Koechlin, Basso, Pietrini, Panzer, & Grafman, 1999). Because of this central control function, it is plausible that measures of working memory are also related to the ability to benefit from correctional intervention.

Furthermore, conducting research in prison limits the research opportunities. For example, only ‘basic’ neurobiological instruments (e.g., neurocognitive measures and heart rate assessment) as opposed to more advanced methods (e.g., such as brain imaging techniques and hormone assessment) were deemed appropriate to use within
the prison setting. This restriction might have hampered the ability to find support for the
low arousal – poor treatment outcome relationship as indicated by the literature review.
On the other hand, we must acknowledge that the hypotheses based on the literature
reviews are also subject to limitations. Especially because the literature reviews mainly
included child and adolescent samples and it is unclear to what extent the findings from
young samples can be generalized to adult samples. In addition, there is a general trend
that studies with statistically significant results are more often published than studies
with non-significant results, which might have biased the hypotheses that were based on
the findings from the literature reviews.

It is also important to note that the behavioral outcome measures should be interpreted
with care, given that the adapted and translated version of the Treatment Gain:
Short Scale for trainers and the self-evaluation questionnaire for prisoners were not
validated. In addition, the sensitivity of the Social Dysfunction Aggression Scale (SDAS)
completed by mentors appears to be too limited for the current research sample since
almost all prisoners showed low aggressive behavior before and after intervention.
Moreover, initially we included four extra questionnaires to measure self-reported
cognitive improvement after intervention. As described in Chapter 1, these questionnaires
are part of the Probation Service assessment procedure and therefore we were able
to get access to the questionnaires completed by the intervention group. Unfortunately,
it appeared that a large number of questionnaires were incomplete or missing, which
made the Probation Service questionnaires inadequate for our study.

Finally, we would like to emphasize that, aside from the D2 Cancellation Task, most of
our included neurobiological measurements appeared to be unrelated to treatment
outcome. Together with results from initial literature, this suggests that empirical
research on the relationship between neurobiological factors and correctional
intervention is still in its infancy. Nevertheless, the potentially predictive value of the
D2 Cancellation Task for treatment dropout has high clinical relevance and might
become more reliable with future research.

Conclusion

Not all prisoners who are selected for correctional CBT benefit equally from it.
Given political and societal wishes to reduce criminal behavior and recidivism
rates, it is essential to better understand why some prisoners are not responsive to
existing intervention programs. In the past decades, significant inroads have been
made in our knowledge base on psychosocial factors related to treatment outcome. However, there has been a relative absence of an integrative neurobiological approach to better understand correctional treatment outcome. The current dissertation contributed to a highly explorative field of research by investigating the relationship between neurobiological impairments and prisoners’ treatment outcome. The results indicate that there is preliminary evidence for a reciprocal relationship between neurobiological deficits and correctional intervention. At the same time, this dissertation highlights important knowledge gaps requiring future research to initiate further research and practical advances. Overall, we have tried to test the added value of neurobiological knowledge against more traditional psychosocial perspectives in order to gain more insight into crime-related issues, such as the large amount of variation in treatment effectiveness.
References


Buysse, W., & Loef, L. (2012). Effectiveness of the cognitive skills treatment (CoVa) for offenders. Amsterdam: DSP-groep.


