DOES A COGNITIVE SKILLS TRAINING PROGRAM FOR PRISONERS AFFECT NEUROCOGNITIVE FUNCTIONING AND HEART RATE ACTIVITY?

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This study investigates changes in neurobiological characteristics after a cognitive skills program for prisoners. It was hypothesized that prisoners who completed a cognitive skills training program would show improved neurocognitive functioning and changes in heart rate (HR) activity. In addition, it was expected that neurobiological changes were related to behavioral improvement. Male adult prisoners were included in the study and divided into two groups: the "intervention group"—prisoners participating in a cognitive skills training program—and the "control group"—prisoners placed on a waitlist. Several neurocognitive skills and HR activity measures were assessed at pre- and posttest assessment. In addition, trainers, prison officers, and prisoners were requested to evaluate behavioral changes over time. Results did not confirm the hypotheses. The absence of both neurobiological and behavioral improvement is discussed in light of the measures used, the content and duration of the current intervention program, and the prison setting.

Keywords: intervention; prisoners; neurocognition; heart rate activity

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Numerous brain imaging studies have revealed impairments in prefrontal brain functioning associated with antisocial and violent behavior (for reviews, see Koenigs, 2012; Wahlund & Kristiansson, 2009; Yang & Raine, 2009). The prefrontal brain area is known to give rise to complex neurocognitive functions, that is, a collection of functions necessary for self-regulation and the regulation of socially appropriate behavior. Impairments in these neurocognitive functions have received considerable research attention in relation to different operationalizations of antisocial behavior (for reviews, see Brower & Price, 2001; Meijers, Harte, Jonker, & Meynen, 2015; Morgan & Lilienfeld, 2000; Ogilvie, Stewart, Chan, & Shum, 2011). Overall, there is empirical evidence for a link between prefrontal brain impairments affecting specific skills, including empathic capacities, self-reflection, behavioral inhibition, and emotion regulation, which in turn may lead to increased risk of engaging in antisocial behavior (Raine, 2008).

During the last decade, several researchers have suggested that neuroscientific findings might provide us with more insight into how to best intervene with criminal behavior (Beauchaine, Neuhaus, Brenner, & Gatzke-Kopp, 2008; Glenn & Raine, 2014; E. H. Ross & Hoaken, 2010; R. R. Ross & Hilborn, 2008; Van Goozen & Fairchild, 2008; Vaske, Galyean, & Cullen, 2011). This is an important matter, as current intervention programs aimed to reduce antisocial behavior show varying degrees of success. For example, cognitive-behavioral therapy (CBT), one of the most well-accepted treatment options for offenders, has a success rate varying from less than 10% to almost 50% reduction of criminal recidivism across different studies (Landenberger & Lipsey, 2005; Lipsey & Cullen, 2007; Lipsey, Landenberger, & Wilson, 2007; McDougall, Perry, Clarbour, Bowles, & Worthy, 2009). A certain amount of that variability reflects statistical noise and unsystematic differences in study procedures and methods. However, according to Lipsey and Cullen (2007), much of it is related to substantive characteristics of the treatment and the offender samples to which the interventions are applied. Overall, the varying results suggest that criminal recidivism rates are not substantially reduced for a fairly large group of offenders.

Recent empirical literature has suggested promising effects of neuroscience in understanding why some intervention programs are effective in reducing recidivism rates and why some offenders benefit more from therapy than others. For example, Mullin and Simpson (2007) reported that poor neurocognitive functioning before a cognitive skills training program for prisoners was predictive of better treatment outcomes. However, in contrast to this finding, Fishbein et al. (2009) found that prisoners with poor neurocognitive functioning benefitted less from correctional intervention compared with those with normal to high neurocognitive functioning. Results from our own research group (Cornet, Van der Laan, Nijman, Tollenaar, & De Kogel, 2015) indicate that a specific neurocognitive task, the d2 test of attention, has the potential to predict prisoners' treatment dropout above and beyond several traditional background and behavioral characteristics, including self-reported treatment motivation. Although these studies indicate that there is a relationship between level of neurocognitive functioning and the effectiveness of correctional intervention, the underlying mechanisms remain poorly understood (Cornet, De Kogel, Nijman, Raine, & Van der Laan, 2014).

Interest in the relationship between neuroscience and the effectiveness of CBT is not limited to the correctional field. Much more research has been conducted on this issue in the field of clinical psychiatry and psychology. For example, Kandel (1998), a well-known psychiatrist and neuroscientist, has hypothesized that long-lasting changes in behavior due to psychotherapies (including CBT) are supported by changes in gene expressions. These changes in gene expression in turn modify the strength of synaptic connections in the brain and structural changes that alter the anatomical pattern of interconnections between nerve cells. In other words, psychotherapy changes not only the mind but also the brain (Kandel, 1998). Empirical studies have confirmed Kandel's hypotheses, showing strong evidence for "normalization" of neural patterns after CBT in patients with various psychiatric disorders (including panic disorder and obsessive compulsive disorder; for reviews on this subject, see Karlsson, 2011; Linden, 2006; Porto et al., 2009). With regard to correctional CBT programs, a theoretical article by Vaske et al. (2011) suggests that CBT may be effective in reducing problem behavior, including crime, because the intervention affects specific areas of the brain that are related to antisocial behavior (such as the prefrontal region).

Overall, both empirical and theoretical studies have shown that brain functioning may moderate correctional treatment outcome. In addition, there appears to be also a clinically relevant relationship between CBT and brain functioning in the way that the effectiveness of CBT is likely to be rooted in how this intervention program affects one's brain functioning. In other words, there might exist a reciprocal relationship between changes in brain functioning and the outcome of behavioral intervention programs (brain functioning ↔ behavioral treatment; Vaske et al., 2011).

Nowadays, several correctional intervention programs (e.g., cognitive skills training and anger management training) claim to address neurocognitive deficits, such as poor problem solving and impulsivity. However, it is unclear as to whether these capacities are actually being targeted or improved (E. H. Ross & Hoaken, 2010). To our knowledge, only three studies have been conducted examining brain functioning after intervention programs aimed to reduce antisocial behavior (Lewis et al., 2008; E. H. Ross, 2012; Woltering, Granic, Lamm, & Lewis, 2011). Both Woltering et al. (2011) and Lewis et al. (2008) found that among children with problem behavior who showed improved behavior after a training program, called "Stop Now and Plan," there was a reduction in ventral prefrontal brain activity as measured with electroencephalography (EEG). According to the authors, a reduction in the ventral brain activity indicates increased efficiency of self-regulatory mechanisms. In contrast, the dissertation by E. H. Ross (2012) showed no significant improvement in neurocognitive functioning among adult prisoners after different intervention programs.

Overall, research on neurocognitive changes after correctional intervention is extremely limited, and results are mixed. On the contrary, there seems to be relatively strong empirical support for changes in psychophysiological factors in response to intervention programs aimed to reduce antisocial behavior. A systematic literature review conducted by our research group revealed that values of specific physiological processes, especially basal cortisol levels, changed after intervention in individuals with different types of antisocial behavior (Cornet, De Kogel, Nijman, Raine, & Van der Laan, 2015). In addition, one of the most replicated physiological correlates of antisocial/aggressive behavior is resting heart rate (HR; Lorber, 2004; Ortiz & Raine, 2004; Portnoy & Farrington, 2015). In other words, individuals with antisocial behavior are more likely to show a lower number of heartbeats per minute in a state of inactivity. Despite the fact that resting HR is frequently associated with criminal behavior, no study was found on changes in resting HR after a behavioral intervention program.

To further explore this issue, HR activity is measured in the current study, and the following hypotheses were formulated. We hypothesized that resting HR increases among prisoners who complete a behavioral intervention program. However, prison populations are often associated not only with antisocial behavior problems but also with other comorbid problems such as depression, anxiety, and psychotic symptoms (Fazel & Danesh, 2002). From the literature, it is known that psychiatric disorders like these have, if anything, been associated with higher (not lower) resting HR (Raine, 2002). Therefore, it was expected that for some prisoners, resting HR may increase and, for some prisoners, HR may decrease following effective intervention, depending on their pretreatment psychiatric condition. In other words, we expect to find changes in HR activity among prisoners who complete a cognitive-behavioral intervention program. Nonetheless, there is poor understanding of the underlying mechanisms that cause these physiological changes, but one idea is that (electro) physiological measures are more sensitive to detect treatment-induced changes than behavioral measures (Bruce, McDermott, Fisher, & Fox, 2009). This suggests that future examination of treatment effectiveness might benefit from a multilevel assessment procedure including neurobiological methods.

The aim of the current study is to further explore the effect of a cognitive skills training program for prisoners on their neurocognitive and physiological (i.e., HR activity) functioning. Results might lead to suggestions on how to improve pre- and postintervention assessment, and how to best tailor current intervention programs toward offenders' neurocognitive deficits/needs to increase the success rate of intervention and reduce the chances of reoffending. First, the current study examines changes in neurocognitive functioning and HR activity in male adult prisoners after cognitive skills training compared with a waitlist control group. Second, the relationship between behavioral changes after intervention and neurobiological changes is investigated in an attempt to better understand the working mechanism of the intervention. We hypothesize the following: Prisoners who complete a cognitive skills training program show (1) improved neurocognitive functioning and (2) changes in HR activity, and (3) it is expected that treatment-induced neurobiological changes are related to behavioral improvement.

METHOD

PARTICIPANTS

Participants consisted of male adult prisoners selected by Probation Service officers for cognitive skills training. In total, 190 prisoners agreed to participate in the study. Their mean age was 29.87 (SD = 9.01 years). Of the full sample, 121 prisoners started with the intervention ("intervention group"), and 69 prisoners served as a waitlist control comparison group ("control group"). The control group participants were selected for the cognitive skills training program but were not able to start the intervention due to various practical reasons (e.g., no trainers available or insufficient number of candidates to start intervention). For both groups, the only reason for exclusion from participation in the current study was an unstable psychological or physical condition as reported by the prisoners themselves. The study was approved by the Medical Ethics Committee of the VU University Medical Center Amsterdam (Ref. no: NL36062.029.11 Central Committee on Research Involving Human Subjects [CCMO]) while informed consent to participate in this study was sought from the prisoners. Participation was voluntary and was compensated with €25.

Of the full sample, almost 63% were born in the Netherlands, about 8% were born in Surinam, and a similar percentage was born in the Netherlands Antilles. Furthermore, almost 5% were born in Morocco, 2% in Turkey, and about 14% were born in other Western or non-Western countries. Compared with the total Dutch prison population (Centraal Bureau voor Statistiek, 2014), there were slightly more Dutch-born (up to 10%) participants in the current study.

COGNITIVE SKILLS TRAINING

The cognitive skills training (called "CoVa") central to this study is an adapted and translated version of the English "Enhanced Thinking Skills" (ETS) program (Clark, 2000). The intervention is provided by the Probation Service and consists of 20 sessions, containing two 2-hr sessions per week. The CoVa training is provided either within or outside the prison setting. In this study, participants received the training program inside the prison. The program aims to improve cognitive skills, to increase prosocial behavior, and to change criminal attitudes. Using role-playing exercises and other practical exercises, an attempt is made to change the criminal thinking patterns of the prisoners. The underlying idea is that criminal thinking patterns predispose to antisocial behavior (Reclassering Nederland, 2004). For detainees, participation in the CoVa training program is voluntary, but refusing treatment may affect the timing of their provisional release from prison.

The Dutch Probation Service is responsible for the treatment allocation procedure. In general, the intervention is developed for prisoners with a medium to high level of recidivism risk in combination with cognitive deficits. With help of guided selection criteria, Probation Service officers decide which prisoners are eligible to participate in the intervention program. In the Netherlands, a screening instrument based on the risk-need-responsivity model called the "RISc"—Recidive Inschattings Schalen, a Dutch translation of the Offender Assessment System (OASys; Howard, Clark, & Garnham, 2003)—is used on a national scale to allocate prisoners to intervention programs based on their criminal needs and cognitive deficits (Vinke, Vogelvang, Erftermeijer, Veltkamp, & Bruggeman, 2003). To complete RISc records, Probation Service officers use criminal record information, interviews with the detainee, and detainee's references to identify relevant cognitive deficits. The following cognitive skill items are central to the RISc assessment: (a) social and interpersonal skills, (b) impulsivity, (c) dominant behavior, (d) self-control, (e) problem insight, (f) problem solving skills, (g) goal-directed behavior, and (h) ability to learn. To be assigned to the CoVa training program, prisoners have to display moderate problem behavior on all eight items or severe deficits on items 2, 5, 6, 7, and 8. Other treatment inclusion criteria are as follows: age 18 or over, sufficient Dutch language proficiency, no special psychiatric care, a valid residence permit, and a remaining sentence duration of 4 months or more (Ferwerda, van Wijk, Arts, & Kuppens, 2009).

DESIGN AND PROCEDURE

Figure 1 displays the recruitment process of participants in both groups. Lists of selected participants for treatment were requested from several prisons in the Netherlands between 2011 and 2014. Recruitment process details of the intervention group are described elsewhere (Cornet, Van der Laan, et al., 2015). Control group participants were put forward by prison contact persons.[1] Inclusion criteria for control group participants were as follows: (a)

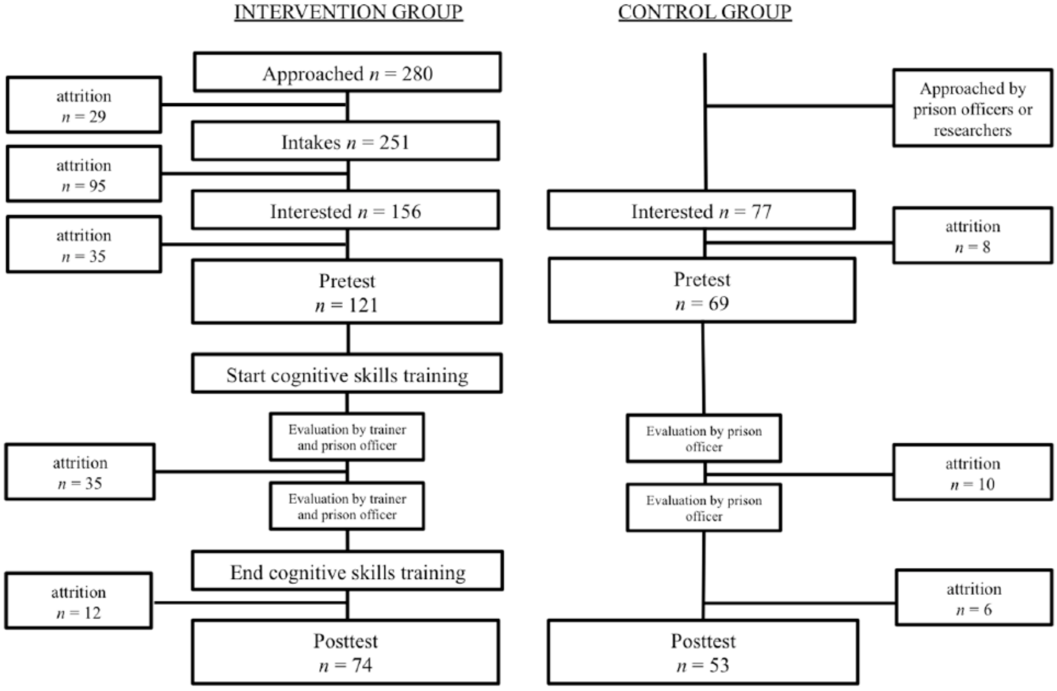

Figure 1: Recruitment Process and Attrition Rate

being selected by Probation Service officers for CoVa participation, (b) no training participation within the upcoming 2 months, and (c) no history of CoVa participation. Once potential participants showed interest in the current study, an introductory meeting was scheduled either between the contact person and the prisoner or between one of the researchers and the prisoner. In total, 77 prisoners volunteered to take part in the study. Of these, 69 prisoners attended the pretest measurement. Reasons for attrition before pretest phase were “no-show” or practical reasons (e.g., other activities were scheduled). Of the 69 participants, 16 prisoners did not complete the posttest measurement due to various reasons, such as provisional release from prison, transfer, or unforeseen CoVa participation. Overall, 53 prisoners in the control group completed both the pre- and posttest measurement.

Researchers and master’s students with a background in psychology, who were independent of the correctional facility, assessed participants at different time intervals. At pretest assessment, participants completed several neurocognitive tasks and underwent HR measurement. This assessment was repeated after intervention completion for participants in the intervention group with an average of 9.44 days (*SD* = 8.17 days, range = 0-55 days) between the completion of intervention and the posttest assessment. Average time between pretest and posttest assessment was 92.96 days (*SD* = 13.46 days, range = 62-132 days). For control group participants, posttest assessment was scheduled on average 78.21 days (*SD* = 10.09 days, range = 59-94 days) after pretest assessment. During posttest, prisoners were asked to evaluate potential changes in their way of behaving and/or thinking. Furthermore, prison officers were asked to evaluate prisoners’ aggressive behavior on the ward twice (shortly after pretest and right before posttest for both groups). In addition, CoVa trainers were also asked to evaluate the behavior of prisoners in the intervention group at two time periods: at the beginning and at the end of intervention.

MEASURES

Verbal Intelligence Level

A Dutch version of the National Adult Reading Test (Nederlandse Leestest voor Volwassenen [NLV]) was used as a measure of verbal IQ (Nelson, 1982; Nelson & O'Connell, 1978; Schmand, Lindeboom, & van Harskamp, 1992). The total NLV score appears to correlate highly with the Wechsler Adult Intelligence Scale's (WAIS) total IQ score (.74) and the total verbal IQ score (.85; Schmand et al., 1992). The NLV score is not valid for non-native Dutch speakers (B. A. Schmand, personal communication, December 22, 2010). For this reason, participants who did not complete at least primary school in the Netherlands were not eligible to complete the NLV test (n = 14, intervention group; n = 8, control group).

Neurocognitive Functioning

Neurocognitive tasks were selected based on the following: (a) literature concerning the relationship between cognitive dysfunctioning and antisocial behavior (Brower & Price, 2001; Morgan & Lilienfeld, 2000; Ogilvie et al., 2011), (b) domains of cognitive functioning addressed by the CoVa training (interpersonal problem solving skills, self-control, social perspective–taking skills, and critical/moral reasoning), and (c) studies included in the literature review that found a predictive value of specific cognitive function tasks in relation to CBT for prisoners (Fishbein et al., 2009; Mullin & Simpson, 2007). This resulted in the selection of the following neurocognitive tasks: the Stroop Color–Word Task, Concept Shifting Test (CST), the d2 test of attention, the Wechsler Adult Intelligence Scale, Third Edition (WAIS-III) Digit Span, the Modified Wisconsin Card Sorting Task (M-WCST), the Tower of Hanoi (TOH), the Stop It Task, the Reading the Mind in the Eyes Task, and the Controlled Oral Word Association Task (COWAT). A detailed description of the selected neurocognitive tasks can be found in the online supplemental information (see Table S1; available at cjb.sagepub.com/supplemental).

Physiological Functioning

HR activity was measured using the VU ambulatory monitoring system (AMS; VU University, Amsterdam; de Geus, Willemsen, Klaver, & Van Doornen, 1995; Willemsen, de Geus, Klaver, Van Doornen, & Carroll, 1996). The device continuously recorded HR (in beats per minute [bpm]) and HR variability (respiratory sinus arrhythmia [RSA] in milliseconds [ms]), which is a measure of parasympathetic functioning (Berntson, Cacioppo, & Quigley, 1991). VU-AMS software package 3.5 automatically scored all beats in the electrocardiogram (ECG). A trained junior researcher used the VU-AMS Manual version 1.1 to manually check the entire recording to detect irregularities. The dependent measures were HR reactivity (HR during stress minus HR during baseline) and RSA reactivity (RSA during stress minus RSA during baseline). The stressful period entailed a 4-min VU-AMS recording during the d2 test of attention. This neuropsychological task assesses attention and concentration skills, and requires participants to mark as many targets as possible within a certain time limit (Brickenkamp, 2007). However, it is almost impossible to complete the task within the given time limit. As a result, it was expected that participants would experience a mild form of stress, or frustration, while completing the d2 test of attention, and therefore, HR activity during the completion of this task may reflect a physiological reaction to cognitive stress. Baseline HR activity was measured during a 5-min relaxation moment in which the participant was sitting behind a laptop screen with headphones on, and was presented with emotionally neutral pictures (e.g., nature pictures) and relaxing classical music.

Sentence-Related Information

Previous research has shown the relationship between specific sentence-related characteristics and treatment outcome of offenders (Fishbein et al., 2009; Mullin & Simpson, 2007). For this reason, we included available sentence-related characteristics for both groups. Information with regard to index offense and the age at first judicial contact was derived from RISc records. The index offense was classified as either violent (e.g., robbery, attempted murder) or nonviolent (e.g., theft, drug trafficking). In addition, level of cognitive deficits as evaluated by the Probation Service was also obtained from RISc files. Prisoners were assessed using the RISc instrument on the following cognitive aspects: impulsiveness, problem insight, problem management, future orientation, and thinking/learning style. Finally, the Custodial Institutions Agency (DJI) of the Ministry of Security and Justice provided information on the total number of previous imprisonments.

Intervention Outcome Measures

To explore whether neurobiological changes are associated with behavioral improvement after intervention, the effectiveness of the intervention on behavior was assessed with three different treatment outcome measures. First, prisoners' behavior in the intervention group was assessed with the English questionnaire Treatment Gain: Short Scale used by Fishbein and Sheppard (2006). The questionnaire was translated into Dutch and edited for the current study. Trainers were asked to complete the questionnaire comprising seven multiple-choice questions on participant's skills, participation, and competence during treatment. The questionnaire was completed at two time points: shortly after the start of treatment and before the end of treatment. Cronbach's alpha was found to be good (.84) for both assessments.

Second, prison officers were asked to evaluate prisoners' behavior using the Social Dysfunction Aggression Scale (SDAS; Wistedt et al., 1990). The SDAS is an 11-item (scaled 0 to 4) period-based instrument that records a variety of aggressive behaviors, ranging from mild to moderate to severely aggressive behavior. The reliability of the SDAS has been found to be sufficient (Kobes, Nijman, & Bulten, 2012; Wistedt et al., 1990; Zaalberg et al., 2015). The SDAS was also completed at two time periods: at the start and end of treatment. Prison officers were asked to rate prisoners' aggressive behavior in the past week with questions such as "To what extent did the prisoner use verbal aggression in the past week?" This questionnaire was also completed at two time periods for prisoners in the control group.

Finally, a three-item questionnaire was specifically designed to assess self-reported treatment gain. Participants in the intervention group were asked to answer the following questions: “Do you think you benefitted from the training?” “To what extent do you think you are able to apply the acquired skills outside prison?” and “Do you notice any changes in the way you think/behave after completing treatment?” The dependent variable is the total score on the three items. The internal reliability of this measure appears to be acceptable (Cronbach’s α = .72). A principal axis factor analysis was conducted on the three items with oblique rotation (direct oblimin). This analysis revealed that the three items loaded on one similar factor (only one factor with an eigenvalue greater than 1 was found that explained more than 60% of the variance).

STATISTICAL ANALYSIS

Attrition Rate and Imputation Strategies

In both groups, missing values were identified on several variables. In the intervention group, the average percentage of missing values per variable was 16.9% (range = 0%-43.8%). Comparable results were found in the control group, with an average percentage of missing values being 16.2% (range = 0%-42%). The highest percentage of missing values was detected on posttest measures. A complete case approach, in which participants with missing values are simply excluded from analyses, would lead to a decrease in statistical power and could result in a biased effect estimate if the remaining cases are not representative of the complete sample. Therefore, we decided to impute missing values with a multiple imputation (MI) technique (Rubin, 1987; van Buuren, 2012).[2]

To impute data, the imputation model should have sufficient data to estimate the model. For this reason, it was decided to exclude participants with a relatively high percentage of missing values (more than 50%; IBM, n.d.; S. van Buuren, personal communication, February 9, 2015). In the control group, five prisoners completed less than 50% of the measures, and therefore, the final sample for imputation consisted of 64 prisoners in the control group. In the intervention group, 35 prisoners did not complete treatment. Because less or no intervention effect on both behavioral and neurobiological measures was expected for noncompleters, we decided not to include these 35 participants in analyses. Of the remaining 86 participants, two prisoners had more than 50% missing data. Thus, 84 participants in the intervention group were found eligible for further analyses.

Statistical Analysis

First, a power analysis was conducted. This power analysis was based upon medium effect sizes (d = .5), as medium effect sizes are considered as clinically more relevant than small effect sizes. Based on Cohen (1988), a total sample size of 100 would be sufficient to detect medium effect sizes with 80% power. This suggests that both groups (intervention and control groups) should include at least 50 participants. The current research samples meet this criteria.

The first statistical analysis included an independent sample t test to test for group differences on relevant background characteristics (see Table 1). Results indicate that both groups were identical on most background characteristics. However, there appeared to be a small, but significant, difference in age between the two groups. In addition, a higher proportion of offenders were imprisoned for a violent offense in the intervention group compared with the control group (80.7% vs. 59.53%, respectively). To account for these differences in

TABLE 1: Background Characteristics of Intervention and Control Group Participants

	Condition						
	Intervention $n = 84$		Control $n = 64$		Independent *t* test		
Characteristic	*M*	*SD*	*M*	*SD*	*df*	*t*	*p*
Age	28.58	7.90	31.84	9.38	122.42	−2.241	.025*
Verbal IQ	80.55	9.85	79.78	9.60	893	.416	.678
Previous imprisonments	3.55	3.04	3.59	3.84	4,756.04	.878	.380
Age at first judicial contact[a]	18.02	5.56	19.05	5.89	2,487	−1.097	.273
Recidivism risk[a]	2.89	0.93	2.98	0.93	260	−.530	.597
Cognitive deficits[a]	5.43	1.90	5.37	1.70	18,179	.183	.855
Index offense[a]					Chi-square test		
Violent offense	80.7%		59.53%		χ^2		*p*
Nonviolent offense	19.3%		40.47%		8.046		.005*

Note. RISc = Recidive Inschattings Schalen.
a. Derived from RISc files completed by Probation Service officers.
*$p < .05$.

background characteristics, age and index offense are treated as covariates in subsequent analyses. Furthermore, ANCOVAs were performed using general linear models to test for intervention effects. Before analyses, assumptions of ANCOVA (e.g., normality, linearity, and homogeneity of regression slopes) were verified. In addition, data were screened for outliers using 5% trimmed mean information and by inspecting boxplots. “Extreme” outliers, as defined by SPSS,[3] were removed from subsequent analyses. These outliers were caused by various factors, such as measurement errors (as happened with the HR equipment), extreme fatigue as reported by the prisoner, or prisoners’ lack of understanding of task instructions.

To account for variation in neurocognitive functioning and HR activity on the posttest, we examined whether participants in both groups differed on specific confounders (country of birth, history of brain injury, smoking, physical activity, medication usage, and body mass index). There appeared to be a small significant difference in the average number of cigarettes smoked per day between the intervention group, who smoked on average 6.62 (SD = 5.81) cigarettes per day, and the control group, who smoked on average 9.50 (SD = 9.85) cigarettes per day, $t(11055.60) = -2.07$, $p = .039$. Furthermore, prisoners in the control group were significantly more likely to report a change in medication usage between pre- and posttest compared with the intervention group, $\chi^2(1, N = 148) = 6.61$, $p = .01$. Because literature has suggested that both smoking and medication can affect HR activity (e.g., Armstrong, Keller, Franklin, & MacMillan, 2009; Portnoy et al., 2014; Scarpa, Haden, & Tanaka, 2010), these variables were included as additional covariates in subsequent analyses. In addition, some medications, such as antidepressants, might affect neurocognitive functioning (Biringer, Rongve, & Lund, 2009), and therefore, change in medication usage between pre- and posttest was also included as a covariate in the ANCOVAs on neurocognitive functioning.

To investigate whether the intervention group showed improved neurocognitive functioning and HR activity after treatment compared with the control group, separate ANCOVAs were run on every posttest score including relevant covariates (e.g., pretest score, age, index offense, medication, and smoking) and group membership (intervention group or control group) as fixed factor. Effect sizes were calculated with the Campbell Collaboration effect size calculator.

RESULTS

CHANGES IN NEUROCOGNITIVE FUNCTIONING AND HR ACTIVITY

Table 2 shows the means and standard deviations on all measures for both the intervention group and the control group. In addition, results of the ANCOVA analyses on posttest scores are displayed. Sample sizes differ due to the removal of extreme outliers and preselection of valid predictors for imputation (i.e., posttest TOH errors in the control group; see supporting information). Neurocognitive tasks are divided into two sections: (a) a collection of measures assumed to decrease between pre- and posttest (e.g., number of errors) and (b) measures that are assumed to increase between pre- and posttest (e.g., total correct). Overall, performances on tasks changed into the expected direction for both groups. However, the results show no support for a treatment effect of the CoVa training on neurocognitive functioning and HR activity.

As mentioned earlier, there are reasons to suspect that specific subgroups benefit more from therapy than others. Based on previous research, we expected that prisoners with low neurocognitive skills pretreatment and older prisoners would benefit less from intervention (Cornet, Van der Laan, et al., 2015; Fishbein et al., 2009; Giedd et al., 1999; Johnson, Blum, & Giedd, 2009; Mullin & Simpson, 2007; Sowell, Thompson, Tessner, & Toga, 2001). However, post hoc ANCOVA analyses including percentile-based subgroups (low, medium, and high neurocognitive functioning, and young, middle, and old prisoners) did not reveal interaction effects on posttest neurocognitive functioning. Overall, we could not confirm the existence of specific subgroups that benefit more from intervention than others.[4] In addition, we expected that prisoners with relatively low initial HR activity would show increased HR activity after intervention and prisoners with relatively high HR activity would show a decrease after intervention compared with the control group. Again, post hoc ANCOVA analyses did not reveal significant interaction effects.[5]

BEHAVIORAL CHANGES

With regard to behavioral changes, evaluations of prisoners' behavior in the intervention group as reported by trainers significantly rose from 17.54 (SD = 3.59) at pretest to 18.73 (SD = 3.20) at posttest, t(11460) = −3.58, p < .001. Nevertheless, this positive change in behavior was not reflected by evaluations of the intervention group reported by prison officers, as SDAS scores were 2.88 (SD = 4.54) at pretest and 2.17 (SD = 3.17) at posttest, t(71406) = .643, p = .520. A similar pattern was observed for prisoners in the control group, where SDAS scores changed from 3.18 (SD = 4.10) to 2.81 (SD = 3.86) from pre- to posttest, t(2063) = .688, p = .492.

With regard to the self-evaluation, prisoners in the intervention group responded relatively positive on Question 1 ("Do you think you benefitted from the training?"), where 66% responded *yes*, and Question 2 ("To what extent do you think you are able to apply the acquired skills outside prison?"), where 81% answered between sufficient and excellent.

TABLE 2: Changes in Neurocognitive Functioning and HR Activity Between Pre- and Posttest Assessment

	Pretest				Posttest						
	Intervention		Control		Intervention		Control		ANCOVA		
	n	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*n*	*M* (*SD*)	*F*	*p*	Cohen's *d*
Measures assumed to decrease											
Stroop Color–Word Task—interference (s)	83	29.71 (15.16)	64	29.47 (11.12)	84	25.27 (10.93)	64	26.33 (12.03)	0.0697	.793	.0439
CST—shifting score (s)	80	−4.21 (7.14)	63	−3.71 (7.60)	84	−2.51 (6.83)	62	−3.53 (5.51)	0.5095	.478	.1213
M-WCST—total errors	84	11.42 (9.58)	64	12.35 (11.45)	84	8.49 (8.29)	64	7.93 (7.45)	1.7011	.197	.2164
TOH—errors	83	6.10 (4.52)	62	7.35 (5.93)	83	5.23 (5.00)	50	5.64 (3.88)	2.5725	.111	.2896
Stop It—SSRT (ms)	84	221.17 (44.88)	63	272.68 (73.06)	84	219.54 (48.15)	64	251.96 (41.68)	4.8322	.031[a]	.3683
Measures assumed to increase											
d2 test of attention—CP	84	170.05 (30.68)	64	164.92 (34.03)	84	192.60 (39.42)	64	189.16 (35.42)	0.4380	.510	.117
WAIS Digit Span—total correct backward	84	5.76 (1.97)	64	5.53 (1.77)	84	6.19 (1.82)	64	5.73 (1.95)	1.4838	.226	.2021
M-WCST—categories correct	84	4.84 (1.67)	64	4.69 (1.90)	81	5.25 (1.31)	64	5.28 (1.23)	1.9464	.167	.234
TOH—total planning time (s)	84	72.95 (28.53)	63	75.232 (30.90)	84	74.42 (28.51)	63	73.77 (30.46)	0.0073	.932	.0142
Reading the Mind in the Eyes—total correct	84	19.70 (3.04)	64	19.39 (3.77)	84	20.23 (2.70)	64	19.80 (2.63)	0.3745	.544	.1015
COWAT—total words correct	84	27.61 (9.51)	64	30.52 (9.74)	83	30.83 (8.81)	64	31.63 (9.20)	0.9378	.335	.1611
HR measures											
HR—rest (bpm)	84	69.07 (9.79)	64	68.83 (13.19)	84	70.07 (10.59)	64	70.97 (9.32)	0.5258	.471	.1203
HR—d2 task (bpm)	84	76.65 (10.93)	63	75.07 (12.69)	84	76.63 (11.44)	64	77.03 (10.43)	0.6792	.412	.1374
RSA—rest (ms)	84	85.99 (52.19)	63	78.20 (44.32)	83	79.26 (50.06)	64	69.93 (36.23)	0.0238	.878	.0258
RSA—d2 task (ms)	82	63.19 (39.90)	61	58.03 (36.77)	79	56.41 (33.62)	64	52.19 (26.02)	0.3269	.569	.0972

Note. CST = Concept Shifting Test; M-WCST = Modified Wisconsin Cart Sorting Test; TOH = Tower of Hanoi; SSRT = Stop Signal Reaction Time; CP = concentration performance; WAIS = Wechsler Adult Intelligence Scale; COWAT = Controlled Oral Word Association Task; HR = heart rate; RSA = respiratory sinus arrhythmia.
a. This result did not remain significant after correction for multiple testing.

TABLE 3: Correlations Between Behavioral Evaluations and Changes in Neurocognitive Functioning and HR Activity

	Trainer change	SDAS change[a]	Self-evaluation
Stroop interference	−.050[b]	.027[b]	−.034[b]
CST shifting	−.061[b]	−.097	−.145
COWAT	−.151	−.122[b]	−.018[b]
d2—CP	.032	.146	−.032
TOH errors	.004[c]	−.069[c]	−.140[c]
TOH planning time	.042	−.108	−.058
Reading the Mind in the Eyes	.079	−.013	−.120
Digit Span backward	.020	.059	.053
M-WCST categories correct	−.052[d]	.079[d]	−.077[d]
M-WCST errors	.136	−.064	.108
SSRT	−.088	−.116	−.044
HR rest	.120	.105	.165
HR stress	.143	.159	.146
RSA rest	−.009[b]	.036[b]	−.086[b]
RSA stress	−.036[e]	−.201[e]	−.174[e]

Note. SDAS = Social Dysfunction Aggression Scale; CST = Concept Shifting Test; COWAT = Controlled Oral Word Association Task; CP = Concentration Performance; TOH = Tower of Hanoi; M-WCST = Modified Wisconsin Cart Sorting Test; SSRT = Stop Signal Reaction Time; HR = heart rate; RSA = respiratory sinus arrhythmia. n = 84 unless otherwise stated.
a. An increase in SDAS indicates an increase in aggressive behavior on the ward.
b. n = 83.
c. n = 82.
d. n = 81.
e. n = 80.

However, answers were mixed on the final question ("Do you notice any changes in the way you think/behave after completing treatment?"), where 45% answered yes and 55% responded either *no* or *don't know*.

The second aim of this study was to investigate the relationship between behavioral changes and changes in neurocognitive functioning and HR activity after intervention. However, no significant changes were detected on neurocognitive tasks and in HR activity in favor of the intervention group. Nevertheless, mean group scores could have masked the presence of individual improvement on specific tasks and behavioral measures. To examine the relationship between neurobiological changes and behavioral improvement, change scores were created by subtracting pretest from posttest scores. Table 3 presents the correlations between changes in behavioral evaluations, as reported by the trainer, the prison officer, and the prisoners themselves, and neurocognitive/HR activity changes. Overall, no significant correlations were found. Thus, the results indicate that the significant behavioral improvement after intervention as reported by trainers was not reflected in neurocognitive or HR activity improvement.

DISCUSSION

The aim of the present study was to examine changes in neurocognitive functioning and HR activity in male adult prisoners following cognitive skills training compared with a waitlist control group. It was hypothesized that prisoners who completed cognitive skills training would show improved neurocognitive functioning and changes in HR activity. Furthermore, it was expected that treatment-induced neurobiological changes were related to behavioral improvement. Overall, the empirical results of the current study did not support these hypotheses.

Results did not provide evidence for a change in neurocognitive functioning in favor of the intervention group. Although these results do not confirm our first hypothesis, they are in line with a similar study conducted by E. H. Ross (2012). In her dissertation, Ross' sample comprised of 119 prisoners, 69 of which completed an intervention (e.g., violence prevention program or substance abuse program), and 50 inmates served as a control group. Overall, no changes in neurocognitive functioning were detected among prisoners who completed intervention. E. H. Ross (2012) argued that one possible reason for the absence of change among these prisoners was a lack of impairments in neurocognitive functioning at pretest. A lack of neurocognitive deficits might suggest that there is no, or at least reduced, potential for improvement. In the current study, data from RISc files completed by Probation Service officers supported the presence of cognitive deficits among prisoners. However, the absence of data from prisoners not selected for intervention or a healthy control group makes it difficult to conclude whether impairments on neurocognitive tasks were also present. To verify if the current sample suffered from impaired neurocognitive functioning at pretest, a post hoc literature comparison was performed.[6]

The balance of the evidence suggests that prisoners in the current sample generated substantially fewer words on the COWAT compared with healthy controls and other offender samples. This phonemic verbal fluency task requires participants to retrieve words from their lexicon memory while remembering the instructions and earlier responses in working memory. In addition, participants are required to suppress irrelevant responses and repetition. In general, the task requires a complex set of cognitive skills and involves executive control processes (e.g., the ability to regulate one's thoughts and direct behavior toward a general goal; Henry & Crawford, 2004; Henry, Crawford, & Phillips, 2004; Lezak, Howieson, Bigler, & Tranel, 2012; Shao, Janse, Visser, & Meyer, 2014). Overall, the results are in contrast with those of E. H. Ross (2012), who found no impairments in prisoners' neurocognitive functioning pretreatment. The impaired verbal fluency skills in the current sample might suggest that there was potential for improvement.

Another possible explanation for the absence of neurocognitive improvement after intervention is related to the selection of the neurocognitive tasks we used. It is conceivable that the selected neurocognitive skills were not targeted during intervention and, therefore, may not have undergone change. Although all measures were selected with care and based on several arguments, there is no golden standard how to best assess neurocognitive deficits in an accurate and valid manner (Chan, Shum, Toulopoulou, & Chen, 2008). Nevertheless, the fact that the current sample displayed impaired verbal fluency skills has clinically relevant implications. This finding suggests that to be more effective, current intervention programs should be tailored toward specific neurocognitive deficits, as it has been shown that these skills, such as impaired verbal fluency skills, are consistently related to antisocial behavior (Morgan & Lilienfeld, 2000; Ogilvie et al., 2011).

The effectiveness of the current intervention program is a hot topic, as research evaluations of the ETS program have provided mixed results regarding its success in reducing reoffending rates. Although there is evidence for a 14% reduction in recidivism rates (Friendship, Blud, Erikson, Travers, & Thornton, 2003), there are also studies that show no difference in reconviction rates between ETS participants and control participants (see, for overview, Gobbett & Sellen, 2014). In addition, a recent study of more than 1,400 prisoners in the Netherlands found that inmates 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 after the CoVa training (Buysse & Loef, 2012). However, definite conclusions about the effectiveness of the CoVa training cannot be drawn from the study by Buysse and Loef because no control group was included. In addition, recidivism data after the CoVa training are currently not available in the Netherlands.[7]

The study by Buysse and Loef (2012) also revealed that one third of the provided CoVa trainings between 2008 and 2012 did not meet the treatment integrity criteria and that 32% of the inmates did not fully meet the CoVa suitability criteria (as described in the "Cognitive Skills Training" section). A relatively low adherence to the suitability criteria was also found in a study by Sadlier (2010) where only 58% of the ETS participants fully met the targeting criteria. Overall, the efficiency of the CoVa training appears to be limited, and behavioral results from the current study seem to support this finding. Although trainers did report some improvement in prisoners' behavior following treatment, this was not reflected by behavioral evaluations completed by prison officers. Furthermore, although inmates were relatively positive about the content of the training, the majority did not experience a change in the way they thought or behaved after intervention. All in all, the relatively low efficiency of the CoVa training could explain the absence of change in behavioral measures and neurobiological factors, and the nonexistence of a relationship between these two concepts.

In response to the mixed success rates, the ETS program is currently being gradually phased out of delivery in England and Wales to be replaced with a newly developed Thinking Skills Program (TSP; Gobbett & Sellen, 2014; Riddly, 2010). The TSP differs from ETS in several ways (Riddly, 2010). For example, the program adopts a greater and more inclusive focus on emotions, and generalizes central cognitive skills to everyday life situations. In addition, the program focuses more on personal needs and strengths by incorporating individual sessions alongside 15 group sessions. A first evaluation study on program effectiveness seems to support greater self-reported behavioral improvements among prisoners who completed TSP compared with those allocated to ETS (Gobbett & Sellen, 2014). Recently, the Dutch Probation Service has proceeded to implement these adaptations to the CoVa training, resulting in "CoVa 2.0."[8] Unfortunately, it is too early to verify whether CoVa 2.0 has more potential to improve offenders' behavior than the original version of the training.

Another important factor that may have hampered significant behavioral and neurobiological changes in our sample concerns the intervention format. The current cognitive skills training program comprises 20 sessions divided over 10 weeks. This is in accordance with a typical course of CBT programs for anxiety or depression, which usually requires up to 15 sessions (Beck, 1995). However, it has been suggested that for more chronic behavior problems, such as personality disorders, 12 months or more is necessary for clinical improvement to occur (Davidson, 2007). Prisoners often suffer from severe and complex mental, behavioral, and physical problems (World Health Organization, 2007). In addition, a meta-analysis comprising more than 18,000 male adult prisoners revealed that 65% suffer from a personality disorder, including antisocial personality disorder (47%; Fazel & Danesh, 2002). This information raises the question of whether the duration of existing correctional training programs facilitates long-term behavioral changes.

Selective attrition within the intervention group could be another reason why no changes in neurobiological functioning were found after intervention. There were a substantial number of treatment noncompleters in the intervention group (35 prisoners out of 121 [30%]). Post hoc analyses revealed that treatment noncompleters did not differ from completers with regard to age, intelligence level, and recidivism risk. However, previous work conducted by our research group has demonstrated that before intervention, noncompleters performed significantly worse on an attention skill test compared with treatment completers (Cornet, Van der Laan, et al., 2015). The performance on this attention skill test appeared to be predictive of treatment dropout. It is possible that lower attention skills provide a larger window of opportunity to learn from intervention (if completed). In other words, if the 35 prisoners who dropped out of intervention would have been able to complete the intervention, then they possibly might have shown more benefit from the intervention simply because there was a greater learning potential. However, we were not able to verify this idea, but it suggests that individuals with attention deficits might benefit from more supervision during treatment to prevent them from dropping out of the training program and to provide intervention to those who are most in need of treatment.

Finally, the prison setting itself may also play an important role in the effectiveness of intervention programs. Prisons are clear examples of impoverished and sedentary environments. For example, prison life is characterized by physical inactivity and little control over daily life routines (Cashin, Potter, & Butler, 2008; Woodall, Dixey, & South, 2014). Results from both animal and human studies have shown that an impoverished environment negatively affects prefrontal cortex 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. Therefore, one assumption is that comprehensive enrichment of the prison setting (including more social challenges and more control over daily activities) combined with prolonged correctional therapy might produce greater effects in improving neurocognitive functions and, as a result, reduce recidivism rates (Meijers et al., 2015).

Our second hypothesis was that prisoners with relatively low initial HR activity would show increased HR activity after intervention and prisoners with relative high HR activity would show decreased HR activity following intervention compared with the control group. However, the results did not support changes in HR activity. To verify whether the absence of physiological change was due to deviant HR levels at pretest, another literature comparison was performed.[9] Only resting HR levels were investigated, as this is the most robust physiological indicator examined in samples with antisocial behavior (Lorber, 2004; Ortiz & Raine, 2004; Portnoy & Farrington, 2015). It appeared that the current sample was characterized by a slightly reduced resting HR compared with healthy controls as well as compared with other offender samples. It has been suggested that indices of low physiological arousal, such as low resting HR, are predictive of less benefit from behavioral intervention programs aimed to reduce antisocial behavior (Cornet et al., 2014). This might explain the nonexistence of neurobiological as well as behavioral improvement after intervention. However, the average HR levels of both groups (69.07 bpm for the intervention group and 68.83 bpm in the control group) are still within a clinically healthy range.[10] In addition, the performed literature comparison did not control for influential factors such as medication usage, psychiatric disorders, and body mass index, which are assumed to affect HR levels.

Overall, definite conclusions cannot be drawn on the effect of initial HR activity on the absence of physiological changes after intervention.

Two unexpected sample characteristics were discovered. First, as displayed in Table 1, both the intervention and control groups showed a relatively low verbal intelligence level (ranging between 79 and 81), whereas a similar study conducted by Mullin and Simpson (2007) found an average verbal intelligence level of 93 (SD = 12) among prisoners selected for ETS. One of the CoVa inclusion criteria is an average IQ more than 90. Prisoners with lower intellectual abilities are generally assigned to an adjusted version of the training ("CoVa plus"). However, an official IQ measurement is currently not part of the pretreatment selection procedure (Ferwerda et al., 2009). A serious practical implication might result from these findings, as there is literature indicating that treatment success is influenced by prisoners' verbal intelligence level (Andrews & Dowden, 2007; Dowden & Serin, 2001). This suggests that the success rate of the cognitive skills training might benefit from better selection procedures concerning the intellectual abilities of the offenders. In addition, Table 1 revealed that participants in the control group were much more frequently confined for a nonviolent offense and less frequently for a violent offense compared with the intervention group. With the limited information available from file records, it is unclear what might have caused these group differences.

Additional limitations central to the current study should be considered. First, as described in the "Method" section, an a priori power analysis was conducted based on medium effect sizes. It was concluded that a total sample size of 100 participants would be sufficient to detect medium effect sizes with 80% power. Although the current sample size (84 and 64) met the criteria to detect medium effect sizes, Table 2 revealed that only small effect sizes ($d < .20$) were present. However, to detect small effect sizes, at least 300 participants should have been included in the research (Cohen, 1988). Unfortunately, with limited time and resources it was impossible to include more than 300 prisoners in the current study. Overall, with the current sample sizes, sufficient statistical power was reached to detect medium effect sizes but not to detect small effect sizes.

Second, of the 69 prisoners in the control group, 19 were offered different training programs between pre- and posttest assessment. Examples of these included "Budgeting" and "Lifestyle" programs, with the latter aimed to reduce substance abuse and gambling behavior. The completion of different training programs by participants in the control group might have reduced potential group differences in neurobiological functioning on posttest measurements. A third limitation that should be considered is the reliability and sensitivity of the behavioral measures used in the current study. For example, the self-evaluation measure has not been previously validated. In addition, the mean SDAS score of 2.87 at pretest in the intervention group is low compared with other studies in forensic or psychiatric samples (e.g., Rossberg & Friis, 2003; Zaalberg, Nijman, Bulten, Stroosma, & van der Staak, 2010; Zaalberg et al., 2015), with the mean SDAS scores being 9.9, 5.1, and 12.2, respectively. This might have reduced the possibilities for a (statistically significant) decline of these scores in the present sample.

Furthermore, the limited number of days (on average 9 days) between treatment completion and self-evaluation of prisoners might not have been sufficient for prisoners to effectively reflect on changes in thinking and/or behavior following the intervention. This was, however, inevitable, as in most cases, prisoners were about to leave prison soon after treatment completion, therefore posttest assessments were scheduled as soon as possible after treatment completion. To investigate long-term effects of intervention on neurobiological factors, future research should consider a larger sample size, a follow-up measurement, and the measurement of recidivism rates.

A final limitation concerns the examination of psychophysiological changes. In the current study, only HR activity was measured. However, there is much stronger empirical support for changes in cortisol levels, which is considered as the stress hormone, among children and adolescents with antisocial behavior in response to intervention (Cornet, De Kogel, et al., 2015). We decided not to collect saliva samples for cortisol analysis to reduce the demand and increase prisoners' willingness to participate in the current study. For this reason, it remains unclear whether a cognitive skills training program is able to change psychophysiological characteristics in prisoners. Future research should verify if cortisol levels are able to change in response to behavioral intervention for adults with antisocial behavior.

This study included only relatively "basic" neurobiological measurements (e.g., HR activity and neurocognitive tasks) as the prison setting limits the use of more sophisticated neurobiological research methods, such as brain imaging techniques. It would be interesting to investigate whether these methods detect more subtle changes in brain functioning than neurocognitive tasks in response to treatment. For example, a literature review conducted by Beauregard (2014) demonstrated that psychotherapy aimed to decrease depression or anxiety symptoms may induce both functional and structural neural changes as detected with methods such as single-photon emission computed tomography (SPECT) and diffusion tensor imaging (DTI).

Another interesting line of research is whether specific genetic expression could mediate treatment outcome of individuals with antisocial behavior. One such study was conducted by Bakermans-Kranenburg, Van Ijzendoorn, Mesman, Alink, and Juffer (2008). Their results demonstrated that among children with a specific genetic polymorphism, the dopamine receptor D4 (DRD4) 7-repeat allele, behavioral intervention appeared to be effective in decreasing cortisol levels. This was not the case for children without the DRD4 t-repeat allele. In other words, their results indicated that children were differentially susceptible to intervention effects dependent on the presence of 7-repeat DRD4 allele. Future research should further investigate the role of genes as treatment moderators for individuals with antisocial behavior.

Overall, the limitations suggest that the absence of change in both behavioral and neurobiological measures do not automatically imply that there was no improvement after intervention at all. The quality and selection of behavioral and neurobiological measures might have hampered the detection of improvement. In addition, changes in neurological structures may take longer than changes in behavior and emotional reactivity, and therefore, it is possible that the lack of neurobiological change may be due to the short space between the two assessment intervals (approximately 2 to 3 months; Johnco, Wuthrich, & Rapee, 2014). For this reason, it is recommended to include follow-up assessments in future research to verify whether neurobiological changes occur on the long term.

In sum, it appears that we are still far away from a thorough understanding of why, how, and for whom correctional interventions are effective. Nevertheless, the current study guides recommendations for future research (i.e., reconsideration of neurobiological measurements) and for forensic practice. Results revealed that correctional rehabilitation might benefit from modifying treatment selection procedures (i.e., including verbal intelligence assessment), treatment content and duration, as well as enrichment of the prison setting itself. Unfortunately, limited manpower, time, and financial resources probably complicate the incorporation of the suggested adaptations. However, there are alternative options that are worthwhile to explore, such as the usage of virtual reality (VR). In the Netherlands, VR is already used in forensic special care hospitals to train patients to control aggressive impulses in real-life situations.[11] VR has the potential to increase treatment intensity/duration by enhancing prisoners' cognitive skills in their own prison cells supplementary to group therapy meetings. Furthermore, VR training programs could be tailored toward the inmate's individual neurocognitive needs/deficits (including verbal fluency impairments) and could also enrich the prison setting by exposing inmates to social challenges or real-life situations. The correctional field might benefit from innovative developments like these, along with the implementation of renewed rehabilitation programs (e.g., CoVa 2.0), in an attempt to effectively enhance (neuro)cognitive deficits and, eventually, reduce recidivism rates.

NOTES

1. Contact persons were prison officers who were involved in the organizational aspects of the cognitive skills training (e.g., arranging trainers, workspace, etc.).

2. The goal of multiple imputation (MI) is to create several complete data sets by replacing missing values with plausible data values (Rubin, 1987; van Buuren, 2012). One assumption for MI is that missing values are missing completely at random, or at least at random. Missing value analysis was conducted to investigate the pattern of missing data. For both groups, Little's Missing Completely at Random (MCAR) Test was not significant—intervention group, $\chi^2(8140) = 5,643.428$, $p = 1.000$; control group, $\chi^2(3359) = 1,320.984$, $p = 1.000$—indicating that there was no particular pattern of missing data. The specific MI model used was the switching regression approach by van Buuren, Boshuizen, and Knook (1999). The MI model was built up by including pretest scores, posttest scores, potential confounders (e.g., physical activity), and behavioral outcome measures. Derived variables, such as Stroop interference score, were not imputed directly, but underlying scores were imputed (time to complete Stroop II and Stroop III) and composed to the derived variable after imputation. Imputations were conducted separately for the intervention group and the control group. After imputation, the two data sets were combined using SPSS 19 for further analyses. The number (m) of imputed data sets was set at 10. In addition, the number of iterations is usually between five and 20, and we decided to set this at 20 (van Buuren, 2012). Predictive mean matching (PMM) option was used, as this imputation method provides realistic values, and it appears that PMM ". . . produced the least biased estimates and better model performance measures" (Marshall, Altman, & Holder, 2010, p. 1). The statistical program R version 3.1.1 with library mice version 2.22 was used to complete the imputation model while performing a preselection of covariates predictive of missingness. Covariates with a correlation of less than .2 with the predicted covariate were left out of the corresponding prediction equations to improve numerical stability. The average number of predictors per variable for the intervention group was 14.87 and for the control group was 12.37. After imputation, posttest values (e.g., self-evaluation and posttest scores on neurocognitive tasks) for participants who dropped out of intervention ($n = 35$) were omitted from further analyses. This method is an acceptable and practical solution for dealing with imputed values that are considered to be "invalid" (S. van Buuren, personal communication, February 16, 2015). The combination of F statistics from an MI in the case of finite sample sizes requires corrected degrees of freedom, derived by Reiter (2007). To apply this, a software implementation written in SPSS MACRO by van Ginkel (2008) was used. To perform ANCOVA analyses, mimul2 package was used for combining multivariate estimates in MI (van Ginkel, 2014). In addition, chi-square tests were combined as described by Li, Meng, Raghunathan, and Rubin (1991), and standard deviations were computed using Ruben's rules.

3. Extreme outliers are scores more than 3 × IQR from the rest of the scores. IQR stands for the "interquartile range," which is the middle 50% of the scores.

4. Equal percentile groups were created based on pretest neurocognitive functioning (low, medium, and high neurocognitive functioning) by combining z scores (some variables were transformed to create one overall z score that indicated strength of neurocognitive performance). Initial ANCOVA analyses were reanalyzed including Group × Level of Pretest Cognitive Functioning interaction term. The modified Hochberg correction was applied for controlling overall Type I error in the case of multiple testing (Rom, 2013). It appeared that none of the subsequent analyses revealed a significant interaction effect of Group × Level of Cognitive Functioning on posttest scores. In other words, no differences were found between intervention and control group participants on their initial level of neurocognitive functioning in relation to posttest outcome. To further explore the existence of age-related subgroups associated with change in neurocognitive functioning after intervention, equal percentile groups were created based on age (low, medium, high age groups). Again, no significant interaction effects of Group × Age were detected on the posttest scores.

5. To test this hypothesis, heart rate (HR) and respiratory sinus arrhythmia (RSA) during rest and stressful phases were transformed to *z* scores, and recoded to create one index of HR activity. Equal percentile groups were formed (low, medium, and high HR activity at pretest) to test for significant interaction effects of Group × Initial HR Activity on posttest HR measures. However, no significant interaction was found.

6. Results from this literature comparison are available from the authors upon request.

7. The Research and Documentation Centre, Ministry of Security and Justice, The Hague, the Netherlands, is currently analyzing recidivism rates of individuals who completed the CoVa training.

8. All prisoners in the current sample completed the original CoVa training.

9. Results from this literature comparison are available from the authors upon request.

10. http://www.heart.org/HEARTORG/Conditions/More/MyHeartandStrokeNews/All-About-Heart-Rate-Pulse_UCM_438850_Article.jsp

11. See, for more information on virtual reality in the Dutch forensic setting, https://decorrespondent.nl/2562/Gaat-Virtual-Reality-ons-betere-mensen-maken-/262656240-64da7127

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