The relation between hot and cool executive functioning and psychopaths

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Abstract

Psychopathy accounts for up to 25% of the prison population and characterized by emotional, interpersonal and behavioral problems. Psychopaths are responsible for a remarkable amount of violence, criminal acts and social distress in every society. Research shows that they function differently at a neurocognitive level; especially executive functions (EF) are distinctive. EF is an umbrella term for certain cognitive abilities, some of those have shown to be disturbed in psychopathic individuals. A distinction between hot and cool EF is made. Hot EF is influenced by emotionally and motivationally processes, for example facial affect recognition or an affective inhibition task. While cool EF operate in affectively neutral environments, for instance an inhibition task or working memory tasks with no emotional influences. Several studies show that psychopathy may be associated with impaired EF, but study outcomes vary and often do not make a distinction between hot and cool EF. In this study, the relationship between hot and cool EF and psychopathy is investigated to gain more knowledge about the ways psychopathic individuals think, behave and act to reduce recidivism and for clinical purposes. This relationship is examined using multiple regression analysis. The Self-Report Psychopathy Scale III (SRP-III) and a hot EF and cool EF task were administered in 137 incarcerated male offenders. For hot EF the Affective Go/No-Go and for cool EF the Stop-it Signal Task (SST) was conducted. The association between cool inhibition, measured with the SST, and psychopathy was not significant. The Erratic Lifestyle (ELS) subscale of the SRP-III was significantly associated with the Fear, Happy and Total False Alarm Rate of the Affective Go/No-Go task. Indicating that psychopathic individuals with high ELS scores have better inhibition abilities when emotional stimuli are involved, because they do not get distracted by emotional information. However, the observed effects where only small. This study shows results that are contradictory with most literature. One of the explanatory reasons might be the low psychopathy levels in this population. It is required to conduct further research to investigate the relationship between different levels of psychopathy and hot and cool inhibition.

Introduction

The number of people diagnosed with a psychiatric disorder is higher within the prison population, compared to those who are not detained (Fazel & Baillargeon, 2011). One frequently seen diagnosis within the prison system is psychopathy, a disorder first described by Clerkly (1941) that gained interest in the past decades. While the estimation of the prevalence of psychopathy is around 1% in the general population (Freeman, Samson & Palk, 2011)., the prevalence rises up to 15% to 25% in the prison population (Hare, 1996). It is twenty to twenty-five times more likely that psychopaths are incarcerated than non-psychopaths (Kiehl & Hoffman, 2011).

Psychopathy is characterized by emotional, interpersonal and behavioral problems. Emotional characteristics are a lack of guilt, lack of attachment to others and low empathy. Superficial charm is an example of interpersonal features and common behaviors are recklessness, manipulation and risk-taking (Hare, 1991). There is some discussion whether criminal behavior is a key feature of psychopathy (Hare, 2003). Psychopaths are responsible for a remarkable amount of violence, criminal acts and social distress in every society (Hare, 1996). It may seem clear that psychopathy is a great problem, not only in prisons, but also in everyday life. This makes it relevant to look into different explanations of the behavior of psychopaths.

One way to look into the behavior of psychopaths is to investigate executive functions (EFs). Psychopathy is not only characterized by emotional, interpersonal and behavioral problems, recent studies also show that psychopaths function differently at a neurocognitive level, especially EFs are affected. EF contains the processes that are important in goal-directed control of thought, consciousness, action and emotions (Zelazo & Carlson, 2012). All these mental states are sometimes summarized in the overarching term ‘cognitive skills’. Suchy (2009) concludes that it is common that people fail to recognize the independent components of EFs and sometimes oversimplify terms like decision-making. Most research focuses on general EF constructs, and most of the current knowledge about more specific EF is based on examining these general constructs. Therefore, it is important to make distinctions, not only in the different sorts of EFs, but also in for example hot and cool executive functioning. Hot EF contains emotionally and motivationally bottom-up processes, important for functioning at emotional level, for example the recognition of facial expressions. In addition, cognitive tasks with a reward or punishment, for instance gambling,

are depending on hot executive functioning. Cool EF are processes that operate in affectively neutral environments, for example a working memory task with remembering a list of numbers (Zelazo & Carlson, 2012). The aim of the current study is to determine what the relation is between the hot and cool executive functions and psychopathy.

It seems logical that psychopathic individuals have difficulties with hot EF, because research shows that they function differently at an emotional level. For example, there is an association between psychopathy and deficits in Theory of Mind (ToM) or mentalizing (Ali & Chamorro-Premuzic, 2010). Some researchers argue that psychopaths do have the ability to make a representation of another persons' mental state, but they miss the propensity to do so (Drayton, Santos & Baskin-Sommers, 2018). Furthermore, Sandvik, Hansen, Johnsen and Laberg (2014) found that different psychopathic traits in male inmates contribute to lower ability to recognize others' mental state, especially antisocial traits and an impulsive lifestyle were associated with this deficit. A recent meta-analytic review found that higher psychopathic traits are related to lower levels of emotional intelligence (Megías et al., 2018). The above mentioned studies are examples of dysfunctions in emotion regulation. Casey, Rogers, Burns & Yiend (2013) show that higher scoring psychopaths are more impaired in emotion regulation with an emotion-processing task. When psychopaths were required to experience a certain emotional response, they were unable to do so. The authors conclude that the precise cognitive mechanisms to this disturbed emotion regulation remain unclear.

Thus, the emotion regulation of psychopathic individuals seems to be disorganized. This also becomes clear when looking into other frequently researched abilities in relation with psychopathy. For example, much evidence shows that men with psychopathy or antisocial behavior score worse on gambling tasks that measure risk taking and decision making, this impulsive behavior is an indication for impaired response inhibition. Higher levels of psychopathy are linked to more advantageous choices in gambling (Hughes, Dolan, Trueblood & Stout, 2015; Mahmut, Homewood & Stevenson 2008; Mitchell, Colledge, Leonard & Blair, 2002).

Another frequently researched ability is facial affect recognition (FAR), which is linked to the hot EF cognitive empathy. For example, Wai & Tiliopoulos (2012) show that psychopathy is associated to a general deficit in FAR. There can also exist a dysfunctional violence inhibition mechanism, which correlates with psychopathy. The poor recognition of sad or fearful faces causes individuals to continue with aggressive behavior (Blair, 2001).

Furthermore, people with any type of antisocial behavior score worse on emotion recognition tasks, especially the recognition of fearful facial expression is impaired (Marsh & Blair, 2008). Thereby, Cigna, Guay & Renaud (2017) show that specific components of the psychopathic personality have a differential influence on FAR. They also conclude that antisocial behaviors contribute to worse outcomes of overall emotion identification. According to the amygdala dysfunction hypothesis by Blair, Colledge, Murray & Mitchell (2001), psychopaths are distinctively impaired in sadness and fear facial expression recognition, these are so-called 'amygdalian emotions'. Psychopaths are not impaired in the recognition of happiness, anger and disgust, the 'nonamygdalian emotions'. However, there are some contradictions in the relation between psychopathy and FAR. Some studies found a greater sensitivity to emotional expression, mostly with the psychopathic trait callous affect (CA). Especially the identification of sadness is better with high callous affect traits. The ability to recognize vulnerability signs can be helpful to manipulate others, a strategy frequently seen in psychopaths (Cigna et al., 2017; Woodworth & Waschbusch, 2007). Thereby, Glass & Newman (2006) found no difference between psychopathic offenders and controls on recognition of facial affect. A more recent study by Pham & Philippot, (2010), shows congruent findings, with no difference between criminal and noncriminal psychopaths and their accuracy of facial expression decoding, when looking into the amygdalian emotions. However, they did find that criminal non-psychopaths were more accurate in decoding nonamygdalian emotions (happiness, anger and disgust) than criminal psychopaths. In overall, the healthy control group performed better than the two criminal groups. This observed relation is in contrast with the earlier mentioned amygdala hypothesis by Blair et al., (2001). It becomes clear that although it may be evident that the emotion regulation of psychopaths is disturbed, it remains ambiguous what the exact influence is on different hot EFs such as response inhibition or FAR.

Some studies also show impairments in cool EF. Blair and colleagues (2006) found only deficits in cool executive functions. Zeier, Baskin-Sommers, Racer and Newman (2012) found deficits in cognitive control, both in psychopaths as individuals with ASP symptoms. They conclude that this cognitive control deficit is related to general antisocial behavior, seen in psychopathy and ASPD. Deficits in inhibition are also seen, for example, Weidacker, Snowden, Boy and Johnston (2017) studied the Go/No-Go task with psychopathic offenders. They concluded that inhibition deficits are related to impulsive lifestyle behaviors, with a

negative association between psychopathy and inhibition. Krakowiski et al., (2015) found a relation between psychopathic traits and number of commission errors made in a Go/No-Go task. Offenders with high psychopathy levels committed more commission errors, compared to low psychopathy healthy controls, suggesting a relation between psychopathy and impaired response inhibition. Research with the Stop Signal Task shows deficits on response inhibition, in people with high psychopathic traits (Heritage & Benning, 2012). A study looking at both inhibition tasks, found reduced performances in psychopaths that scored high on impulsive antisocial behaviors (Michalowski, Drozdziel & Harciarek, 2015). However, some researchers report no or a positive relation between psychopathy and cool executive functioning. Munro et al., (2007) found that, with a Go/No-Go task, offenders made more commission errors than healthy controls, although there was no relation between the number of errors and the level of psychopathy. Pera-Guardiola et al., (2015) found a positive effect of psychopathy on cool EF. The male offenders with ASPD and psychopathy did not differ in cool EF performance, while the offenders without psychopathy performed poorer on a cool EF task. Dolan (2012) also found that psychopathic traits did not contribute to greater cool executive dysfunctions. Mol, van den Bos, Derks & Egger (2009) found no difference between performance on the WCST, a cool EF task, in psychopathic and non-psychopathic offenders. Lastly, a study by De Brito et al., (2013), compared hot and cool executive functioning in relation to psychopathy in male offenders. This is the only study found that looked into both hot and cool EF. The authors compared performances of cool (verbal working memory and alteration of motor responses to spatial location) tasks and hot (reversal learning, decision-making under risk and stimulus-reinforcement-based decision-making) tasks in groups of violent antisocial offenders with and without psychopathy and in a healthy non-offender group. The offender groups showed impaired verbal working memory performances, failed to learn from punishment cues and made poorer quality decisions in comparison with the healthy non-offender group. However, no differences in hot and cool EF performances where found when comparing the offenders with and without psychopathy. As stated, this is the only study found comparing both hot and cool EF in psychopathic individuals. However, this study looks into different EF levels. To the best of my knowledge, there has not been conducted a study that reviews both hot and cool executive functioning of the same category task, namely inhibition, in relation to psychopathic individuals. Thus the current study will be a contribution to the literature about EF and psychopathy.

Overall, the literature about hot and cool executive functioning and the relationship with psychopathy is inconsistent. Furthermore, the amount of research that examines both hot and cool executive functioning is inconsiderable. The studies that do consider both often use a different level of executive functioning. The current study has the intention to determine what the relation is between the same level of hot and cool executive functions, namely inhibition, and psychopathy. It is expected that high psychopathy scores predict poor performance on the Emotional Go/No-Go task. To be more specific, Erratic Lifestyle (ELS) and Criminal Tendencies (CT) will contribute to worse performance and especially the fear condition of the Go/No-Go task. However, it seems possible that there is a negative relation between Callous Affect (CA) and this fear condition. Implying that high scores on the CA subscale will contribute to better performance on the fear condition of the Emotional Go/No-Go task. Additionally, it is anticipated that high psychopathy scores predict worse performance on the Stop-it Signal task. Particularly CT will contribute to an insufficient performance.

Methods

Design

This cross-sectional study was conducted as part of a larger study into psychosocial and neurobiological characteristics of detainees in the Netherlands. The research was approved by the Psychology Research Ethics Committee of the Criminology Department. Prior to implementing the tasks, participants were asked to give written consent. Furthermore, when the participants completed the research they received €7,50. The participants were tested with several measures in approximately two hours.

Participants

For this research 137 male participants were recruited in different penitentiary institutions in the Netherlands, from May to December 2017. In total seven different prisons were involved in this research. The heavily secured wards of the different prisons where not included in this research, thus this population does not comprise the most hazardous criminals. The mean age of the participants was 37 years, with an average of 13 years of education. The inmates were asked to participate in the research and if they wanted to participate, information letters were given to the inmates, so they have knowledge about the research before they participate. As a reward the participants receive €7,50 when completed the research.

Table 1. *Population characteristics.*

	N	**Range (min-max)**	**Mean ± SD**
Age	137	18.0 - 72.0	37.1 ± 12.1
Years of education	137	5.0 - 22.0	13.2 ± 3.4

Procedure & Materials

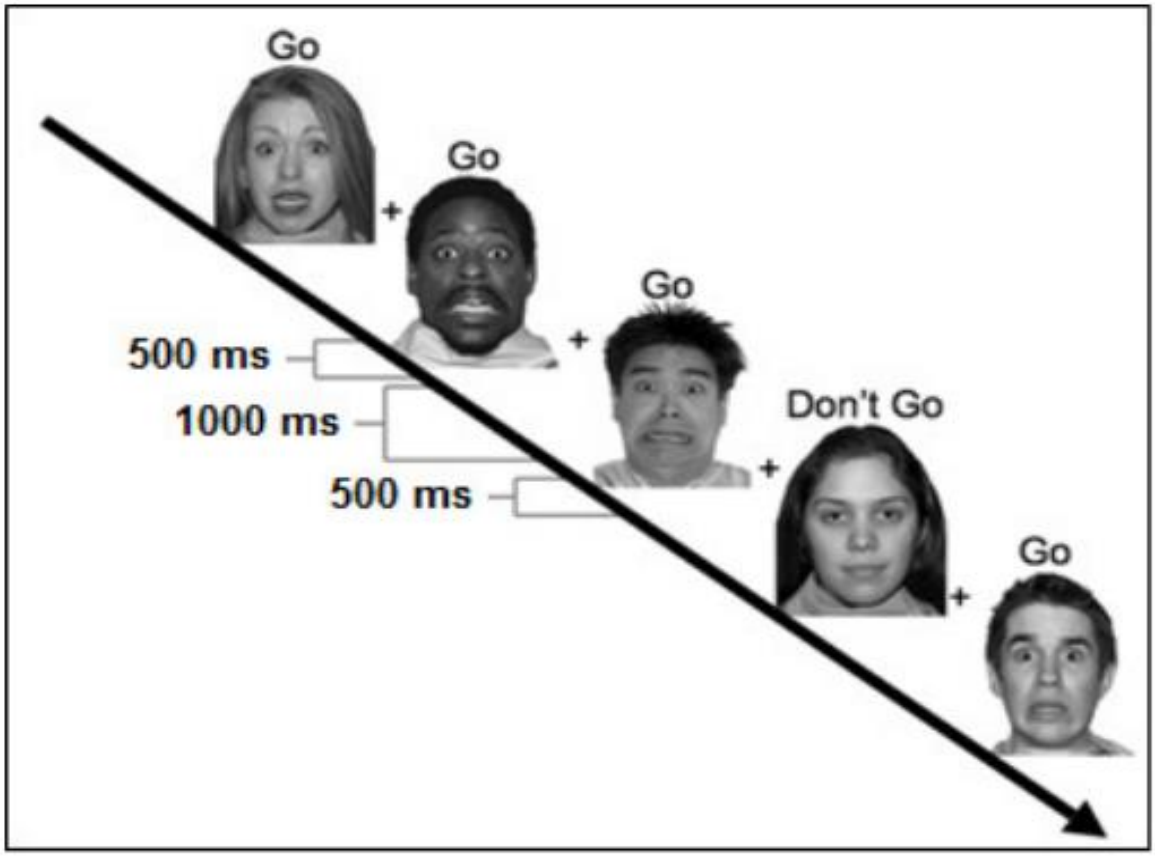
Stop-It Signal Task. The Stop-IT Signal Task is a computer task which measures response inhibition, a cool executive function. In this task the participant has to react appropriately to a visual stimulus, either a square or circle, and press the corresponding key on the keyboard as quick as possible. When a square is shown the Z key need to be pressed. When a circle is shown the /? key needs to be pressed. The visual stimuli is presented on the computer screen until the participant responds, or when 1250 milliseconds (msec) expire.

However, in 25% of the cases a loud noise, the stop-signal, is heard through the headphones. This sound is unpredictable and heard at different time intervals, initially the sound is heard after 250msec. When this happens, the participant needs to inhibit his reaction and not press the key. This is essential for generating the primary outcome measure, the Stop Signal Reaction Time (SSRT), which measures the time required to stop a response. If the participant is successful in inhibiting his response, the stop-signal delay decreases with 50msec. If the participant is not successful, there is an increase of 50msec for the stop-signal delay. There is one practice round with 32 trials, followed by an experimental phase. The experimental phase consists of three blocks with 64 trials. Each round takes approximately 2.5 minutes and the duration of the Stop-it Signal task is about 10 minutes (Verbruggen, Logan, & Stevens, 2008). The SSRT is used as the outcome measure in this study. As stated above, this is the mean time required to stop a response. The mean time is determined at the end of all the trials, and this is computed to the SSRT of one participant.

Emotional Go/No-Go. The Emotional Go/No-Go uses E-Prime 2.0 software (Psychology Software Tools, Inc., Pittsburgh, PA; Schneider, Eschman, & Zuccolotto, 2002). The Emotional Go/No-Go task is also a response inhibition task. However, because emotions are involved this task measures hot executive functioning. In six blocks, participants have to respond, with pressing space, to one specific facial expression, either fear, happy or neutral. Two expressions are shown within one block, with one expression as the Go stimulus and one expression as the No-Go stimulus. Each block consisted of 48 randomized trials. Prior to a block the participant was informed which facial expression would be the approached stimulus emotion, or the Go stimulus. The participant is not told what the No-Go facial expression is, but are told not to react when any other face than the Go facial expression is shown. The Go stimulus is presented at 73% of the trials and 27% of the trials is the No-Go stimulus. Each block consists of different combinations of go/no-go stimuli (go/no-go: fear/happy, fear/neutral, happy/fear, happy/neutral, neutral/fear, neutral/happy). Stimulus duration is 500ms, with between the stimuli a fixation point displayed for 1000ms. The interstimulus interval is 1000ms, to make sure that the participants have enough time to respond. Randomization was used for presenting the order of the blocks. The facial expressions are collected from the NimStim set (Tottenham et al., 2009) and represent four different individuals, two males and two females, in gray-scale. The individuals represented the following races: African American, Asian and Caucasian. The images were normalized for

luminance and size. An example for a go/no-go block is seen in Figure 1. Participants are instructed to respond as accurate and fast as possible (Megías, Guttièrrez-Cobo, Gómez-Leal, Cabello & Fernández-Berrocal, 2017). Per go/no-go combination three important different emotional response inhibition measures are made. The HitRate, percentage of the number correctly responses to the Go stimulus and the reaction time. Thereby, the outcome measure used in this study, the False Alarm rate. This measures percentage the number of incorrectly responses to the No-Go stimulus.

Figure 1. *Visual representation of the stimulus presentation for one of the go/no-go blocks. The fear expression is the 'go' stimulus and the neutral expression is the 'no-go' stimulus. The stimuli are presented for 500ms, with a 1000ms interstimulus interval.*
From: Herpertz-Dahlmann, Konrad & Kohls (2015)



Self-Report Psychopathy scale – version III (SRP-III). The SRP-III was constructed along the four-factor model of psychopathy (Paulhus, Hemphill & Hare, in press). These four factors are (a) interpersonal manipulation, looking at pathological lying and manipulating, (b) callous affect, measuring low empathy (c) erratic lifestyle, referring to recklessness and impulsivity, and (d) criminal tendencies, measuring antisocial behaviors and committing crimes (William,

Paulhus & Hare, 2007). The questionnaire is designed to measure the core features of psychopathy in both the general population as well as within the prison populations. Each of the 64 items is rated on a 5-point Likert scale from 1 (disagree strongly) to 5 (agree strongly). Twenty-one items across the four subscales are scored in reverse. The responses are summated for each subscale to deliver four scores, namely interpersonal manipulation (IPM), callous affect (CA), erratic lifestyle (ELS) and criminal tendencies (CT). Per subscale, a total score is obtained, with a possible range of 16 to 80. A total score is obtained by summing the four subscale scores, with a minimum score of 64 and a maximum score of 320. Paulhus et al., (in press) found a good internal consistency for the SRP-III (Cronbach's alpha = .81). For this study the Dutch version of the SRP-III is used (Uzieblo, De Ruiter, Crombez, Paulhus, & Hare, 2007). The SRP-III total score for an individual will be approached in a continuum, rather than a cut-off score. With a low total score suggesting little indication for psychopathy and a high total score implying a considerable chance of psychopathy.

Statistical analyses

To test the different hypotheses, the Statistical Package for the Social Sciences (SPSS) version 25.0 was used. In order to assess which variables should be incorporated as a covariate correlation analyses were performed between age, years of education, the executive functions and psychopathy. Regression analysis in SPSS was conducted to determine whether higher psychopathy scores were related to impaired hot executive functions. Thereby, to test whether there was a positive relation between psychopathy and cool executive functions another regression analysis was conducted.

Before interpreting the results of the regression analyses, a number of assumptions were tested and checks were performed. Data inspection controls for outliers, measure means and the assumptions for the normal distribution. A scatterplot was conducted to examine the relationship between the predictor variables. Thereby two-sided Pearson's r correlations were measured, with $p < 0.05$ and $p < 0.01$ to estimate the linear relationship between the predictor variables.

The multiple regression analyses were separately conducted for hot and cool EF. They contained a two-sided test with $\alpha = 0.05$ to determine statistical significance of the results. When in lack of significant predictors, the non-significant outcomes are showed. To determine whether impaired cool EF was related to higher psychopathy scores, a second

multiple regression analysis was conducted with the Stop-Signal Reaction Time (SSRT) as dependent variable and psychopathy as the independent variable, while again correcting for age and years of education. The SSRT was measured in milliseconds from the Stop-it Signal task. For psychopathy, the total scores of CA, IPM, ELS and CT were used, in addition to the overall total score of the SRP-III.

Furthermore, in order to assess whether lower hot EF was related to higher psychopathy scores, a multiple regression analysis was conducted with the False Alarm rate of the Emotional Go/No-Go as the dependent variable and psychopathy, measured with the SRP-III, as the independent variable, while correcting for age and years of education. The False Alarm rate of the Emotional Go/No-Go was divided in three facial expressions: fear, happy and neutral. For psychopathy, the total scores of CA, IPM, ELS and CT were used, in addition to the overall total score of the SRP-III.

Results

Descriptive statistics

The descriptive statistics show the features of the participants. Table 1 shows that the participants (N = 137) were on average 37 years of age, with an average education duration of 13 years. Furthermore, the mean score of psychopathy is 171, while the participants have an average score on the subscales of 43. The average false alarm rate is 25 and the SSRT has an average of 285msec.

Table 2. *Descriptive Statistics of the variables.*

	Range (min-max)	Mean ± SD
Age	18.0 - 72.0	37.1 ± 12.1
Years of education	5.0 - 22.0	13.2 ± 3.4
SRP-III total score	87.0 - 279.0	171.4 ± 35.1
SRP-III CA	20.0 - 66.0	42.1 ± 8.4
SRP-III ELS	20.0 - 72.0	46.1 ± 10.7
SRP-III CT	16.0 - 77.0	43.1 ± 12.2
SRP-III IPM	17.3 - 76.0	42.2 ± 10.4
Fear False Alarm Rate	00.0 - 80.8	23.4 ± 14.8
Happy False Alarm Rate	00.0 - 100.0	27.0 ± 18.4
Neutral False Alarm Rate	00.0 - 76.9	25.9 ± 18.6
Total False Alarm Rate	3.9 - 69.2	23.2 ± 13.3
SSRT	20.8 - 537.7	285.2 ± 73.3

SRP-III = Self-Report Psychopathy version III
SSRT = Stop-Signal Reaction Time
CA = Callous Affect
ELS = Erratic Lifestyle
CT = Criminal Tendencies
IPM = Interpersonal Manipulation

Assumptions

The data did not violate any of the assumptions. The subscales and the total score of the SRP-III were divided through a normal distribution, in addition to age and years of education. Finally, multicollinearity was measured to estimate if the correlation between the predictors is not too high, with a variance inflation factor (VIF). VIF measures how much the predictor variable variance was influenced by the correlation with other predictor variables. A VIF higher than 10 means that the predictor variables approximately measure the same and that

they are dependent. The Cohen's D Effect sizes were manually calculated where possible and were classified as small ($d \geq 0.2$), moderate ($d \geq 0.5$) or large ($d \geq 0.8$) (Cohen, 1988).

Correlation analyses

The correlation analyses between age, years of education, psychopathy and hot and cool executive functions, reveal that age and years of education significantly correlated with the psychopathy subscales. Therefore, these measurements are included in the regression model.

To check the regression assumptions, the correlation between the executive functions and the psychopathy scores are viewed. There is a significant negative relation between the False Alarm rate of fearful faces and the SRP-III ELS (*r = -.177, p = 0.026),* suggesting that a low number of false alarms with the fear emotion is related to a high score on the ELS subscale of the SRP-III. Less suffering from interfering information (fearful facial expression) could contribute to better response inhibition. There are no other significant correlations between hot or cool executive functions and the subscales or total score of the SRP-III (all *p > .055).*

The results from the correlation analyses reveal that there is a significant relation (*r = -.183, p = 0.030*) between age and SRP-III erratic lifestyle (ELS). This indicates that how older the individual, the lower the score on this subscale. Years of education has significant negative relations with SRP-III total score (*r = -.191, p = 0.025),* SRP-III callous affect (CA) (*r = -.218, p = 0.011)* and SRP-III criminal tendencies (CT) (*r = -.247, p = 0.004).* This suggests that more years of educations correlates with lower scores on these items (see table 3).

Lastly, there is a significant positive relation between the SRRT and the variables fear false alarm rate (*r = .233, p = 0.005)* and the total false alarm rate (*r = .222, p = 0.008).* This indicates that a high score on the SRRT is related to higher scores on the fear and total false alarm rate. This confirms that both tasks measure the same underlying construct, namely inhibition.

Table 3. *Pearson r correlations of the variables used in the regression analyses.*

	Age	Years of education	SRP-III total	SRP-III CA	SRP-III ELS	SRP-III CT	SRP-III IPM	Fear False Alarm Rate	Happy False Alarm Rate	Neutral False Alarm Rate	Total False Alarm Rate	SSRT
Age												
Years of education	-0.107											
SRP-III total	-.132	-.191*										
SRP-III CA	-.095	-.218*	0.823**									
SRP-III ELS	-.183*	-.091	0.882**	.652**								
SRP-III CT	-.097	-.247**	0.872**	.610**	.725**							
SRP-III IPM	-.065	-.105	0.840**	.648**	.624**	.607**						
Fear False Alarm Rate	-.078	-.041	-.127	-.032	-.177*	-.105	-.094					

Happy False Alarm Rate	-.025	-.088	-.121	-.010	-.148	-.114	-.106	.590**			
Neutral False Alarm Rate	-.063	-.141	-.040	.028	-.056	-.047	-.029	.480**	.803**		
Total False Alarm Rate	-.055	-.093	-.125	-.014	-.162	-.121	-.095	.804**	.879**	.862**	
SSRT	-.078	-.052	.036	.072	-.002	.022	.054	.233**	.091	.149	.222**

SRP-III = Self-Report Psychopathy version III
SSRT = Stop-Signal Reaction Time
CA = Callous Affect
ELS = Erratic Lifestyle
CT = Criminal Tendencies
IPM = Interpersonal Manipulation
** is p <0.05*
*** is p <0.01*

Regression analyses

Cool EF

A multiple regression analysis was performed to assess whether psychopathy is associated with Cool EF. In model 1 in the multiple regression analysis age and years of education were included as covariates to control whether these are significant predictors. The results show that these variables accounted for a non-significant 0,7% of the variance in the SSRT, $R^2 = .007$, $F(2,134) = .505$, $p = .605$.

In model 2, the SRP-III total score was added, to determine what the relation is between cool executive function and the psychopathy total score. This variable accounted for a non-significant 1.0% of the variance, $R^2 = .015$, $F(3,133) = .275$, $p = .601$.

The total score of the SRP-III gave a non-significant outcome, to conclude if one of the subscales of the SRP-III gave a significant outcome, the subscales were added in the equation in model 3 and the SRP-total score was removed. These predictor variables were excluded to the equation. Together these variables accounted for a non-significant 1.5% of the variance, $R^2 = .015$, $F(4,130) = .236$, $p = .917$. Furthermore, none of the predictor variables were associated with cool EF performance, indicating that there is no relation between cool EF and psychopathy in this population.

Table 4. *Unstandardized (B) and standardized (β) regression coefficients and squared semi-partial correlations (sr^2) and the standard error for each predictor variable on each model of the multiple regression analysis predicting SSRT with psychopathy and the control variables*

		SSRT				
		B [95% CI]	SE (B)	β	sr^2	Sign
Model 1	Age	.428 [-.626, 1.483]	.533	.070	.005	.423
	Years of education	-.962 [-4.661, 2.738]	1.871	-.044	.002	.608
Model 2	Age	.468 [-.600, 1.536]	.540	.076	.005	.450
	Years of education	-.754 [-4.546, 3.038]	1.917	-.035	.001	.755
	SRP-III total	.098 [-.271, .467]	.187	.047	.002	.601
Model 3	Age	.439 [-.646, 1.523]	.548	.071	.005	.425
	Years of education	-.590 [-4.544, 3.365]	1.999	-.027	.001	.768
	SRP-III CA	.734 [-1.490, 2.957]	1.124	.084	.003	.515
	SRP-III ELS	.437[-2.373, 1.498]	.987	-.063	.002	.656
	SRP-III CT	-.005[-1.628, 1.617]	.820	-.001	.000	.995
	SRP-III IPM	.319 [-1.422, 2.061]	.880	.045	.001	.717

SRP-III = Self-Report Psychopathy version III
SSRT = Stop-Signal Reaction Time
CA = Callous Affect
ELS = Erratic Lifestyle
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Hot EF

Various multiple regression analyses were performed to assess whether psychopathy is associated with hot EF. Four different multiple regression analyses were conducted, one for the total false alarm rate, one for fear false alarm rate, for happy false alarm rate and lastly a regression analysis for neutral false alarm rate.

The first multiple regression analysis was performed to assess whether psychopathy is associated with the total false alarm rate. In model 1 in the multiple regression analysis age and years of education were included as covariates to find out if they are significant predictors. Results indicate that these variables accounted for a non-significant 1,8% of the variance in the total false alarm rate, $R^2 = .018$, $F(2,134) = 1.251$, $p = .289$.

In model 2, the SRP-III total variable was added, to determine whether psychopathy was related to cool executive functioning. This variable explained a significant 4.7% of the variance, $R^2 = .047$, $F(3,133) = 4.013$, $p < .05$.

The SRP-III total score contributed to a significant outcome. In model 3 the subscales of the psychopathy questionnaire were added, to tell if one of the subscales contributed to the significant outcome. Only the ELS subscale was not removed from the equation and explained an extra 5,7% of the variance compliance. $\triangle R^2 = .057$, $\triangle F(3,133) = 5.522$, $p < .05$. By Cohen's (1988) conventions, a combined effect of this magnitude can be considered "negligible" ($f^2 = 0.060$).

As can been seen in Table 4, the only significant predictor of the total false alarm rate in the final regression model is the erratic lifestyle (ELS) subscale of the SRP-III ($sr^2 = .040$). This significant relation shows that high ELS scores are correlating with less false alarm rates.

Table 5. *Unstandardized (B) and standardized (β) regression coefficients and squared semi-partial correlations (sr^2) and the standard error for each predictor variable on each model of the multiple regression analysis predicting Total False Alarm rate with psychopathy and the control variables*

		Total False Alarm rate				
		B [95% CI]	SE (B)	β	sr^2	Sign
Model 1	Age	-.110 [-.299, .080]	.096	-.099	.010	.254
	Years of education	-.406 [-1.070, .259]	.336	-.104	.011	.299
Model 2	Age	-.136 [-.32537, .053]	.096	-.123	.015	.156
	Years of education	-.546 [-1.218, .125]	.339	-.140	.019	.110
	SRP-III total	-.066 [-.132, -.001]*	.033	-.174	.029	.047
Model 3	Age	-.148 [-.337, .041]	.096	-.133	.018	.124
	Years of education	-.492 [-1.149, .166]	.332	-.126	.016	.141
	SRP-III ELS	-.252 [-.463, -.040]*	.107	-.202	.040	.020

CI = confidence interval
SRP-III = Self-Report Psychopathy version III
ELS = Erratic Lifestyle
** is p <0.05*

Secondly, the multiple regression analysis of psychopathy and fear false alarm rate. This analysis is conducted to assess if psychopathy is related with fear false alarm. In model 1 of the multiple regression analysis age and years of education were included as covariates, to ascertain if they are significant predictors. Results show that these variables accounted for a non-significant 1,5% of the variance in the fear false alarm rate, R^2 = .015, F(2,134) = 1.024, p = .362.

To demonstrate the relation between the fear false alarm rate and psychopathy was the SRP-III total score added in model 2. This variable explained a non-significant 3.,9% of the variance in the fear false alarm rate with R^2 = .039, F(1,133) = 3.342, p = .070.

In model 3, all the subscales of the psychopathy questionnaire were included to determine which of the subscales contributed to the significant outcome. Only the ELS subscale was not removed and accounted for an extra 5,6% of the variance compliance. $\triangle R^2$ = .056, $\triangle F$(3,133) = 5.831, p = .017. By Cohen's (1988) conventions, a combined effect of this magnitude can be considered "negligible" (f^2 = 0.059).

As can been seen in Table 5, the only significant predictor of the fear false alarm rate in the final regression model is the erratic lifestyle (ELS) subscale of the SRP-III (sr^2= .042). This significant relation shows that high ELS scores are correlating with less false alarm rates in the fear condition.

Table 6. *Unstandardized (B) and standardized (β) regression coefficients and squared semi-partial correlations (sr^2) and the standard error for each predictor variable on each model of the multiple regression analysis predicting Fear False Alarm rate with psychopathy and the control variables*

		Fear False Alarm rate				
		B [95% CI]	SE (B)	β	sr^2	Sign
Model 1	Age	-.144 [-.355, .067]	.107	-.116	.013	.179
	Years of education	-.230 [-.971, .510]	.374	-.053	.003	.540
Model 2	Age	-.171 [-.355, .040]	.107	-.138	.019	.080
	Years of education	-.373 [-1.123, .377]	.379	-.086	.007	.376
	SRP-total	-.068 [-.141, .006]	.037	-.160	.025	.070
Model 3	Age	-.188 [-.398, .023]	.106	-.152	.023	.080
	Years of education	-.329 [-1.060, .403]	.370	-.076	.006	.376
	SRP-III ELS	-.288 [-.524, -.052]*	.119	-.207	.042	.017

CI = confidence interval
SRP-III = Self-Report Psychopathy version III
ELS = Erratic Lifestyle
** is p <0.05*

A third multiple regression analysis was performed to assess whether psychopathy is associated with happy false alarm rate. In model 1 in the multiple regression analysis age and years of education were included as covariates, to determine whether they are significant predictors. Results indicate that these variables accounted for a non-significant 1,0% of the variance in the happy false alarm rate, $R^2 = .010$, $F(2,134) = .705$, $p = .496$.

In model 2, the SRP-III total score was added, to look into the relation between psychopathy and the happy false alarm rate. The SRP-III accounted for a non-significant 3,6% of the variance in the happy false alarm rate with $R^2 = .036$, $F(1,133) = 3.510$, $p = .63$.

The non-significant contribution of the SRP-III total score, lead to adding all the subscales of the psychopathy questionnaire in model 3. Only the ELS subscale was not excluded in this equation and accounted for an additional 4,2% of the variance compliance. $\triangle R^2 = .042$, $\triangle F(3,133) = 4.424$, $p = .037$. By Cohen's (1988) conventions, a combined effect of this magnitude can be considered "negligible" ($f^2 = 0.042$).

As can been seen in Table 6, the erratic lifestyle (ELS) subscale of the SRP-III is the only significant predictor of the happy false alarm rate in the final regression model ($sr^2 = .033$). This significant relation shows that high ELS scores are correlating with less false alarm rates in the happy facial expression condition.

Table 7. *Unstandardized (B) and standardized (β) regression coefficients and squared semi-partial correlations (sr^2) and the standard error for each predictor variable on each model of the multiple regression analysis predicting Happy False Alarm rate with psychopathy and the control variables*

		Happy False Alarm rate				
		B [95% CI]	SE (B)	β	sr^2	Sign
Model 1	Age	-.082 [-.347, .184]	.134	-.053	.003	.544
	Years of education	-.508 [-1.439, .423]	.417	-.093	.009	.283
Model 2	Age	-.117 [-.382 .149]	.134	-.075	.005	.386
	Years of education	-.692 [-1.635, .251]	.468	-.127	.016	.149
	SRP-III total	-.087 [-.179, .005]	.046	-.164	.026	.063
Model 3	Age	-.130 [-.396, .136]	.134	-.084	.007	.336
	Years of education	-.616 [-1.542, .309]	.468	-.113	.013	.190
	SRP-III ELS	-.317 [-.615, -.019]*	.151	-.182	.033	.037

CI = confidence interval
SRP-III = Self-Report Psychopathy version III
ELS = Erratic Lifestyle
** is p <0.05*

The last multiple regression analysis was performed to assess whether psychopathy is associated with neutral false alarm rate. In model 1 in the multiple regression analysis age and years of education were included as covariates, to see if they are significant predictors. Results show that these variables accounted for a non-significant 2,9% of the variance in the neutral false alarm rate, $R^2 = .029$, $F(2,134) = 2.035$, $p = .135$.

In model 2, the relation between neutral false alarm and psychopathy was investigated. The SRP-III total score variable was added, this explained a non-significant 3,8% of the variance with $R^2 = .038$, $F(3,133) = 1.235$, $p = .269$

In model 3, all the subscales of the psychopathy questionnaire were included to determine if one of the subscales had a significant relation with neutral false alarm. None of the predictor variables were included to the equation. Together these variables accounted for a non-significant 4,6% of the variance, $R^2 = .046$, $F(4,130) = .554$, $p = .696$.

Table 8. *Unstandardized (B) and standardized (β) regression coefficients and squared semi-partial correlations (sr^2) and the standard error for each predictor variable on each model of the multiple regression analysis predicting Neutral False Alarm rate with psychopathy and the control variables*

		Neutral False Alarm rate				
		B [95% CI]	SE (B)	β	sr^2	Sign
Model 1	Age	-.154 [-.420, .111]	.134	-.099	.010	.251
	Years of education	-.833 [-1.764, .098]	.471	-.152	.023	.079
Model 2	Age	-.175 [-.443, .092]	.135	-.112	.013	.197
	Years of education	-1.894 [-1.894, .007]	.481	-.172	.028	.052
	SRP-III total	-.052 [-.145, 0.41]	.047	-.097	.009	.269
Model 3	Age	-1.77 [-.488, .094]	.137	-.113	.013	.199
	Years of education	-.899 [-1.889, .091]	.500	-.164	.024	.075
	SRP-III CA	.221 [-.336, .778]	.281	.099	.005	.434
	SRP-III ELS	-.142 [-.627, .342]	.245	-.081	.003	.562
	SRP-III CT	-.133 [-.539, .273]	.205	-.087	.003	.518
	SRP-III IPM	-.057 [-.493, .379]	.220	-.032	.001	.797

SRP-III = Self-Report Psychopathy version III
CA = Callous Affect
ELS = Erratic Lifestyle
CT = Criminal Tendencies
IPM = Interpersonal Manipulation

Discussion

The aim of this study was to investigate the relationship between both hot and cool executive functioning and psychopathy. It was expected that high psychopathy scores predict poor performance on the Emotional Go/No-Go task. To be more specific, ELS and CT would contribute to a higher false alarm rate and especially in the fear condition of the Emotional Go/No-Go task. Thereby, a negative relation between CA and the false alarm rates in fear condition was expected. These results would imply that individuals with high scores on the CA subscale are less affected by the fear facial expression and make only few mistakes. Additionally, it was anticipated that high psychopathy scores predict worse performance on the Stop-it Signal task. Particularly CT will contribute to an insufficient performance. None of the expected relations are found. However, results of the regression analyses with hot executive functioning and psychopathy show that none of the hypothesis are confirmed. Significant negative relations are found between the Erratic Lifestyle (ELS) subscale and the total false alarm rate, specifically for emotional (happy, fear) and not for the neutral conditions of this task. This implicates that individuals that score high on the ELS subscale, are less affected by emotional information, as they make less mistakes during the emotional conditions of this task. Although this effect may be small, this outcome is not seen in relation within the affectively neutral conditions. Meaning no significant outcomes in both the neutral condition of the Go/No-Go task and in the cool Stop-it Signal Task.

The outcomes of the current study are in contrast with most literature found about psychopathy and hot EF. Although research with hot inhibition tasks, such as the affective Go/No-Go, in relation with psychopathy is not often executed, some studies show similar outcomes. One study that looked into an emotional-linguistic Go/No-Go task with psychopathic and antisocial individuals and a healthy control group, found similar results. They found that the psychopathic group showed weakened processing of negative emotional words, regardless of inhibition demands. They show that psychopathic individuals are less sensitive to emotional contexts, they ignored the emotional distractors when performing in an inhibition task. Thereby, the antisocial group showed impaired inhibition abilities when emotional words needed to be processed. This group showed an inability to control their behavior in emotional conditions. These authors conclude that the ability of psychopaths to stay ‘cool’ in

situations that demand inhibition can explain their effectiveness at premeditation and committing fraud (Verona, Sprague & Sadeh, 2012). A study by Wai & Tilopoulos (2012) looked into two different forms of empathy (cognitive and affective) and the relation with, amongst other things, psychopathy. They found that psychopathic personalities correlated negatively with global empathy. However, this effect was significant for affective empathy, but only weak for cognitive empathy. These authors conclude that psychopathic individuals are able to discern emotional states of others, but are unable to generate an appropriate emotional reaction in response to another person's emotions. Psychopaths process emotional information at a superficial level and are not distracted by emotional information when they want to attain a goal.

Furthermore, Verona et al., (2012) explain that processing of emotional information and inhibition are not mutually exclusive processes. Blair et al., (2007) found that cognitive task performance was disturbed with the influence of emotional distractors in healthy individuals. Reaction time increased with emotional distractors and not with neutral distractors. Hence, inhibition is not operating as an isolated executive function, but emotion processing and facial recognition influence it. Nevertheless, the results of studies that look into Facial Affect Recognition (FAR) and psychopathy are rather contradictory. Some literature suggests a general FAR deficit in psychopathic or antisocial individuals (Blair, 2001; Blair et al., 2001; Marsh & Blair, 2008; Wai & Tilopoulos, 2012), while other suggest that some psychopathic traits can contribute to enhanced FAR (Cigna et al., 2017; Woodworth & Waschbusch, 2007). The studies that found enhanced FAR in psychopathic individuals conclude that some psychopathic traits can contribute to a better facial expression recognition, especially fear recognition is enhanced. This improved identification of vulnerability can help psychopaths to better manipulate and persuade others. Cigna et al., (2017) state that callous affect (CA) is the psychopathic trait related to this improved fear recognition ability. Furthermore, they also found improved facial recognition with erratic lifestyle (ELS) and not only in fear emotions, but also in happy facial expression. These results are not in line with the results found in the current study. The current outcomes indicate that psychopathic individuals with high ELS scores are less able to process emotional information and are, in that regard, less sufficient in facial recognition. Cigna et al., (2017) add to their finding about ELS and improved facial recognition, that this effect is probably due to their small sample size (N = 38).

Overall, previous studies suggest that psychopathic individuals are able to process emotional information but they are not able to feel them properly. In this way they do not get distracted by this kind of information which clarifies why low levels of false alarm rates are found in the emotional (happy and fear) condition in relation with ELS. However, the relation between hot inhibition and psychopathy remains slightly ambiguous. These results challenge current theories that focus only on psychopathy in relation to deficits in FAR or heightened sensitivity to fear expressions, and they encourage further theoretical development.

As stated above, no significant relation was found between cool executive functioning and any of the psychopathy variables. Furthermore, no relation was found between the Neutral condition of the affective Go/No-Go and psychopathy. The expectation was to find a negative relationship between cool inhibition and psychopathy. Generally, literature shows that high psychopathic individuals have reduced inhibition abilities (Heritage & Benning, 2012; Krakowiski et al., 2015; Weidacker et al., 2017). However, there are some explanations for this non-found relation between cool executive function and psychopathy. First, a recent study by Delfin, Andiné, Hofvander, Billstedt & Wallinius (2018) also did not find an association between psychopathy and inhibition. The study measured inhibition in the same way as this research, namely with a Stop Signal Task (SST). The authors conclude that this task might not be suited, because if participants achieve either too low (<40%) or too high (>60%) levels of inhibition, the task stops measuring (Logan, Cowan & Davis, 1984). This can easily happen if the participant gets, for example, distracted. Thereby, this can also happen if the participant scores either very high or very low on psychopathy traits (Delfin et al., 2018). In the current study, the levels of psychopathy are relatively low. The highest total score on the SRP-III in this population is 279 out a possible 320. The mean and standard deviation of the total psychopathy score is 179±35, thus most individuals have a moderate psychopathy score between 144 and 214. It could be that these levels are too low to measure an association between impaired inhibition and psychopathy. Studies that did found a relation between psychopathy and impaired inhibition used a forensic (Krakowiski et al., 2015; Weidacker et al., 2017) or a non-forensic population with moderate psychopathic traits (Michalowski et al., 2015). In addition to this, a forensic or non-forensic group does not seem to be predominant. One study looked into psychopathic traits in non-forensic and forensic groups. They found that psychopathic traits predict

worse performance on inhibition, measured with the Stroop Task. However, group was a non-significant predictor of inhibition. There was no difference in inhibition between forensic and non-forensic psychopaths (Pasion, Cruz & Barbosa, 2018). The study by Delfin et al., (2018) studied relatively low psychopathic incarcerated individuals, and did not find an association between impaired inhibition and psychopathy. Along these lines, level of psychopathy may be explanatory why this study did not find an association between psychopathy and inhibition. This is something to keep in mind when future research is designed.

Secondly, the fact that inhibition is a somewhat ambiguous concept may explain why the current study did not find this relation. Often it is described as a unitary construct, which reflects the ability to ignore and suppress irrelevant information. A distinction is made between on the one hand inhibition of prepotent responses, namely the ability to stop dominant responses. On the other hand the resistance to distracter interference, or the ability to ignore distracting information (Rey-Mermet, Gade & Oberauer, 2018). This study mainly focusses on inhibition of prepotent responses. It seems possible that the relationship between psychopathy and inhibition deficits is more evident in the resistance to distracter interference type of inhibition. The response modulation hypothesis explains why psychopathic individuals are worse in ignoring distracting information. This hypothesis claims that psychopathic individuals are unable to sufficiently respond to important peripheral information if this is unrelated to the main goal (Smith & Lilienfeld, 2015). A study by Zeier, Maxwell and Newman (2009) confirmed this hypothesis. They compared psychopathic and non-psychopathic incarcerated individuals and found that psychopathic individuals are unable to process important inhibitory information. Thus, there is evidence that psychopathic individuals are worse at resistance to distracter interference inhibition and not so much for inhibition of prepotent responses.

Lastly, it is questionable to what extend this study really distinguishes cool EF from hot EF. The participants receive €7,50 for their participation. This reward makes the research motivationally driven and thus play hot executive functions a role. This could be of influence and can be an explanatory factor of why there are no significant relations found, although their remuneration was not dependent on their performance.

After discussing the outcomes of both hot and cool executive functioning, it is important to look into the definition of executive functioning. Executive functions

(EFs) are a broad range of different abilities. As stated before, there is a distinction between hot and cool EFs, respectively emotionally and motivationally driven and without these intentions (Zelazo & Carlson, 2012). The broad range of abilities belonging to EFs are for example: inhibition, interference control, working memory, cognitive flexibility, self-control and selective attention, altogether sometimes called cognitive skills. Nonetheless, in the neuropsychological research cognitive skills refers to brain processes of perceiving and processing information from the environment, without the influence of attitudes and believes. While in, for example, the forensic rehabilitation literature cognitive skills often refer to certain prosocial thoughts, attitudes and actions. With more complex tasks of planning, problem solving and decision-making both hot and cool EFs are necessary. Most research focuses on general EF constructs, and most of the current knowledge about more specific EF is based on examining these general constructs. This research focuses on one specific EF, namely inhibition. It could be possible that, when looking into the research of executive functioning, outcomes are different when using the more specific EFs. Further exploration of the concept cognitive skills, but also of the more specific EFs, is necessary. With that, it is important to keep in mind that EFs never function in isolation and that it is almost impossible to measure one single EF in cognitive tasks. This is necessary, not only for making firm conclusions in research, but also to appreciate the relevancy of executive functioning in offender rehabilitation.

Finally, the question remains to what extent psychopathy is related with executive functioning. The interest in research of psychopathy has bloomed over the past decades. Where there is a shift going from cold-hearted, violent murders to a much more complex understanding of psychopathic individuals. Psychopathy is still one of the biggest predictors of criminal behavior, so it is important to gain knowledge about how they think, behave and act to reduce recidivism and for clinical purposes. This research contributes to this understanding.

Limitations & Recommendations

The results of this study should be interpreted with some limitations. An important first note is that high correlations between the subscales of the SRP-III and the total score are present. This can contribute to multicollinearity and influences the multiple regression analyses. The data was checked for multicollinearity and thereby, Gordts,

Uzieblo, Neumann, van den Bussche & Rossi (2015) have researched the factor structure of the SRP-III questionnaire. They found that this questionnaire has a good fit with the four-factor model of psychopathy. Each of the subscales measures different factors of the construct psychopathy. This in combination with the VIF scores below 10, makes the high correlations of the subscales, sufficient to still use in the regression analyses.

The SRP-III is a self-report instrument measuring psychopathy. Psychopathy has certain features that make it logically to have concerns about dishonesty and social desirability. These may at their turn effect validity of the results. However, this questionnaire has multiple advantages and a review by Lilienfield & Fowler (2006) shows that it has good psychometric properties. Thereby, a recent study shows that psychopathic traits are well detected by self-report measures (Ray et al., 2013). Furthermore, the study involved a relatively small sample size, although comparable or bigger than most investigations with forensic samples. With that, there was no healthy control group to compare the outcomes. It is highly recommended for further research to add a healthy control group or look into psychopathic individuals in community samples, instead of only forensic populations.

Another suggestion for prospective research is to measure cool inhibition with different tasks, to see whether the SST is a valid task to measure inhibition in psychopathic individuals. In addition, levels of psychopathy must be investigated more profound, it could be possible that impaired inhibition is only seen in certain levels of psychopathy. Further research should also focus on extra-secured prisoners with probably higher psychopathy scores. Thereby, research that looks into the influence of a reward in an actually cool inhibition task needs to be conducted.

Conclusion

The present study contributes to the existing literature in a way that only one EF, namely inhibition, with hot and cool conditions is investigated in relation to psychopathy. The significant relation between ELS and hot inhibition is explained by that psychopathic individuals do not get distracted by emotional information, resulting in better inhibition skills. For cool inhibition no significant relations were found, this could be explained by low psychopathy levels found in this study.

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