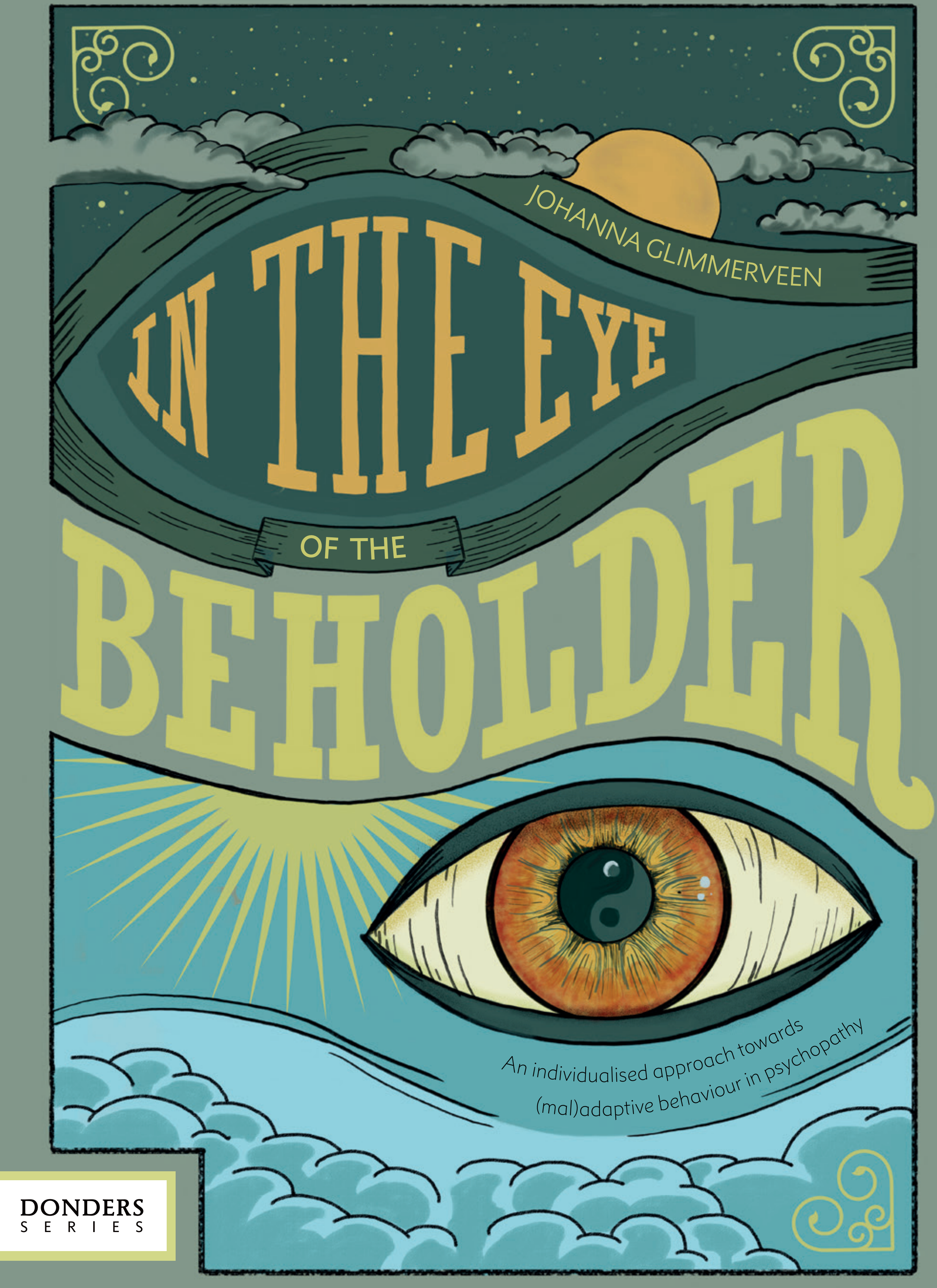
JOHANNA GLIMMERVEEN
IN THE EYE
OF THE
BEHOLDER
An individualised approach towards
(mal)adaptive behaviour in psychopathy
DONDERS
SERIES

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JOHANNA GLIMMERVEEN

COLOFON

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CHAPTER 1

General introduction

In a healthy social environment, children learn by trial-and-error how to behave according to the norms and values of their society. In general, positive and negative feedback from caregivers, teachers and peers serve as reinforcers that will eventually distil a behavioural style that is considered as socially well-adapted. For example, when hitting one's brother or sister, this will likely result in multiple aversive outcomes: witnessing the pain and sadness of the other child, as well as negative responses and disapproval by one's parents. On the other hand, sharing a toy or a piece of chocolate with another child will result in positive outcomes: a happy friend as well as parental appraisal. These experiences with positive and negative outcomes of behaviour (i.e., feedback) will help to predict the outcomes of future actions. Through these mechanisms, socially adaptive behavioural repertoires become internalised, which will support these children to function as socially well-adapted individuals in adulthood. Likewise, impairments in feedback-based learning and disrupted processing of predictive information will increase the likelihood of adult maladaptive or even antisocial behaviour. Antisocial behaviour and criminality have an immense impact on both individual lives and society as a whole, and, as such, law enforcement is still largely focused on repercussion and punishment, despite the high reoffending rates in antisocial individuals, especially those with psychopathy. This thesis takes another perspective, focusing on how positive outcomes of behaviour can be used to promote adaptive learning and decision making in psychopathic offenders.

1.1 DISORDERS ASSOCIATED WITH ANTISOCIAL BEHAVIOUR

The section above described how cognitive variables, particularly the processing of feedback and predictive information, may lead to the development of antisocial behaviour. However, environmental factors such as harsh and inconsistent parenting styles, a lack of parental supervision and monitoring, deviant peers, and parental antisocial behaviour increase the likelihood that a child is exposed to violence, substance abuse and criminality. Hence, children growing up in such environments are at risk of failing to internalise the societal norms and values that are required to behave appropriately (Fairchild et al., 2019; Freeze et al., 2014; McCabe et al., 2005). These cognitive and environmental factors in combination with biologically determined temperament and personality characteristics, such as impulsivity and sensation seeking, are risk factors for the development of conduct disorder (CD) during childhood and adolescence (Fairchild et al., 2019; Freeze et al., 2014; Loeber et al., 2009; McCabe et al., 2005; Raine, 2002). Youth with CD engage in multiple antisocial behaviours such as bullying, lying, stealing, vandalism, and physical aggression (Fairchild et al., 2019; Moffitt et al., 2008), and it is often regarded as a developmental precursor for adult antisocial personality disorder (ASPD).

Both prospective and retrospective research has shown that between 30 and 50% of youth with conduct disorder develop adult ASPD, and between 60 and 90% of adults with ASPD are found to have had CD during adolescence (Loeber et al., 2002; Moffitt et al., 2008). Individuals with ASPD act with a disregard for (the rights of) others, engage in violence and criminal activities, and consequently often end up in the criminal justice system (Glenn et al., 2013; Wilson, 2014). In fact, research shows that between 50% and 80% of prisoners meet the criteria for a diagnosis of ASPD (Hare, 2003a). Although ASPD already is associated with considerable costs for society at large (e.g., police time, prison services, (mental) health care, damage to property, emotional and physical harm to victims; see National Collaborating Centre for Mental Health, 2010), a subgroup of individuals with ASPD present with more severe and versatile antisocial tendencies, and have additional emotional and interpersonal impairments. This constellation of traits is referred to as psychopathy, and is considered to be a reliable risk factor for violent crimes and for reoffending after imprisonment (Douglas et al., 2018; Hemphill, Templeman, et al., 1998; Leistico et al., 2008). Importantly, the development of psychopathy is partly distinct to the development of ASPD; research suggests that the personality features that are believed to be at the core of psychopathy (i.e., callousness and unemotionality) are highly heritable and predictive of persistent future antisocial behaviour (Kahn et al., 2013; Viding et al., 2005).

A number of conceptualisations of psychopathy have been developed over the course of years, but there is still debate on the definition of the syndrome. The first to describe patients with psychopathic features was Hervey Cleckley (1941, 1976). In his classic and seminal book 'The Mask of Sanity' (1976), he describes a clinical profile including 16 criteria such as pathological lying, superficial charm, a lack of guilt, and a failure to learn from aversive experiences such as punishment (see Table 1.1). This work is still considered to be the basis for all models and their associated assessment instruments later to be developed, in which most of these features are still present. Currently, the most influential instrument to assess psychopathy in clinical samples is the Psychopathy Checklist-Revised (PCL-R; Hare, 2003a).

TABLE 1.1 Cleckley criteria for psychopathy

CATEGORY	ITEM
Positive adjustment	• Superficial charm and good intelligence • Absence of delusions and irrational thinking • Absence of "nervousness" • Suicide rarely carried out
Emotional-interpersonal deficits	• Untruthfulness and insincerity • Lack of remorse or shame • General poverty in major affective reactions • Pathologic egocentricity and incapacity for love • Specific loss of insight • Unresponsiveness in general interpersonal relations
Behavioural deviance	• Inadequately motivated antisocial behaviour • Poor judgment and failure to learn by experience • Unreliability • Fantastic and uninviting behaviour with drink or sometimes without • Sex life impersonal, trivial, and poorly integrated • Failure to follow any life plan

Note. Categories adopted from Patrick (2006).

TABLE 1.2 Hare criteria for psychopathy

FACTOR 1		FACTOR 2	
Interpersonal facet	**Affective facet**	**Lifestyle facet**	**Antisocial facet**
Glibness/superficial charm	Lack of remorse or guilt	• Need for stimulation / proneness to boredom	• Poor behavioural control
Grandiose sense of self-worth	Shallow affect	• Parasitic lifestyle	• Early behaviour problems
Pathological lying	Callous/lack of empathy	• Lack of realistic, long-term goals	• Juvenile delinquency
Conning/ manipulative	Failure to accept responsibility for own actions	• Impulsivity • Irresponsibility	• Revocation of conditional release • Criminal versatility

Note. The items 'Many short-term marital relationships' and 'Promiscuous sexual behaviour' are not included in the factor structure.

1.2 THE PCL-R

The PCL-R (Hare, 1991, 2003a) is a 20-item inventory, which is scored by two trained clinicians based on a semi-structured interview as well as file information regarding clinical and offence history. Originally, each item (with the exception of two more general items) of the PCL-R and its predecessor, the PCL (Hare, 1980), loads on one of two factors, referred to as Factor 1 and Factor 2 (Hare, 1991). Items loading on Factor 1 reflect emotional and interpersonal difficulties, such as shallow affect, glibness, reduced guilt, and lack of empathy. Factor 2 contains items reflecting impulsive antisocial behaviour, such as a need for stimulation, poor behavioural control, a parasitic lifestyle, and juvenile delinquency. Later research on the PCL-R has shown that each factor can be divided into two subfactors (or facets), which led to the second edition of the PCL-R (Hare, 2003a). In this four-factor model of psychopathy, Factor 1 is subdivided in a facet reflecting affective disturbances and a facet representing interpersonal traits, and Factor 2 is comprised of a facet capturing lifestyle and impulsivity and a facet representing antisocial tendencies (see Table 1.2). Total scores on the PCL-R range from 0 to 40, with higher scores reflecting a higher degree of psychopathy. Besides this dimensional score, a cut-off score is also used to classify individuals for clinical, legal and research purposes. However, partly due to cultural differences, the cut-off differs between countries; in North America a cut-off of 30 is used, while in most European countries a cut-off score of 26 is applied (see Hare *et* al., 2000).

One critique on the PCL-R is that it focuses exclusively on maladaptive traits and behaviours (Cooke *et* al., 2005; Patrick, 2006), not taking into account the adequate social adjustment and positive psychological functioning as originally described by Cleckley (1941, 1976). Furthermore, due to its widespread use to identify individuals with psychopathy, criticism has pointed to the risk of conflating the PCL-R with psychopathy itself (e.g., Cooke *et* al., 2005). In addition, there are a number of problems regarding the feasibility of PCL-R administration. First, it is time-consuming and requires extensive training to administer. Further, detailed clinical history and criminal records do often not exist or are not accessible for non-clinical samples (Lilienfeld & Fowler, 2007). However, different self-report measures have been developed to (also) assess psychopathy in non-clinical and sub-clinical samples. One instrument closely related to the PCL-R, as it is based on the factor structure of the PCL-R, is the Self-Report Psychopathy Scale (SRP-III; Paulhus et al., 2016).

1.3 SELF-REPORT MEASURES

The original SRP Scale (Hare, 1985) was developed as a self-report version of the PCL (Hare, 1980). In the course of years, it has undergone several revisions (SRP-II: Hare *et* al., 1989; SRP-III: Paulhus *et* al., 2016). The most recent version, the 64-item SRP-III (Paulhus *et* al., 2016) and its abbreviated 29-item SRP-Short Form (SRP-SF; Neumann & Pardini, 2014; Paulhus et al., 2016), has a four-factor structure and can be applied in both clinical and non-clinical samples (Neumann & Pardini, 2014). The factors of the SRP are similar to the four facets of the PCL-R, and labelled Interpersonal Manipulation, Callous Affect, Erratic Lifestyle, and Criminal Tendencies.

Another self-report measure is the Psychopathic Personality Inventory (PPI; Lilienfeld & Andrews, 1996) and its revised version, the PPI-R (Lilienfeld & Widows, 2005). The PPI was originally developed to overcome the dependence on antisocial behaviour in existing psychopathy measures, and instead lay greater emphasis on the personality traits inherent to psychopathy. The PPI is a 154-item self-report questionnaire that defines psychopathy as a construct with two main factors, named Fearless Dominance (PPI-I), reflecting affective and interpersonal personality traits, and Antisocial Impulsivity (PPI-II). There seems correspondence between the PCL-R and the PPI regarding total or global psychopathy score (Copestake *et* al., 2011), and the two factors of the PPI have been considered to be similar to the PCL-R factors (Benning et al., 2003). However, research suggests that the factors of both instruments are not equivalent, particularly those reflecting affective and interpersonal features (Copestake et al., 2011; Malterer et al., 2010). One important distinction is that the PPI factor Fearless Dominance covers adaptive traits regarding affective and interpersonal functioning, whereas the PCL-R exclusively focuses on maladaptive features.

A more recently developed instrument is the Triarchic Psychopathy Measure (TriPM; Patrick, 2010), a 56-item self-report questionnaire to assess psychopathy in both clinical and community samples. The TriPM is an operationalisation of the Triarchic Model (Patrick & Drislane, 2015; Patrick et al., 2009), which defines psychopathy as a construct that is composed of three main factors: Boldness (social dominance and emotional resilience), Meanness (aggressiveness and disregard for others), and Disinhibition (impulse control problems and negative affect). However, recent findings suggest that the TriPM may have a different structure than originally proposed, comprising six or even seven instead of three factors (Collison et al., 2020; Roy et al., 2020). Importantly, antisocial individuals without psychopathy, but with ASPD, are believed to have high scores on the factor Disinhibition but not on the Boldness and Meanness factors (Patrick et al., 2009). This supports the notion that psychopathy is, although there is considerable overlap, distinct from ASPD. Moreover, Meanness and Boldness are considered to be different expressions of an underlying biological predisposition towards experiencing low fear, but its phenotypic expression as either Boldness or Meanness is believed to be dependent on environmental factors, such as parenting style (Kochanska et al., 2002; Patrick et al., 2009).

1.4 INTEGRATION

In general, all the above-mentioned models propose a general tendency towards experiencing low fear and anxiety levels (but see Derefinko, 2015; Hoppenbrouwers et al., 2016), high impulsivity, and a lack of interpersonal relatedness to be central characteristics of having a psychopathic personality. In addition, individuals with psychopathy, particularly those in offender populations, often show high levels of sensation seeking and maladaptive responses to aversive outcomes. Among the well-known consequences of these characteristics are impairments in feedback-based learning and decision making. For instance, psychopathy is associated with high re-offending rates (Hemphill, Hare, et al., 1998; Olver & Wong, 2015), suggesting that punishment in the form of, e.g., imprisonment does not withhold psychopathic offenders from making the same maladaptive choices again. The relation between this maladaptive behaviour and psychopathy was proposed a long time ago (see Hoppenbrouwers et al., 2016) and has often been seen to result from reduced learning from negative experiences. However, there is still debate about the mechanisms involved in the reinforcement learning impairments associated with psychopathy. In the course of years, different models and theories have been developed, with a particular focus on either attentional or emotional processes. The next section describes the most prominent theoretical frameworks regarding reinforcement learning deficits in psychopathy.

1.5 THEORETICAL FRAMEWORKS

1.5.1 Two-factor learning theory

One of the influential models explaining the reinforcement learning deficits in psychopathy is, in essence, a more general theory of reward and punishment processing. The two-factor learning theory (Gray, 1987) conceptualises reward and punishment processing in terms of the behavioural activation system (BAS) and the behavioural inhibition system (BIS). The BAS responds to appetitive stimuli and serves to initiate goal-directed action in response to reward. The BIS is focused on detecting threat cues and serves to inhibit behaviours leading to aversive outcomes, such as those associated with punishment. According to the two-factor learning theory, decreased inhibition of behaviour leading to punishment (i.e., lower BIS reactivity) is associated with reduced negative arousal in response to punishment and with increased ongoing engagement in reward-seeking behaviour in the face of potential punishment. As such, modifications of this theory have been used to explain psychophysiological as well as behavioural data from studies showing disturbed reward and punishment processing in psychopathy (e.g., Fowles, 1980), such as poor aversive conditioning (Lykken, 1957; Schmauk, 1970) and passive avoidance learning (Lykken, 1957; Newman & Kosson, 1986; Newman & Schmitt, 1998; Schmauk, 1970). In these studies, psychopathic individuals showed a smaller increase in skin conductance level in anticipation of aversive stimuli, and were less able to use punishment cues to avoid aversive outcomes.

Despite the fact that different aspects of the two-factor learning theory have been incorporated in psychopathy-specific models of contingency learning (e.g., Low Fear hypothesis, Lykken, 1957; Response Modulation hypothesis, Patterson & Newman, 1993), the theory itself has been losing traction over time. Part of the reason is that the theory lacks specificity and does not account for inter-individual differences stemming from variations in the aetiology of psychopathy. Perhaps more important is the fact that anxiety proneness is directly related to BIS sensitivity, but anxiety is also believed to be a key factor contributing to the heterogeneity observed across psychopathic individuals (e.g., Newman et al., 2005; Skeem et al., 2007). As such, although attractive and able to provide useful theoretical elements, the two-factor learning model is not able to explain the complex and heterogeneous nature of psychopathy. However, the notion that impaired experience of negative affective states plays a key role in understanding learning impairments in psychopathy was a cornerstone for other theories of psychopathy as well, such as the low-fear hypothesis (Lykken, 1957, 1995).

1.6.2 Low-fear hypothesis

According to the low-fear hypothesis (Lykken, 1957, 1995), the most important mechanism underlying the impairments seen in psychopathy is a deficient emotional response to aversive events. The main assumption is that a deficit in experiencing fear in response to aversive outcomes impedes appropriate learning about the events leading to these bad outcomes. The belief is that psychopathic individuals already show difficulties in adapting their behaviour at an early stage of socialization. During typical (moral) socialization, children learn to behave appropriately by their tendency to avoid (parental) punishment, but children that are less sensitive to the negative valence of punishment are more likely to engage in the same (punished) behaviour again. Moreover, this theory assumes that the capacity to consider and act upon the negative consequences of behaviour largely relies on emotional processing. According to the low-fear theory, this explains why psychopathic individuals are more prone to take risks that non-psychopathic individuals would avoid. Although the avoidance learning deficits (Lykken, 1957; Newman & Kosson, 1986; Newman & Schmitt, 1998; Schmauk, 1970) and reduced electrodermal reactivity to threat cues (Hare, 1965; Lykken, 1957; Schmauk, 1970) observed in individuals with psychopathy can be regarded as evidence for the low-fear hypothesis, more recent advances in cognitive and neuroscientific research has indicated that it is likely that the involved mechanisms are far more complex than the low-fear theory assumes (see Hoppenbrouwers et al., 2016). In addition, Lykken (1995) has utilised constructs from the work of Fowles (1980) and Gray (1987) to adapt the original low-fear theory (Lykken, 1957). Indeed, psychopathy has been related to low fear, low anxiety, and reduced BIS reactivity (e.g., Baskin-Sommers et al., 2010; Lykken, 1995; Newman et al., 2005; Skeem et al., 2007). However, most of these studies measured BIS sensitivity using the BIS scales (Carver & White, 1994), which primarily assesses anxiety instead of fear (see Poythress et al., 2008). As anxiety and fear are two distinct constructs (Grillon, 2008), it seems unlikely that a reduced experience of fear as an emotion, rather than more basal threat processing impairments, is the core mechanism underlying psychopathic behaviour (Hoppenbrouwers et al., 2016). In addition, given that reinforcement learning requires, among others, memorizing and updating affective information, theories explicitly incorporating the involvement of higher-order cognitive processes have gained more ground. One of the first cognitive theories that opposed the aetiological explanations provided by the low-fear account was the Response Modulation hypothesis developed by Newman and colleagues (Gorenstein & Newman, 1980; Newman & Kosson, 1986; Patterson & Newman, 1993).

1.6.3 Response Modulation hypothesis

The Response Modulation (RM) hypothesis (Gorenstein & Newman, 1980; Newman & Kosson, 1986; Patterson & Newman, 1993) is an attention model postulating that psychopathic individuals have a strong preference for reward in combination with an early attentional bottleneck (see Figure 1.1). When presented with both reward and punishment information, the attentional filter prevents peripheral (i.e., punishment) information from being processed as long as target (i.e., reward) information is available.

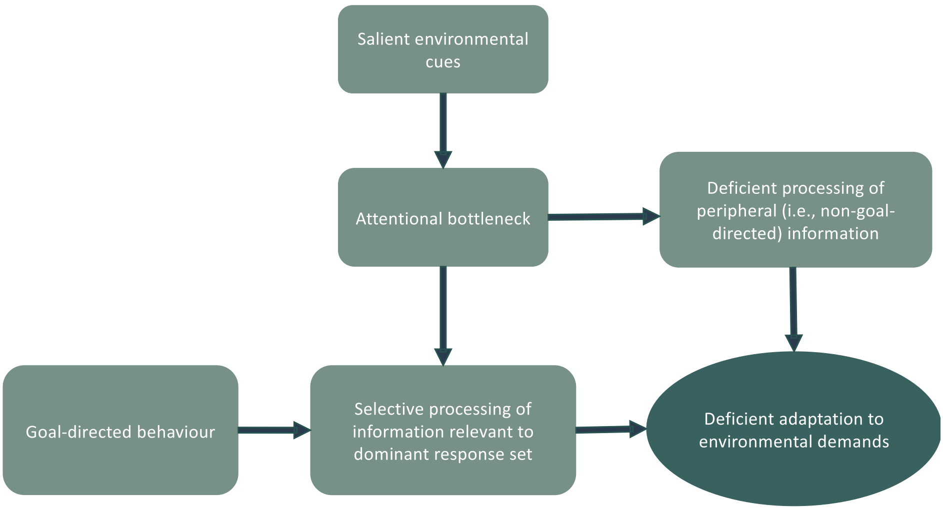

FIGURE 1.1 Schematic outline of the response modulation (RM) hypothesis. *The RM hypothesis states that, when engaged in goal-directed behaviour, an attentional bottleneck prevents peripheral (i.e., punishment) information from being processed as long as target (i.e., reward) information is available, resulting in adaptive learning deficits associated with psychopathy.*

When certain behaviour (e.g., robbing a bank; pressing a button in an experimental task) is rewarded under some conditions (e.g., getting away with money; earning points) and punished under other conditions (e.g., getting caught by the police; losing points), the experience of being rewarded will result in a dominant response set for exhibiting this behaviour, whereas punishment information will not have enough impact to produce avoidance behaviour. This decreased cognitive flexibility of psychopathic individuals, once a dominant response set has been established, results in perseveration of behaviour even when it is inappropriate (Lykken, 1957; Newman & Kosson, 1986; Schmauk, 1970).

However, different aspects of the model have been critiqued (see Blair & Mitchell, 2009), specifically for a lack of integration with more contemporary theories of attention. For instance, general models of top-down attention (e.g., Posner & Rothbart, 2007) do not predict the automatic allocation of top-down resources to peripheral information in healthy individuals, raising the question why this is considered to be an impairment in psychopathic individuals. In addition, psychopathic individuals perform comparably to healthy individuals in attentional set-shifting tasks, in which allocating attention to peripheral information is also required (Lapierre et al., 1995; Mitchell et al., 2002). Moreover, the model lacked integration with more recent neuroscientific findings about dysfunctional emotion circuitry in the brain, suggesting that abnormalities in the limbic system are fundamental to the emotional and behavioural dysregulation associated with psychopathy (e.g., Kiehl, 2006). A theory more directly incorporating such neuroscientific findings is the Integrated Emotion Systems model developed by Blair (2005).

1.6.4 Integrated Emotion Systems model

The Integrated Emotion Systems (IES) model (Blair, 2005) is a neurocognitive model that assigns a central role to dysfunctional interactions between the amygdala and the ventromedial prefrontal cortex (vmPFC). According to the IES model, the dysfunction results in impaired reinforcement-based decision making in individuals with psychopathy under specific circumstances that are reliant on amygdala-vmPFC integration (see Figure 1.2). In healthy individuals, the learning of stimulus-outcome associations, both aversive and appetitive, is dependent on the amygdala (Everitt et al., 2003; LeDoux, 2007). When an individual learns certain behaviours to gain reward or to avoid punishment (i.e., during instrumental learning), the amygdala sends the corresponding associations and expectancy information to the vmPFC. In turn, the vmPFC signals whether the expected reinforcement is present, continuously updating reinforcement expectancy representations. However, individuals with psychopathy have been

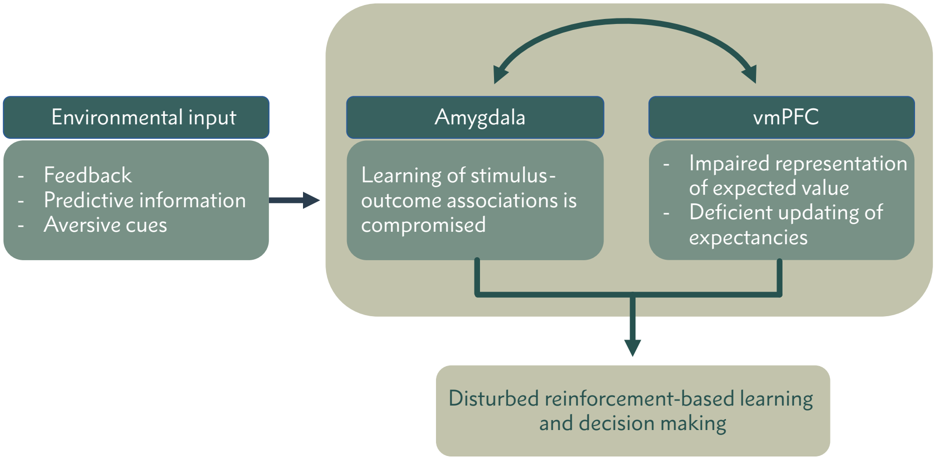

FIGURE 1.2 Schematic outline of the Integrated Emotion Systems (IES) model. *The IES model proposes that dysfunctional interactions between the amygdala and the vmPFC underlie the deficits in reinforcement-based learning and decision making associated with psychopathy.*

found to be impaired in stimulus-outcome learning, particularly in reversal learning (e.g., Baskin-Sommers et al., 2015; Brazil et al., 2013; Budhani et al., 2006; Mitchell et al., 2002).

One explanation for this impairment might be that during reversal learning, psychopathic offenders show increased vmPFC signalling when a previously rewarded response is punished, whereas healthy individuals and non-psychopathic offenders show decreased activation (Gregory et al., 2015). This suggests that the updating of expectancy representations may therefore be compromised. In addition, psychopathic individuals have also been found to be impaired in aversive conditioning (Lykken, 1957; Rothemund et al., 2012; Schmauk, 1970), and psychopathy has been associated with reduced amygdala activity during aversive conditioning (Birbaumer et al., 2005). Moreover, the transfer of reinforcement information from the amygdala to the vmPFC, which is essential for instrumental learning, is disrupted in individuals with psychopathy, as indexed by both reduced integrity of the white matter tracts and reduced functional connectivity between amygdala and vmPFC in psychopathy (Craig et al., 2009; Motzkin et al., 2011; Sundram et al., 2012; Vermeij et al., 2018).

1.6.5 Summary of explanatory models

Thus far, I have described four explanatory models of the reinforcement learning deficits of psychopaths, and how they place different weights on the affective and attentional aspects of emotional information processing. The Two-Factor model and the Low-Fear model rely on the idea that impaired processing of aversive events explains the learning difficulties observed in psychopathic individuals. According to the Response Modulation hypothesis, an attentional bottleneck prevents (meaningful) peripheral information from being processed during ongoing goal-directed behaviour. The Integrated Emotion Systems (IES) model postulates that dysfunctional interactions between the amygdala and the vmPFC result in impaired reinforcement-based decision making. The outline above also illustrates how theories of reinforcement learning in psychopathy have been influenced by general technical and neuroscientific developments. Importantly, these developments also affected the way in which experimental testing is conducted. However, there may be an important shortcoming in the design of studies performed thus far, which will be further explained in the next section.

1.7 CONSIDERING ECOLOGICAL VALIDITY AND SUBJECTIVITY OF REWARD VALUE

In order to be able to evaluate the findings from earlier experiments it is necessary to understand how these results were obtained and in which way the experimental paradigms evolved through time. This will be dealt with in more detail in Chapter 2. Most importantly, experimental studies show deficient responding to (predictors of) punishment, especially when facing a competing reward, as well as impaired learning and decision making following reward. However, a possibly crucial limitation of the studies performed until now is that the rewards that were used may not have been ecologically valid, and consequently not relevant or motivationally significant for participants with psychopathy, particularly for those that were incarcerated. The performance of psychopathic individuals in studies that focused on feedback-based learning and risky decision making in the lab setting may, therefore, not be fully generalisable to the problems they encounter in daily life. Incorporating a variety of ecologically valid rewarding stimuli in task design could be a way to overcome this problem, such as food, small goods, or pleasant activities.

However, in this light it should be considered that psychopathic individuals might be impaired in neural coding for subjective reward value, which should normalise the values of rewards of different natures. Normalising reward values is necessary when, for instance, comparing or choosing between a chocolate bar and a movie ticket. More specifically, there is convincing evidence that, in healthy individuals, a subarea of the vmPFC/orbitofrontal cortex (OFC) represents the subjective value of different reward types in a common neural currency that is used to direct decision making in daily life (Levy & Glimcher, 2012). This system, representing subject-specific values, has been found to be active across various tasks. The suggestion that this system is dysfunctional in individuals with psychopathy is based on findings in neuropsychological studies and in structural and functional imaging studies, as outlined next.

Psychopathy has been associated with impaired performance on neuropsychological tasks relying on the vmPFC/OFC (Baskin-Sommers et al., 2015; Brazil et al., 2013; Budhani et al., 2006; Mitchell et al., 2002). Neuroimaging studies have also linked psychopathy to abnormalities in vmPFC/OFC structure and functioning. For instance, on the structural level, reductions in orbitofrontal grey matter have been observed in psychopathic individuals compared to non-psychopathic individuals (Boccardi et al., 2011; de Oliveira-Souza et al., 2008; Tiihonen et al., 2008). Moreover, in a sample of individuals with high levels of psychopathic traits, grey matter volume and cortical thickness in the OFC was reduced in those with self-reported criminal convictions compared to those without a criminal record (Yang et al., 2010). This is compatible with the finding that cortical thickness in the OFC region is inversely related to response perseveration (Yang et al., 2011), an impairment in executive functioning typically linked to antisocial behaviour as observed in criminal psychopathic individuals (Morgan & Lilienfeld, 2000; Newman et al., 1987). In addition, although there is some evidence for increased activity in the vmPFC/OFC during specific tasks (e.g., instructed lying; see Glenn et al., 2017), the majority of functional imaging studies focussed on the vmPFC/OFC in psychopathy show reduced activity in these areas, using a variety of tasks tapping different underlying mechanisms. These findings include reduced medial vmPFC/OFC activity in psychopathic individuals during aversive conditioning (Birbaumer et al., 2005), during cooperation choices in the prisoner's dilemma paradigm (Rilling et al., 2007), as well as in adolescents with psychopathic tendencies during reinforcement in a passive avoidance task (Finger et al., 2011).

If coding for subjective reward value in the vmPFC/OFC is also compromised in psychopathic individuals, this would implicate that their failure to learn from negative consequences and their tendency to make suboptimal -sometimes catastrophic- choices in daily life might partly stem from an inability to weigh their behavioural options on a common scale. However, we do not know whether, or to what extent, this function of the vmPFC/OFC region is also affected, or that psychopathic individuals still have more or less intact coding for subjective value. Regarding the lab setting, there is often no evidence on whether psychopathic individuals find the rewards as equally attractive as, or at least comparable to, the control groups. As such, it seems important to find a way to test this assumption, for instance, by including reward attractiveness as an experimental variable. One way to achieve this could be to make subjective reward values more explicit, or to use tailor-made rewards to ensure their motivational relevance. Using this approach, it could be investigated whether psychopathic individuals' deficient responding to (potentially) punishing stimuli, as well as their disturbed processing of rewards, would remain visible. The evidence from experimental studies that have been performed in this area until now (which will be dealt with in the next chapter) suggests that motivationally insignificant reinforcers (i.e., mere points or small amounts of money) are likely to induce performance deficits during associative learning and decision making. However, we hypothesised that the 'right' rewards and punishers may motivate psychopathic offenders to make more appropriate behavioural adaptations, both in the lab setting and in real life situations. The studies reported in this thesis take these issues into consideration when studying passive avoidance learning, reversal learning, and risky decision making in psychopathy.

1.8 AIMS AND SCOPE OF THIS THESIS

As outlined above, psychopathy is associated with abnormalities in reward and punishment processing, which has primarily been experimentally studied during feedback-based learning and risky decision making. However, the motivational significance of the rewards and punishers used in these studies may have been insufficient to promote adaptive behaviour in psychopathic individuals. The work presented in this thesis takes into account the subjective values of personalised rewards in incarcerated offenders with psychopathy, and how these values may affect associative learning and risky decision making. To provide an overview of prior empirical research that is relevant to the research questions of this thesis, Chapter 2 summarises and discusses the existing literature regarding maladaptive learning and risky decision making in psychopathic offenders. Chapter 3 describes an explorative study aimed at identifying rewards that are considered attractive by forensic patients, using a combination of qualitative and quantitative analyses methods. The results of this study were used as input for the experimental studies on associative learning and risky decision making. More specifically, we selected and provided a number of naturalistic rewards that our participants could earn by performing well during two experimental tasks of which the results are presented in Chapters 4 and 5. In Chapter 4, a study on passive avoidance and reversal learning is reported. For each participant, subjective values were obtained for the selected naturalistic rewards, which were linked to overall performance. Chapter 5 describes an experimental study on risky decision-making, also using rewards with individually obtained subjective values. Finally, Chapter 6 provides a summary and a more general discussion of the findings.

CHAPTER 2

Maladaptive behaviour in psychopathic offenders:

An overview of associative learning and risky decision-making studies

ABSTRACT

Individuals with psychopathy present with maladaptive tendencies that have been linked to disturbed processing of outcomes during decision making in particular with respect to aversive outcomes. In general, individuals with psychopathy show risk-seeking behaviour, as well as excessive reward-oriented behaviour. This chapter provides an overview of empirical work on maladaptive behaviour in psychopathy in the context of reinforcement learning and risky decision making.

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2.1 INTRODUCTION

Psychopathy is a personality disorder characterised by interpersonal and emotional dysfunctions, as well as impulsive and maladaptive behaviour, with an increased risk for the development of an antisocial lifestyle. The disorder is prevalent among offender populations and is a strong predictor of various forms of recidivism (Hawes et al., 2013; Leistico et al., 2008). This tendency for psychopathic individuals to reoffend at a much higher rate than non-psychopathic offenders is indicative of a reduced ability to adapt behaviour appropriately in response to negative outcomes (e.g., incarceration). Historically, the maladaptive tendencies have been attributed to a relative insensitivity to punishment, or at least an incapacity to learn from experiences leading to aversive outcomes. The relationship between maladaptive behaviour and psychopathy has been described since the early 1800's (see Hoppenbrouwers et al., 2016, for an overview).

Through time, many experimental paradigms have been employed in an attempt to unravel and explain the core impairments associated with the maladaptive behavioural tendencies observed in psychopathy. Among the most extensively studied impairments observed in individuals with psychopathy are those related to the disturbed processing of reward and punishment in relation to different forms of learning and decision making. The main goal of this chapter is to provide an overview of the empirical work on maladaptive behaviour in psychopathy, with a particular focus on aversive conditioning, instrumental learning, and risky decision making.

2.2 AVERSIVE CONDITIONING

Aversive conditioning studies focus on autonomic reactivity to aversive stimuli, most often by measuring electrodermal responses. They are based on the principles of classic conditioning, in which an emotionally salient event (UCS) that evokes a biological (reflexive) response (UCR) is repeatedly paired with a neutral stimulus (NS). The NS becomes associated with the UCS, and is eventually transformed into a conditioned stimulus (CS) that will evoke the reflexive response (conditioned response: CR) in the absence of the UCS. During appetitive conditioning, repeated pairing of a pleasant stimulus with a neutral stimulus will eventually result in approach-related reflexes in response to the neutral stimulus, whereas pairing with unpleasant stimuli during aversive conditioning typically results in withdrawal-related reflexes. As such, abnormal conditioned reflexes may indicate deficient or excessive processing of appetitive or aversive events, or normal processing but deficient association of these unconditioned events with the NS. Physiological reactivity to conditioned threat cues can therefore be used to investigate the fear deficits that may underlie the failure to refrain from previously punished behaviour observed in psychopathic individuals.

David Lykken (1957) was the first to obtain experimental evidence for what he believed were fear-based learning deficits in individuals with psychopathy (for a contemporary view, see Hoppenbrouwers et al., 2016). Lykken (1957) measured electrodermal reactivity to conditioned auditory cues for electric shock in an offender sample and found that individuals with psychopathy developed weaker anticipatory responses to threats than healthy controls. Almost a decade later, Hare (1965) reported that besides the slower acquisition of conditioned fear responses to shock cues in psychopathic offenders, these responses also generalised less to unconditioned cues than in controls. Schmauk (1970) found that anticipatory electrodermal reactivity to both shock cues and social disapproval cues was lower in psychopathic offenders than in controls, but no differences were found in anticipation of loss of money. Another two decades later, in a study by Ogloff and Wong (1990), psychopathic offenders displayed increased heart rate but no significant increase in electrodermal activity during anticipation of an aversive auditory stimulus.

Since the early days, several studies on brain activation during aversive conditioning in criminal psychopaths have been performed. Birbaumer et al. (2005) measured electrodermal responding and brain activation using fMRI during anticipation of painful pressure. Compared to healthy controls, criminal psychopaths (although non-incarcerated at the time of testing) showed reduced electrodermal reactivity and reduced brain activation in areas associated with the acquisition of conditioned threat (e.g., amygdala, orbitofrontal cortex, anterior cingulate, anterior insula; see Büchel & Dolan, 2000). However, when comparing probability and contingency ratings between the two groups, no differences emerged. This suggests that the psychopathic participants were able to predict the occurrence of harmful events from threat cues on a cognitive level, with deficits emerging during the emotional processing of this information. Similar results were obtained in a study by Rothemund et al. (2012), in which psychopathic individuals displayed deficient conditioned startle and skin conductance responses, whereas cognitive processing of the stimuli appeared intact.

In line with this central role for deficient emotional information processing, Veit et al. (2013) showed that deficient threat conditioning in psychopathic offenders, as reflected by reduced electrodermal reactivity in anticipation of electric shock, was most strongly related to the affective facet of psychopathy.

On the other hand, event-related brain potentials (ERPs) showed scores on the interpersonal facet to be related to increased information processing, whereas the antisocial facet was related to decreased attention to the conditioned threat cues. Interestingly, Larson et al. (2013) showed in another fMRI study that manipulating the focus of attention could regulate the reduction in amygdala activation observed in psychopathic individuals during threat anticipation. When attention was explicitly directed to the threat cues signalling an electric shock, non-psychopathic and psychopathic offenders did not differ in amygdala activation during threat conditioning. Conversely, when attention was directed to goal-relevant non-threatening stimuli prior to the presentation of the threat cues, psychopaths displayed decreased amygdala activation and increased activation in the lateral prefrontal cortex. Schultz et al. (2016), however, observed enhanced amygdala responding to conditioned threat cues in psychopathic individuals relative to controls. Moreover, disrupted processing of conditioned threat cues in psychopathy was related to level of anxiety. BOLD activity patterns and electrodermal responses in low anxious psychopathic individuals were consistent with normal threat conditioning, whereas electrodermal responses and brain activity patterns consistent with fear inhibition were observed in high anxious psychopathic individuals.

2.2.1 Summary: Aversive conditioning in psychopathy

Offenders with high levels of psychopathy consistently show reduced autonomic responding to conditioned threat cues as indexed by electrodermal reactivity, at least when threat cues indicate physical harm (i.e., electric shock; painful pressure; loud noises) or social disapproval. However, cues indicating loss of money do not elicit abnormal autonomic responding. It might be argued that cues regarding social disapproval and loss of money require more higher-order cognitive processing, whereas the primary reflexes associated with the avoidance of physical harm may reflect a more direct measure of threat conditioning. More recently, imaging studies have provided evidence for reduced activation in brain areas associated with threat conditioning, such as the amygdala and the orbitofrontal cortex. However, the focus of attention during aversive conditioning may modulate amygdala reactivity to threat cues, with explicit direction of attention to aversive stimuli resulting in normal amygdala responses. Interestingly, one study to date showed enhanced instead of reduced amygdala activation in psychopathy and suggests that the threat-conditioning deficit pertains exclusively to high anxious as opposed to low anxious psychopathic individuals. All in all, it is evident that more research is needed to investigate how the different underlying aetiological mechanisms of psychopathy (e.g., on a factor or facet level) contribute to the observed deficiencies in threat conditioning. Other forms of associative learning have also been studied, with a focus on instrumental learning.

2.3 INSTRUMENTAL LEARNING PARADIGMS

2.3.1 Passive avoidance learning

One of the most extensively studied instrumental learning deficits in psychopathy is passive avoidance learning. During passive avoidance learning, participants are instructed to learn by trial and error, which stimuli to respond to and which stimuli to withhold responding to. Immediately after responding to a stimulus, positive (i.e., rewarding) or negative (i.e., punishing) feedback is presented. The participant should use this feedback information to guide future behaviour during encounters with the stimuli.

Lykken (1957) found that psychopathic offenders were less successful than non-psychopathic offenders and controls in learning to avoid shock punishment. Participants were instructed to learn a sequence of twenty 'choice points' in a mental maze, each consisting of four alternatives. In each choice point, one alternative was correct and one of the three incorrect alternatives gave an electric shock punishment. The manifest task was to learn to choose the (rewarded) correct alternatives, whereas the latent task was to learn to avoid the punished incorrect alternatives. Lykken (1957) found that psychopathic offenders performed significantly worse than controls on the latent task. This was the first study providing evidence for avoidance learning deficits in psychopathy. In a similar paradigm, Schmauk (1970) partly replicated this finding, as psychopathic offenders performed worse than healthy controls when electric shocks or social disapproval were used as punishment, but performed equally well when the punishment was loss of money. Also using a similar task, Schachter and Latané (1964) found that an injection with norepinephrine, which increases (emotional) arousal, improved avoidance learning in offenders with psychopathy, but not in non-psychopathic offenders. These results were regarded as evidence for deficient punishment processing, or, more general, a fear deficit.

Newman and Kosson (1986) developed a go/no-go discrimination task, in which participants were presented with eight different two-digit numbers of which half were go-stimuli (S+) and the other half were no-go stimuli (S-). Participants were instructed to learn to respond to S+ and to withhold a response to S-. The task was performed under two conditions: a punishment-only condition, in which participants only had the opportunity to learn from punishment for incorrect responses, and a reward+punishment condition, in which both correct responses were rewarded and incorrect responses were punished. Interestingly, there were no differences between psychopathic and non-psychopathic offenders in the punishment-only condition, but in the reward+punishment condition, psychopathic offenders made significantly more commission errors than the non-psychopathic offenders. There were no group differences in the number of omission errors. According to Newman and Kosson (1986), these results could not be explained by a 'simple' fear deficit, as in that case there also would have been differences in the punishment-only condition. Instead, they attributed the differences to disturbances in attentional processing and developed the RM-hypothesis (see previous section).

A number of variations of this task have been developed over the last decades. For example, to establish a dominant response set, by providing a high probability of reward for responding at the start of the task, Newman et al. (1990) gave participants a four-trial reward pre-treatment for the four S+. Again, psychopathic and non-psychopathic offenders did not differ in the number of omission errors, and psychopathic offenders did make significantly more commission errors than the non-psychopathic offender group. Newman and Schmitt (1998) replicated this finding using the reward pre-treatment, but when the groups were split in low-anxious and high-anxious subgroups, the difference was only observed in the low-anxious subgroups. When applying this variation of the paradigm in incarcerated female offenders, no group differences in either commission or omission errors were observed between psychopathic and non-psychopathic offenders, or between low-anxious and high-anxious subgroups (Vitale et al., 2011).

In addition, Newman et al. (1990) measured reflection after negative feedback, as indexed by the response time to terminate visual feedback on the screen in order to move on to the next trial. The extent to which participants slow down after punishment is generally the most predictive of passive avoidance learning (Patterson et al., 1987). Psychopathic offenders displayed less reflection after negative feedback, and when reflection required the interruption of a dominant response set, the differences between the two groups in passive avoidance errors were most profound. In another adaptation of the go/no go-task of Newman and Kosson (1986), Arnett et al. (1993) measured autonomic responsivity to reward and punishment feedback. Low-anxious but not high-anxious psychopathic offenders displayed lower heart rate responding following punishment than following reward. Moreover, following punishment, psychopathic offenders showed weaker heart rate and skin conductance responding than non-psychopathic offenders. These results were interpreted as the first evidence of psychopaths being less reactive to punishment, as until then, there was only evidence of reduced autonomic responding in anticipation of punishment. Importantly, no behavioural differences in either commission or omission errors were observed between the psychopathic and non-psychopathic offenders. However, this might be explained by the long and variable inter-stimulus intervals (8 – 14 s) that were incorporated to measure autonomic responding to feedback, forcing longer time to reflect on the outcomes of previous responses.

In order to evaluate effects of differential reward and punishment value on passive avoidance learning, Blair et al. (2004) attached different values to the four different S+ and S- stimuli in the design of Newman and Kosson (1986). As expected, psychopathic offenders made more commission errors than non-psychopathic offenders. In addition, psychopaths displayed a weaker learning effect across blocks than non-psychopathic offenders. It should be noted, however, that intelligence was a significant covariate and only a modest correlation between PCL-R score and commission errors remained after controlling for IQ. Interestingly, punishment value was not related to the performance of psychopathic offenders, but non-psychopathic offenders made more commission errors as punishment level increased. In addition, both groups were more likely to respond under high reward conditions, as indexed by a decrease in omission errors. De Brito et al. (2013) used the same task as Blair et al. (2004) in offenders with and without psychopathy and included a healthy control group. Both offender groups tended to make more commission errors than healthy controls, although this difference did not reach statistical significance. However, contrary to previous findings, there were no differences in the number of commission errors between the two offender groups. In addition, unlike the two comparison groups, psychopathic offenders were more likely to respond under the lowest reward value condition, which is a different finding than reported in Blair et al. (2004).

A portion of these studies suggests an effect of anxiety level on passive avoidance learning in psychopathic individuals. Both Lykken (1957) and Schmauk (1970) divided their psychopathic participant groups in 'primary (low-anxious) sociopaths' and 'neurotic (high-anxious) sociopaths'. In Lykken's study, the difference in performance of low anxious and high-anxious psychopaths was not statistically significant. In the study of Schmauk (1970), low-anxious psychopaths showed stronger passive avoidance learning deficits than high-anxious psychopaths in the psychical punishment condition. However, in the social punishment and the tangible punishment condition, the two psychopathic subgroups did not differ in passive avoidance learning. Other studies analysing subgroups of low-anxious and high-anxious offenders have found that the observed effects were either stronger in the subgroup of low-anxious psychopathic offenders (Arnett et al., 1993), or the difference between psychopathic and non-psychopathic offenders was only present between the low-anxious subgroups (Newman & Schmitt, 1998). On the other hand, psychopathic and non-psychopathic offenders in the study of Newman and Kosson (1986) did not differ in anxiety levels. Moreover, Kosson et al. (1990) as well as Thornquist and Zuckerman (1995), both using the go/no go-task of Newman and Kosson (1986), found PCL-R score and anxiety to be unrelated, although group differences based on anxiety level were not directly assessed. Vitale et al. (2011) did find a positive relation between PCL-R score and anxiety in female offenders, but there were no differences in passive avoidance learning between the low- and high-anxious subgroups. In addition, Newman et al. (1990), finding that low-anxious psychopathic offenders were less likely to interrupt a dominant response set to process negative feedback than low-anxious non-psychopathic offenders, reported that their results were even stronger when high-anxious participants were included. Others, such as De Brito et al. (2013) and Blair et al. (2004), did not include measures of anxiety level. Overall, the exact role of anxiety in passive avoidance learning remains unclear.

Differences in psychopathy-related passive avoidance learning deficits have also been reported in relation to ethnic differences, but it is still unclear what underlies these observations. Moreover, ethnic differences are not consistently observed in all passive avoidance studies. Newman and Schmitt (1998) and Thornquist and Zuckerman (1995) only observed the expected psychopathy-specific passive avoidance learning deficit in Caucasian offenders, and not in African-American or Hispanic offenders. However, Kosson et al. (1990) did observe the expected pattern of psychopathy-specific passive avoidance learning deficits in African-American offenders, but the effect was not as profound as observed in previously obtained data from Caucasian offenders, since group differences did not reach statistical significance. Importantly, when combining the data from this sample with the previously obtained data from their Caucasian offender sample, there were no effects of ethnic background on passive avoidance learning. Although not explicitly testing for ethnic differences due to a small number of non-Caucasian participants, Blair et al. (2004) reported that there were no indications that psychopathic and non-psychopathic African-American offenders performed differently than the Caucasian offenders in these respective groups. Other forms of instrumental learning, in particular reversal learning, have also been comprehensively studied in relation to psychopathy.

2.3.2 Reversal learning

As discussed in the section on passive avoidance learning, psychopathy is associated with deficiencies in learning stimulus-outcome contingencies. However, psychopathic individuals also have difficulties to adapt their behaviour to changing contingencies (e.g., Baskin-Sommers et al., 2015; Brazil et al., 2013; Budhani et al., 2006; Mitchell et al., 2002). The updating of information on reward and punishment contingencies appears disturbed, which is typically studied in reversal learning paradigms. During reversal learning, participants first acquire stimulus-reinforcement associations guiding them to discriminate between rewarding and punishing stimuli. At a certain point, however, the learned reinforcement contingencies will reverse and participants have to re-learn the discrimination in order to gain reward and to avoid punishment.

In the first study on reversal learning in psychopathic offenders, Lapierre et al. (1995) used a go/no-go paradigm. In the first fifty trials a strong response set was created, by having participants learn to respond to one stimulus (a square) and to avoid responding to another stimulus (a cross). In the next 150 trials participants had to withhold their response to the square and to respond to the cross. Psychopathic offenders made more commission errors than non-psychopathic offenders in the reversal phase, but there were no differences in omission errors or reaction times. However, Lapierre et al. (1995) did not report on performance during acquisition, whether there were any rewards or punishments contingent on responding, or how feedback was provided. More recently, Brazil et al. (2013) also used a go/no-go reversal task with two stimuli, but this time including two distinct cues indicating whether a go or a no-go stimulus was more likely to follow. Halfway the task, the predictive (probabilistic) relationship between the cues and the stimuli was reversed. Participants performed the task twice: once without instructions on the predictive relationship between the cue and the stimulus (i.e., automatic learning) and once with explicit instructions on this relationship (i.e., controlled learning). Psychopathic offenders, unlike healthy controls, displayed abnormal response reversal during controlled learning (as indexed by prolonged reaction times), but this impairment was absent in the automatic learning condition. These results suggest that psychopathic individuals do not have a general response reversal deficit, but that they experience problems in behavioural adaptation when information on predictive relationships between stimuli is actively processed.

Mitchell et al. (2002) used the intradimensional/extradimensional (ID/ED) shift task to assess reversal learning, which is a multicomponent instrumental learning task. The ID/ED shift task has nine phases, in which participants have to respond to different features of presented stimuli. After a fixed number of correct trials, the task shifts to the next phase. The task starts with two different shapes and the participant has to learn to respond to shape 1 and to withhold a response to shape 2. Once the participant has learned this discrimination, the contingencies are reversed. In the next phases, new shapes and features are added, cueing participants to adapt their responding (i.e., attentional set shifting), or the newly learned contingencies are simply reversed again (i.e., response reversal). The measure of interest in this task is the number of errors within a phase, before shifting to the next phase (i.e., errors to criterion).

Mitchell et al. (2002) found that psychopathic offenders made more errors than non-psychopathic offenders in two of the four reversal phases, whereas there were no differences in attentional set shifting performance. Dargis et al. (2017) obtained similar results with the ID/ED shift task, but also found an interaction between psychopathy and childhood maltreatment history. Offenders with higher levels of psychopathic traits who had suffered a greater degree of childhood maltreatment performed worse on reversal learning. Interestingly, when controlling for childhood maltreatment history, psychopathic offenders did not differ from offenders with low and intermediate levels of psychopathy on reversal learning performance. Dolan (2012), however, found that offender groups with differing levels of psychopathic traits all performed worse than healthy controls in the reversal phases as well as the attentional shift phases, but there were no differences between the offender groups. In addition, psychopathy scores were not related to any outcome measures of the ID/ED task.

Another reversal learning paradigm was developed by Budhani et al. (2006). On each trial, participants were presented with two images. Using probabilistic feedback that was provided after choosing one of the two images, participants learned by trial and error which image was the correct choice most often and were instructed to stay with this choice until the contingencies were reversed. During reversal, psychopathic offenders made more errors and were less likely to stay with a rewarded response than controls, whereas no impairments were observed during acquisition. De Brito et al. (2013) also applied this paradigm, but only observed differences between a combined offender group and controls in the number of errors during reversal. Similar to the previously discussed results of their passive avoidance study, which were obtained in the same sample, the subgroups of offenders that were high and low in psychopathy did not differ in response reversal performance.

Mitchell et al. (2006) designed an instrumental learning task with two reversal phases, which was presented to offender groups with differing levels of psychopathy. In the acquisition phase, participants were instructed to choose one of two stimuli presented on each trial, learning the stimulus-outcome associations by trial and error. In the first reversal phase, the contingencies of two of the four of the stimuli were reversed and in the second reversal phase the contingencies of the other two stimuli were reversed. Highly psychopathic offenders performed worse during acquisition and the second reversal phase than the group with low levels of psychopathy. The intermediate group also performed worse than the low-psychopathy group in the second reversal phase. Although there were no performance differences between the high and intermediate psychopathy group, psychopathy scores were negatively related to performance during acquisition and the second reversal phase.

In order to further disentangle the relation between psychopathy level and response reversal deficits, Gregory et al. (2015) investigated the neural basis of reversal learning in antisocial offenders with and without psychopathy. Although behavioural differences between the groups were not observed, there were remarkable group differences regarding brain activation in response to rewarded and punished responses. In psychopathic offenders, activity in the posterior cingulate cortex and anterior insula was increased in response to punished reversal errors. Additionally, offenders in this group were hyporesponsive to reward information in the superior temporal gyrus. These patterns were not seen in offenders without psychopathy and suggest that prediction error signalling and consolidation of reward information is dysfunctional in psychopathy.

2.3.3 Summary: Instrumental learning in psychopathy

Psychopathy has consistently been found to be related to deficits in instrumental learning based on stimulus-outcome contingencies. During passive avoidance learning, psychopathic offenders show deficits in withholding responses to avoid punishment, particularly when a dominant response set for reward has been established. However, the influence of other variables on passive avoidance learning, such as anxiety levels or ethnic background, is still unclear. Offenders with high levels of psychopathy are also impaired in adapting their behaviour to changing contingencies as indexed by reversal learning. However, performance differences between offender groups with different levels of psychopathy are not as robust as the differences found when comparing psychopathic offenders with healthy controls. In addition, other cognitive and clinical variables, such as the level of processing of predictive information or childhood maltreatment history, appear to play an important role in the severity of the reversal learning impairment in psychopathy. Also, several maladaptive behavioural outcomes share underlying mechanisms of cognitive impairments associated with psychopathy. For instance, impaired processing of predictive information, such as the probability of upcoming aversive outcomes, does not only affect reversal learning and passive avoidance, but also promotes risky decision making, which we will further discuss in the next section.

2.4 RISK-TAKING STUDIES

A key characteristic of psychopathy is a strong need for stimulation; psychopathic individuals often show excessive risk behaviour, such as sexual risk taking and substance abuse. Moreover, offences committed by psychopathic individuals often have a violent and/or sexual nature and can therefore be characterised as behaviour intended to gain immediate rewards despite potential punishment. As such, risk-taking studies performed in psychopathic offenders focus on the ability to forego potential large immediate rewards for small longer-term rewards to avoid larger losses.

Risk-taking behaviour has often been explained using the framework of the somatic marker hypothesis (Bechara et al., 1994), which states that autonomic physiological reactions to learned appetitive or aversive cues rather than cognitive processes guide choices under ambiguous circumstances. The Iowa Gambling Task (IGT; Bechara et al., 1994) involves probabilistic learning using (monetary) reward and punishment information and was developed as a test of the somatic marker hypothesis. Participants are given four decks of cards, of which two are 'risky decks' involving high reward and even higher punishment magnitudes, and the other two are 'non-risky decks' involving lower reward and punishment magnitudes. Over time, selection of the non-risky decks results in the greatest accumulated reward magnitude. In healthy individuals, increased anticipatory electrodermal responses are present before choosing cards from the risky decks and these implicit, unconscious markers guide them to choose advantageously throughout the task. However, individuals with lesions in the vmPFC do not develop these anticipatory warning signals (i.e., somatic markers), resulting in impaired decision making. Individuals with psychopathy show behavioural and affective similarities with orbitofrontal patients, such as impulsivity, low empathy and impaired learning from experience, and recent research suggests that psychopathic individuals are indeed impaired in recognizing their bodily sensations during stressful events (Gao et al., 2012; Nentjes et al., 2013).

The IGT has also been used to study risk behaviour in psychopathy, but studies focusing on IGT performance in psychopathic offenders primarily use behavioural measures rather than including additional indices of autonomic physiological responses. Only one (unpublished) study (Broom, 2011) included autonomic measures and found stronger electrodermal responses in psychopathic offenders compared to non-psychopathic offenders after selecting cards from the non-risky decks. Contrary to predictions based on the somatic marker hypothesis, no relation was found between psychopathy and anticipatory autonomic responses. Although this study used a modified version of the IGT including contingency reversals, overall psychopathy score was related to impaired performance throughout the task. In the previously discussed Mitchell et al. (2002) study, psychopathy was also related to impaired performance on the IGT. In line with the somatic marker hypothesis, psychopathic offenders tended to choose cards from the risky decks more often and failed to become risk averse over the course of the task. Similar results were obtained in a sample of ex-offenders (Beszterczey et al., 2013). Both PCL-R total score (reflecting overall psychopathy) and PCL-R Factor 2-score (reflecting an unstable and antisocial lifestyle) were positively related to IGT performance. Interestingly, IGT-scores strongly predicted recidivism at follow-up. Conversely, Lösel and Schmucker (2004) found no relation between psychopathy and IGT performance in offenders. However, analysing high-attentive and low-attentive subgroups revealed that low-attentive psychopathic offenders performed worse than individuals in the high-attentive psychopathic subgroup, whereas no differences were found between the non-psychopathic offender subgroups. Using both psychopathy and level of anxiety as grouping variables, Schmitt et al. (1999) found low-anxious offenders to perform worse than high-anxious offenders, but no predictive relation between psychopathy and learning in the IGT. Along the same line, Kuin and Masthoff (2016) found no relation between IGT performance and general psychopathy or specific psychopathic traits. Contradictory to other findings, Hughes et al. (2015) found psychopathy to be positively related to IGT performance. However, this study was somewhat atypical, since all three groups of participants (healthy controls, non-psychopathic and psychopathic offenders) failed to show learning over the course of the task.

Another well-known risk-taking task is the Balloon Analogue Risk Task (BART; Lejuez et al., 2002), in which participants are instructed to accumulate money or points by inflating balloons. Every button press inflates a balloon presented on a computer screen and increases the amount of money in a temporary bank. The money that has been accumulated in the temporary bank can be transferred into a permanent bank at each point in the experiment, after which a new balloon is presented. However, inflating the balloon too much will make it 'pop', resulting in a loss of all money accumulated in the temporary bank. Unlike the IGT, the BART does not involve a learning component. Although risk behaviour on the BART correlates with real-world risk behaviour also seen in psychopathic individuals such as substance abuse, gambling, stealing and unsafe sex (Lejuez, Aklin, Jones, et al., 2003; Lejuez, Aklin, Zvolensky, et al., 2003; Lejuez et al., 2002), Swogger et al. (2010) found no relation between psychopathy scores and BART performance in offenders, although there was a relation between psychopathy and self-reported real-world risk-taking behaviour. Moreover, similar to the results of Schmitt et al. (1999) obtained in the IGT, there was a negative relation between anxiety and BART performance. Snowden et al. (2017) did find a relation between psychopathy and risk taking on the BART in a mixed offender and community sample, but this effect could be largely attributed to Boldness dimension of the triarchic psychopathy model (Patrick et al., 2009) rather than to the Meanness and Disinhibition dimensions. As such, BART performance seems stronger related to psychopathy-associated fearlessness than to affective impairments and antisocial tendencies.

De Brito et al. (2013) used the Cambridge Gambling Task (CGT; Rogers et al., 1999) to assess risk taking in psychopathic offenders. Like the BART (Lejuez et al., 2002), the CGT does not include a learning component. On each trial, participants are presented with a row of ten boxes that are either red or blue. Participants have to guess under which of the two colours a token has been hidden by betting a proportion of their earned points or money. De Brito et al. (2013) did find controls to outperform offenders with and without psychopathy on decision-making quality (i.e., the proportion of trials the most likely colour is chosen), but there were no group differences in risk taking (i.e., the percentage of earned points that is betted in each trial) and pre-betting deliberation time. These findings suggest that both offender groups were cognitively aware of the risks associated with certain choices, but failed to adjust their behaviour accordingly. Since there were no differences between psychopathic and non-psychopathic offenders, antisociality rather than psychopathy seems to account for these performance deficits.

2.4.1 Summary: Risk-taking behaviour in psychopathy

According to the somatic marker hypothesis, psychopathic individuals should fail to develop anticipatory warning signals towards risky events or choices. Although research findings are quite mixed, most studies suggest that psychopathy is negatively related to task performance in risk-taking tasks. However, attention may moderate the relation between psychopathy and impaired learning in the IGT. Moreover, primarily psychopathic characteristics related to lifestyle instability and antisociality appear to be related to impaired decision making under risk in the IGT, rather than interpersonal and affective psychopathic features. This makes sense as the similarities between patients with orbitofrontal lesions and those with psychopathy mostly pertain to the behavioural domain. However, research using the BART in psychopathic offenders indicates that performance on the BART is stronger related to low anxiety levels associated with psychopathy, rather than emotional deficits or antisocial and impulsive behavioural tendencies. Moreover, one study using the IGT and one study using the BART did not find performance to be related to psychopathy, but to anxiety level. Taken together, findings from studies using behavioural measures of risk taking are far from conclusive, and more research is needed to disentangle the mechanisms explaining risk behaviour in psychopathic offenders. Specifically, the role of anxiety, attention and the underlying aetiology of the psychopathy construct in offenders needs to be further clarified.

2.5 CONCLUSION

Maladaptive behaviour involving aversive and appetive outcomes (i.e., punishment and reward) in relation to psychopathy has been extensively studied in the past decades. To summarise, psyhopathy has been related to deficient aversive conditioning, as indexed by reduced autonomic responding to conditioned threat cues, as well as reduced activation in the amygdala and orbitofrontal cortex during implicit threat conditioning. However, research suggests that the locus of attention and level of trait anxiety modulate the aversive conditioning impairment in psychopathy; low anxiety and an explicit focus on threat cues appear related to normal processing of aversive stimuli. Studies involving both aversive and appetitive stimuli have also consistently shown impairments in instrumental learning based on stimulus-outcome contingencies, such as passive avoidance learning (withholding responses to avoid punishment) and reversal learning (adapting behaviour to changed contingencies). However, as with aversive conditioning, there are indications that anxiety modulates these deficits, although in reversed direction; anxiety level seems positively related to task performance during instrumental learning. In addition, instrumental learning performance is affected by the level of processing of predictive information, such as the probability of upcoming aversive outcomes. The latter factor would also promote other forms of maladaptive behaviour, such as risky decision making. Although the literature suggests a positive relation between psychopathy and risk taking, findings are mixed, possibly also due to the use of a variety of experimental tasks relying on different paradigms. In addition, it appears that increased risk taking in psychopathy is primarily related to the behavioural factors associated with psychopathy (lifestyle instability and antisocial behaviour), rather than to interpersonal and affective deficits.

Taken together, there is overwhelming evidence that psychopathic offenders show maladaptive behaviour in the face of potential reward and punishment, but the exact mechanisms and moderating factors that are involved remain center of debate. As pointed out in the previous chapter, one of the things that most of these studies have in common is that the experiments used (near-)hypothetical rewards, such as mere points or small amounts of money. We hypothesised that these 'rewards' may not have been sufficiently motivationally salient for psychopathic offenders, but that using relevant rewards could possbly enhance processing of predictive information. However, what kinds of rewards are considered attractive by psychopathic and non-psychopathic offenders, especially those incarcerated or under imposed treatment? Do their preferences differ from those under community treatment, or from healthy individuals subsiding in society? Or are there more or less universal 'themes' to identify? We aimed on answering these questions in Chapter 3.

CHAPTER 3

Uncovering naturalistic rewards and their subjective value in forensic patients

ABSTRACT

The use of relevant reinforcers during treatment is essential for successful interventions. This especially applies to forensic psychiatric populations, which are known to be resistant to treatment. However, it is not clear which rewards are of importance for different types of forensic patients. The aim of the present study was to investigate reward preferences in two forensic patient populations. Applying the concept mapping methodology, 34 male incarcerated violent offenders under imposed psychiatric treatment and 41 male forensic outpatients generated, prioritised and categorised 98 and 115 rewards, respectively. Multidimensional scaling and hierarchical cluster analyses resulted in two concept maps with eight (inpatients) and five (outpatients) reward categories. In both maps, one dimension represented the effort required to achieve the rewards. The other dimension represented either the rewards' independency of the clinical environment (inpatients) or the level of arousal associated with the rewards (outpatients). Both inpatients and outpatients tended to rate high-effort rewards as the most valuable, especially when the rewards involved the clinical environment of the patient or when rewards were associated with lower levels of arousal. The results highlight the importance of considering individual differences in reward preferences in the development of therapeutic interventions.

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3.1 INTRODUCTION

The use of reinforcers is a key element of interventions aimed at behavioural modification (e.g., Buehler et al., 1966; Kazdin, 2012; Lussier et al., 2006; Petscher et al., 2009), in both psychiatric and non-psychiatric forensic settings (e.g., Timmerman & Emmelkamp, 2005; Wodahl et al., 2011; Wong et al., 2007). Finding relevant reinforcers may be of importance for promoting treatment response in forensic patients, because low treatment responsivity is common in these populations (Hanson & Morton-Bourgon, 2005; Howells & Day, 2007; Ogloff et al., 1990). Given the growing focus on considering individual differences in responsivity to treatment (Brazil et al., in press; Insel & Cuthbert, 2015), the use of patient-specific reinforcers is a key step towards developing individualised mental health care and may have positive contributions to the patient's motivation for treatment.

However, to be effective, reinforcement must be tailored to the needs, preferences, and values of each patient. This is in line with the responsivity principle of the Risk-Need- Responsivity model (RNR; Bonta & Andrews, 2007), which is one of the most prominent theories regarding forensic interventions. The RNR model highlights three principles that promote treatment success: the Risk Principle focuses on the level of risk of the individual offender (i.e., higher-risk offenders will benefit more from more intensive treatment), the need principle highlights the importance of criminogenic needs (i.e., only significant criminogenic factors should be targeted in interventions), and the responsivity principle describes how treatment should be provided (i.e., the intervention should be matched to offender characteristics such as motivational level, learning style, and (inter)personal circumstances). The RNR model has been criticised for over-emphasising risk and criminogenic factors, at the expense of attention to individual needs and values (Ward et al., 2007), which led to the development of the Good Lives Model as an alternative or complementary approach (GLM; e.g., Ward, 2002; Ward & Gannon, 2006). The GLM states that relapse in risky behaviour can be ameliorated by incorporating and emphasising positive factors during treatment, such as the use of positive reinforcement. The use of positive reinforcement strongly predicts treatment effectiveness within various clinical disciplines (Marshall et al., 2003; Marshall et al., 2002).

Importantly, a critical consideration for all forms of reinforcement-based (treatment) programs is that for something to be experienced as rewarding, several requirements must be met: (a) it must be attractive (affective aspect), (b) it must motivate the individual for action (motivational aspect), and (c) the thought of obtaining the reward must lead to an expectation of an enhanced positive state (cognitive aspect; Berridge & Robinson, 2003). This highlights the multi-facetted nature of the experience of reward as well as the need to consider how individual preferences may differ according to these aspects.

There are also more general psychological processes that influence valuation of reward. For instance, the degree of attractiveness of an expected reward is positively related to the amount of effort needed to obtain the reward. This tendency to give greater value to rewards that are harder to obtain has been referred to as effort justification (Aronson & Mills, 1959). It has also been accounted for by the within-trial contrast model (Alessandri et al., 2008; Klein et al., 2005), which assumes that the value of a reward is dependent on the value of the event that preceded it. In other words, the contrast between a relatively aversive event (such as the exertion of great effort) and a relatively pleasant event (e.g., the reward that follows it) inflates the subjective value of the reward.

Another example is that the temporal distance to the delivery of an expected reward is negatively related to the subjective value of that reward, a phenomenon called delay discounting or temporal discounting (Kirby & Maraković, 1996; Logue, 1988). In other words, individuals generally prefer a smaller immediate reward over a larger delayed reward, but the rate at which the value of the delayed reward decreases differs across individuals. More rapid discounting of rewards is associated with impulsivity-related dysfunctional behaviour (Reynolds, 2006), such as substance abuse (Bickel & Marsch, 2001), pathological gambling (Alessi & Petry, 2003), and overeating (Weller et al., 2008). Moreover, rapid discounting is related to antisocial behaviour in both children (Barkley et al., 2001) and adults (Petry, 2002). It is important to take these discounting effects into account in reinforcement-based therapy, especially in (clinical) populations known to have high discounting rates (e.g., Lussier et al., 2006).

Error justification and delay discounting are examples of how subjectivity affects motivation and reward valuation, depending on individual characteristics and the context in which a reward can be obtained. As such, it should not only be considered how important the use of reward is, but also how reward is experienced, which, in turn, extends to clinical practice. A prominent example of a successful therapeutic approach that incorporates reward and subjective valuation is the Community Reinforcement Approach (CRA), a treatment method for substance use disorders (Hunt & Azrin, 1973). This approach assumes that the use of naturalistic reinforcers with high ecological validity, such as enjoyment of a new hobby, new employment opportunities, or other pleasant activities, promote the development of alternative behavioural styles that are expected to ultimately become more rewarding relative to disruptive tendencies (i.e., substance abusing). One of the main objectives of CRA is to increase the number of healthy social, vocational, and recreational activities that are experienced as rewarding by determining relevant reinforcers for each individual.

Studies on the effectiveness of CRA and its derivatives have yielded positive results in non-residential treatment settings (for a review, see Meyers et al., 2011). Adaptations of CRA employ contingency management by rewarding desirable behaviours by, e.g., giving vouchers for drug abstinence (e.g., Secades-Villa et al., 2013). These vouchers are explicit, material reinforcers, and have specific monetary values. Contingency management programs are also used in correctional settings. Points (or vouchers) earned for showing good behaviour can be cashed-in to receive material goods or to participate in activities. When such programs are individualised, this may help to decrease both misconduct and reported offender complaints in the prison setting (French & Gendreau, 2006; Gendreau et al., 2014; Webb, 2003).

In forensic populations, deficiencies in reward and punishment responsivity have been associated with chronic adult offending (e.g., Buckholtz et al., 2010; Glenn & Yang, 2012), which makes it even more challenging to find well-tailored individualised reinforcers that can be used during treatment, especially in populations of psychiatrically ill offenders. A portion of forensic inpatients has not been continuously engaged in society for a long time, as they have spent time in prison and under imposed forensic psychiatric care. Consequently, they may have developed different needs and thus may experience different stimuli and activities as rewarding compared with individuals who are active members of society in the outside world. Importantly, the desirable and adaptive behavioural tendencies acquired through treatment must be generalised to life outside of incarceration. However, for forensic inpatients, behavioural change should first be established within the boundaries of the institution. It is therefore essential for in- and outpatients to identify and use those reinforcers that are experienced as being the most rewarding, but are also sufficiently meaningful in their current lives.

Despite the importance of incorporating reinforcers with high subjective value to promote treatment success, it still remains to be assessed which stimuli and activities are generally experienced as sufficiently rewarding by forensic in- and outpatients. To this end, the aims of the present study were to: (a) identify categories of naturalistic rewards that are considered relevant by forensic inpatients and outpatients; (b) investigate how these rewards are valued by these groups of patients; and (c) identify the dimensions across which these rewards can vary.

3.2 METHODS

3.2.1 Concept mapping

An approach known as concept mapping (e.g., Jackson & Trochim, 2002; Trochim, 1989) was applied to answer the central questions of this study. In general, concept mapping consists of a standardised research protocol that allows the exploration and quantification of how different types of items are clustered into coherent sets and how these sets are mapped on to a higher-order target concept (determined a priori by the experimenter). Ultimately, this approach yields a multidimensional graphical map depicting clusters of items and their interrelationships, and each cluster describes a different aspect of the target concept. It involves collecting qualitative data obtained in processes such as question-driven item generation and unstructured sorting, which in turn are analysed quantitatively by multidimensional scaling techniques. The concept mapping process used in the present study comprised six stages based on the procedure described by Trochim (1989): (1) participant selection, (2) item generation, (3) item rating, (4) item sorting, (5) statistical analyses, and (6) interpretation.

STAGE 1: PARTICIPANT SELECTION

In order to obtain representative samples of both in- and outpatients, inclusion depended exclusively on the judgment of the head therapists regarding the current mental and emotional stability of the patient. Some of the most prevalent reasons for head therapists advising against recruiting a patient at that particular time were (a) severe depressive symptoms, (b) diminished or disturbed contact with reality (e.g., psychosis), or (c) an intellectual level that was considered too low for constructive contributions to the tasks. Information about the clinical status and index offences of the patients was obtained from their patient files. Sample characteristics, including the most prevalent diagnoses and index offence categories in the patient samples, can be found in Table 3.1. Psychopathological diagnoses were defined by the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision (DSM-IV-TR; American Psychiatric Association, 2000).

JG conducted the recruitment and consent procedures, with the assistance of interns and the clinicians in the respective treatment facilities. All patients were approached for participation only after consulting and having obtained permission from their head therapists. All participants received written and oral information about the study, a financial compensation, and gave written informed consent. Potential participants were allowed a period of at least two weeks to consider and discuss their participation before signing the consent form. The protocol was approved by the local academic ethics committee.

Inpatient sample. Thirty-four male inpatients (item generation: N=11; item rating: N=34; item sorting: N=33), with ages ranging from 21–64 years (M=43.00, SD=10.40), and 76% having a Dutch cultural background, were selected from the population of a high security forensic psychiatric institute in The Netherlands.[1] All individuals constituting the inpatient population have committed serious criminal offences in connection with having a DSM-IV axis-I and/or axis-II disorder. Placement in the institute falls under a measure known as 'Ter Beschikking Stelling' (TBS), which is a court-ordered intensive inpatient treatment measure on behalf of the state. TBS can be imposed when the following conditions are met: (a) an offender suffered from a mental disorder at the time of the offence, (b) there is a risk of recidivism due to this disorder, and (c) the offence is punishable by a custodial sentence of at least four years. The inpatient data were collected in 2013 (item generation: N=11; item rating: N=15; item sorting: N=14) and 2016 (item rating and sorting: N=19).

Outpatient sample. The outpatient sample consisted of 41 male patients (item generation: N=13; item rating and sorting: N=31), from three affiliated Dutch forensic outpatient treatment centres[2], with ages ranging from 20–67 years (M=40.02, SD=12.71) and 83% having a Dutch cultural background. Individuals in the outpatient sample were engaged in treatment programs focused on problems of aggression regulation or sexual misconduct. Treatment of these patients is voluntary or has been ordered by the court (e.g., as part of probation). The collection of outpatient data took place in 2015.

1 Forensic Psychiatric Centre Pompestichting, Nijmegen, The Netherlands.

2 Kairos forensic outpatient treatment centers. locations: Arnhem, Den Bosch, and Nijmegen, The Netherlands.

TABLE 3.1 Sample characteristics

MEASURE		INPATIENTS	OUTPATIENTS
N		34	41
Age			
Average number of years (*SD*)		41.97 (9.98)	40.12 (12.71)
Range		21 - 64	20 - 67
Ethnicity			
Both parents Dutch nationality		76%	83%
At least one parent Asian, African or South American		24%	17%
Type of offence			
Sexual offence		65%	12%
	Age of victim < 16 years	47%	10%
	Age of victim ≥ 16 years	18%	2%
Violent offence (no sexual or material motive)		26%	34%
Miscellaneous (incl. burglary, theft, stalking, arson)		9%	7%
No known offence		0% (N/A)	46%
Legal pressure			
Court mandated		100%	41%
Voluntary		0% (N/A)	54%
Not yet sentenced		0% (N/A)	5%
Time in treatment			
≤ 3 months		0%	29%
4-9 months		0%	34%
10-18 months		6%	20%
> 18 months		94%	17%
Psychopathology			
Axis I	Depressive disorder	0%	22%
	Attention deficit (hyperactivity) disorder	9%	24%
	Pervasive developmental disorder	18%	5%
	Substance abuse disorder	50%	46%
	Intermittent explosive disorder	0%	37%
	Paedophilia	47%	10%
	Other axis I disorder	24%	34%
	No axis I disorder	9%	0%
Axis II	Cluster A personality disorder	3%	0%
	Cluster B personality disorder	35%	32%
	Cluster C personality disorder	0%	10%
	Personality disorder NOS	56%	41%
	With characteristics of cluster A / B / C	3% / 29% / 21%	2% / 27% / 12%
	Without specified characteristics in record	21%	5%
	No personality disorder	6%	17%

STAGE 2: ITEM GENERATION

Items were generated in group sessions that lasted approximately 90 min, focusing on a central question that incorporated the three central elements of reward as outlined by Berridge and Robinson (2003): "What do you regard attractive (affective aspect) to an extent that you would be willing to take effort to achieve it (motivational aspect), because you expect it would bring you a pleasant feeling (cognitive aspect)?" These three elements served as criteria that all items were required to meet in order to be included. In addition, this formulation allowed for the identification of both material and immaterial rewards.

Participants were encouraged to generate as many items as possible, which were directly displayed on a big screen. Both the central question and the generated items remained visible throughout the entire session. When participants came up with items that did not meet all three elements of the central question, they were stimulated to restate the item or to think of related concepts. The same was done when items were considered too vague, too broad, too specific, or when items were formulated negatively (e.g., "Not having (...)").

Highly similar items within one of the two patient samples were removed or merged. When a group of items was considered to consist of examples of a higher order concept, the exemplary items were merged into one item that was named according to this higher order concept. For instance, the items 'Playing soccer', 'Playing tennis', and 'Playing volleyball' were merged into the higher order item 'Playing ball games'. A stopping rule was applied after more than 70% of items generated in a single session overlapped the total pool of items generated in previous sessions.

Inpatient sample. Two item generation sessions were organised for the inpatient sample. Six patients participated in the first session and five other patients took part in the second session. In the first session, a total of 108 items were generated, of which 54 items (50%) remained in the final list after selection and merging of items by the authors; 150 individual items were generated in the second session, of which 44 items (29%) remained. The final list consisted of 98 individual items.

Outpatient sample. Item generation by the outpatient sample occurred in four sessions, in groups of two (sessions 1, 2, and 4) or seven patients (session 3). In the first session, 55 items were generated, of which 42 items (76%) remained in the final list after selection and merging of items by the authors; 72 individual items were generated in the second session, of which 36 items (50%) remained; 42 items were generated in the third session, of which 17 items (40%) remained; and 74 items were generated in the fourth session, of which 20 items (27%) remained. The final list consisted of 115 individual items.

STAGE 3: ITEM RATINGS

All items were numbered and printed on plastic cards. During individual appointments, participants were given a sheet of paper containing five sections numbered 1 (labelled least important) to 5 (labelled most important). It was explained to participants that their personal attitudes towards the items were of interest and they were then instructed to distribute all rewarding concepts evenly over the five sections. For the inpatient sample, this meant that the 98 cards were to be divided in such a way that two sections would contain 19 cards and three sections would contain 20 cards. Outpatients were instructed to put 23 cards in each section, as their item set contained 115 cards.

STAGE 4: SORTING TASK

The sorting task was performed immediately after the rating task. Participants were instructed to group the cards based on similar themes or content in different piles. It was explicitly stated that the sorting should be done in a way that made sense to the participant, and that at least two piles should be created. In addition, the participants gave each pile a label that covered the connection between the items. The sorting data of one inpatient were removed as this participant combined all his categories into one pile at the end of the task and refused to re-establish his previously formed categories. However, the item ratings of this participant (obtained in stage 3) were preserved. Therefore, in the inpatient sample, $N_{\text{item sorting}} = 33$, whereas $N_{\text{item rating}} = 34$.

STAGE 5 AND STAGE 6: ANALYSES AND INTERPRETATION

In order to analyse the sorting data, a binary similarity matrix was created, in which the rows and columns represented the individual reward items (inpatient sample: 98×98 matrix; outpatient sample: 115×115 matrix). In this matrix, cell values represented the number of participants that placed a pair of items in the same category. Thus, higher scores reflected higher similarities between items. The similarity matrices served as input for nonmetric multidimensional scaling analyses (MDS, PROXSCAL) using SPSS (IBM Corp., 2015), in order to translate the similarity of items into coordinates in a two-dimensional space. For each sample, these coordinates were plotted in a point map, with smaller distances between items on the map reflecting higher similarities.

When evaluating the congruence between the raw data and the final configurations in our study, we deviated from more traditional practices regarding the judgment of MDS solutions in two ways. First, the goodness of fit of the final model is reflected by the stress index, ranging from 0 (perfect fit) to 1 (random configuration). The average stress value of .28 reported in concept mapping studies (Rosas & Kane, 2012) is higher than recommended in the literature on MDS (e.g., Kruskal, 1964), which states that configurations with stress values >.20 are to be considered unreliable (for detailed explanations, see Trochim (1993) and Kane and Trochim (2007)). Importantly, this threshold was established based on simulations and experimental data, which differ fundamentally from the type of data generated using the protocol for concept mapping. Therefore, it seems more appropriate to judge the stress value of our model in relation to results of similar studies, rather than using stress value thresholds obtained from very different data collection protocols (Rosas & Kane, 2012).

The second consideration concerns the primary purpose of the MDS configuration in concept mapping studies, which is to display the clustering results visually. Although a better fit of the data might be observed using more than two dimensions, it would be difficult to generate equally parsimonious and interpretable results in three or more dimensions (Kruskall & Wish, 1978). In addition, Sturrock and Rocha (2000) showed that two-dimensional MDS solutions have less than a 1% probability of having no structure or a random configuration when stress values are below an upper limit of .39. As we expected our stress value to be close to the average stress value of .28 found in concept mapping studies (Rosas & Kane, 2012), we chose to restrict the MDS analyses in the current study to a two-dimensional solution.

Next, hierarchical cluster analysis using Ward's algorithm was performed on the MDS coordinates in order to group individual items into clusters, each representing a reward category. The cluster analysis was set at a maximum of 20 clusters and a minimum of 3 clusters (Trochim, 1989). On each step in the analysis, the cluster solution was moved to a lower number of clusters (e.g., from 20 to 19 clusters). The within-cluster sum of squared errors, reflected by the agglomeration coefficient, naturally increases with each step in the clustering procedure. Small coefficients indicate fairly homogeneous clusters, whereas large coefficients or a sudden large incremental percentage change in the coefficient indicates heterogeneous clusters (Hair et al., 1998). The decision on the number of clusters was therefore based on the percentage change in the agglomeration coefficient when moving through the different cluster solutions, as well as on interpretability (i.e., whether a grouping still made sense for the items in the conceptualisation).

In order to label the dimensions represented by the axes of the concept maps, the authors independently evaluated the distribution of the items in terms of shared reward features. In other words, it was determined which features were common to rewards on one extreme of an axis and discerned them from those at the other extreme of the axis. For each axis, these features were combined into one dimensional concept that correctly represented all items in the concept map. Finally, average patient ratings for items and clusters were calculated.

3.3 RESULTS

For clarity and readability purposes, the individual item names have been omitted from the two concept maps. However, the complete lists of reward items are provided as supplemental material (see Supplement 3A).

3.3.1 Inpatient sample

The MDS procedure performed on our inpatient data resulted in a final stress value of .26 after 22 iterations. Hierarchical cluster analysis was performed on the item coordinates and inspection of the agglomeration coefficients (see Table 3.2) shows that the first large percentage change occurs when moving from the eight- to the seven-cluster solution after relatively small increases, and a second jump when moving from the four- to the three-cluster solution. Since (1) the first jump indicates that in the seven-cluster solution two dissimilar clusters have been combined, and (2) the eight-cluster solution was judged by the authors to have the most clearly interpretable reward categories, this indicated that the eight-cluster solution is both statistically and conceptually the most appropriate. Figure 3.1 shows the inpatient concept map, depicting the eight reward clusters and their average ratings in two-dimensional space. Exemplary items of the clusters are presented in Table 3.3.

TABLE 3.2 Clustering agglomeration coefficients of the inpatient sample

INPATIENT SAMPLE			
Number of clusters	Agglomeration coefficient	Differences in coefficient	Percentage change in coefficient in next level
15	1.834	0.183	0.09
14	2.017	0.239	0.11
13	2.256	0.274	0.11
12	2.530	0.31	0.11
11	2.840	0.427	0.13
10	3.267	0.526	0.14
9	3.793	0.624	0.14
8*	4.417*	1.405*	0.24*
7	5.822	1.467	0.20
6	7.289	2.029	0.22
5	9.318	2.264	0.20
4	11.582	6.595	0.36
3	18.177	9.911	0.35
2	28.088	17.241	0.38
1	45.329		

Note. * *indicates an abrupt large percentage change when moving to a lower number of clusters.*

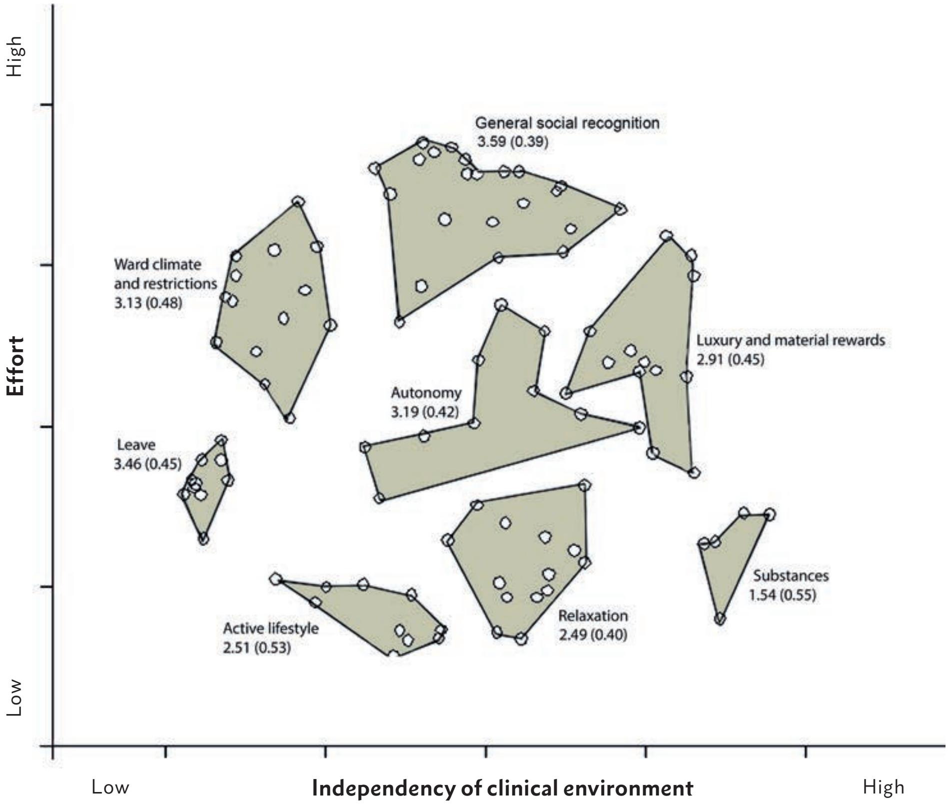

FIGURE 3.1 **Concept map resulting from multidimensional scaling and hierarchical cluster analysis for the inpatient sample.** *The figure shows the position of the eight reward clusters, the cluster names and average ratings (between parentheses). Dots represent the individual reward items generated by the inpatients. Lines depict the cluster boundaries.*

TABLE 3.3 Cluster names and exemplary items of inpatient rewards

INPATIENT REWARDS	
Cluster name	**Exemplary items**
Luxury and material rewards	• Salary raise • Coffee
General social recognition	• Promises being kept • Helping others
Ward climate and restrictions	• Visits of volunteers • Possibilities to look for a partner outside the clinic
Active lifestyle	• Swimming • Organizing or attending activities in the clinic
Substances	• Cigarettes • Marijuana
Autonomy	• Taking care of pets • Individually adjusted internet access
Relaxation	• Singing and making music • Watching a movie
Leave	• Going on leave in the evening • Meeting someone from outside during leave

3.3.2 Outpatient sample

Performing MDS on our outpatient data resulted in a stress value of .27 after 39 iterations. An abrupt change in the size of the agglomeration coefficients resulting from hierarchical cluster analysis (see Table 3.4) indicated that dissimilar groups of items were merged when moving from the five- to the four-cluster solution. As the five-cluster solution was also judged to consist of conceptually coherent reward item groups, this solution was identified to be the best representation of the current data. Figure 3.2 depicts the outpatient concept map, showing the five reward clusters and their average ratings in two-dimensional space. Table 3.5 presents exemplary items of the clusters.

TABLE 3.4 Clustering agglomeration coefficients of the outpatient sample

OUTPATIENT SAMPLE			
Number of clusters	Agglomeration coefficient	Differences in coefficient	Percentage change in coefficient in next level
15	2.351	0.272	0.10
14	2.623	0.275	0.09
13	2.898	0.327	0.10
12	3.225	0.455	0.12
11	3.680	0.628	0.15
10	4.308	0.631	0.13
9	4.939	0.733	0.13
8	5.672	0.83	0.13
7	6.502	0.973	0.13
6	7.475	1.222	0.14
5*	8.697*	4.428*	0.34*
4	13.125	5.045	0.38
3	18.170	9.542	0.34
2	27.712	25.16	0.48
1	52.872		

Note. * *indicates an abrupt large percentage change when moving to a lower number of clusters.*

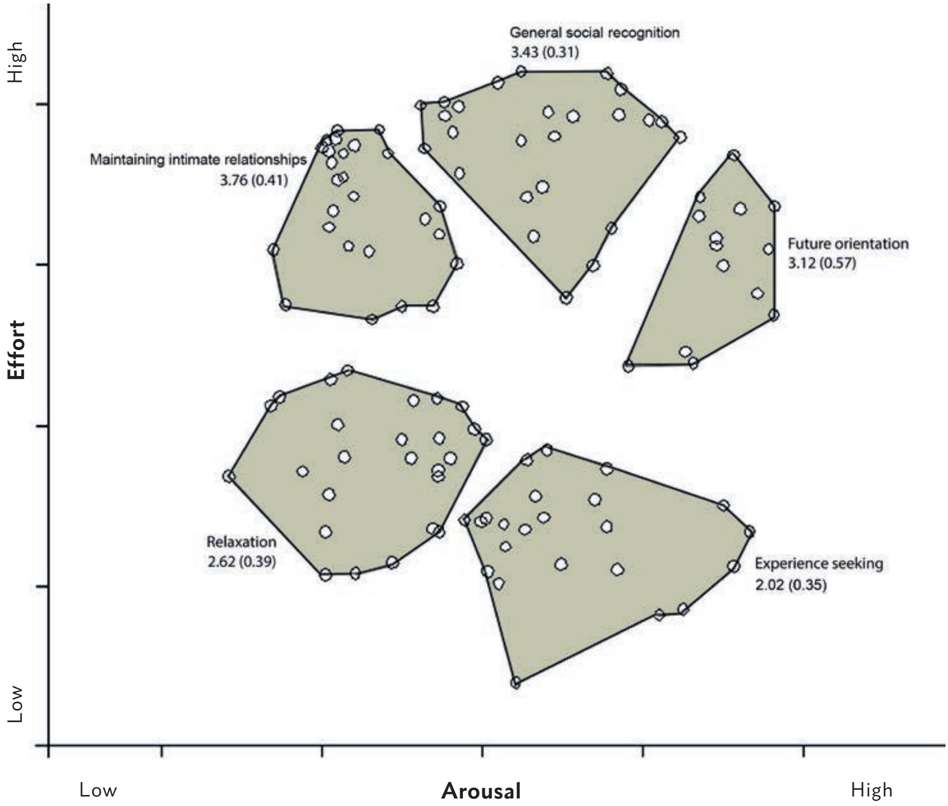

FIGURE 3.2 Concept map resulting from multidimensional scaling and hierarchical cluster analysis for the outpatient sample. *The figure shows the position of the five reward clusters, the cluster names and average ratings (between parentheses). Dots represent the individual reward items generated by the inpatients. Lines depict the cluster boundaries.*

TABLE 3.5 Cluster names and exemplary items of outpatient rewards

OUTPATIENT REWARDS	
Cluster name	**Exemplary items**
Maintaining intimate relationships	• Having contact with my children on a regular basis • Having a life partner
General social recognition	• Being appreciated for my efforts • Being seen and acknowledged as a person
Future orientation	• Having a job • Making a deadline
Relaxation	• Watching a good movie or documentary • Walking the dog
Experience seeking	• Speeded activities (e.g., quad driving) • Holidays and travelling

3.4 DISCUSSION

3.4.1 Main findings

The present study identified relevant reward categories for forensic in- and outpatients, as well as the dimensions across which these rewards vary. In addition, preference ratings were collected and mean ratings for each reward category were calculated. Cluster analysis resulted in eight reward categories in the inpatient sample and five reward categories in the outpatient sample. A conceptual comparison of the reward categories of the two samples (see Figures 3.1 and 3.2) suggested that both groups identified categories of rewards related to social functioning and personal efficacy, as well as more tangible rewards such as concrete items and activities. Not surprisingly, these shared categories concern topics that are important common denominators in the lives of most individuals and are central to classic and contemporary models of human motivation (e.g., Kenrick et al., 2010; Maslow, 1943; Ryan & Deci, 2000).

The labelling procedure applied on the axes of the two concept maps resulted in one comparable dimension and one dimension differing between the two samples. Both for inpatients and outpatients, the experience of rewards varied according to the amount of effort required to achieve a reward (y-axis, Figures 3.1 and 3.2). Low-effort rewards (e.g., material items or relaxing activities) concerned items that are relatively easy to access, as opposed to high-effort rewards that would require more cognitive and emotional effort and larger time investments. Although this label parallels one of the three reward aspects in the instructions during item generation (based on Berridge & Robinson, 2003), the decision to label this dimension 'effort' was reached by comparing the reward items and their positions in the map. For the inpatient group, the other dimension referred to the degree to which the rewards were independent of the clinical environment (x-axis, Figure 3.1). In the outpatient group, this dimension concerned the level of arousal associated with the rewards (x-axis, Figure 3.2).

In both samples, patients tended to rate high-effort rewards as the most valuable, especially when the rewards involved the clinical environment of the patient (inpatient sample) or when the rewards were associated with lower levels of arousal (outpatient sample). One interpretation is that the rewards requiring higher effort were more abstract and long-term rewards that are associated with more intrinsic motivation, which in turn has been shown to be reduced by extrinsic, tangible rewards (Deci et al., 1999; Ryan & Deci, 2000).

The change in cluster ratings when moving along the environment dimension of the inpatients' concept map shows that the inpatient group rates rewards that apply to their current situation and status in the forensic psychiatric clinic as more valuable than rewards relating to their future lives outside. Low-effort and high-effort rewards related to low independency of the clinical environment are more applicable to patients in later treatment stages. One prediction generated from these findings is that the subjective values of the rewards shift as treatment progresses, so that patients who have the end of incarceration in sight show stronger preferences for rewards that are focused on their lives outside. Further research relating treatment stage to reward (cluster) ratings is needed to explore this hypothesis.

The outpatient group gave higher ratings to rewards that involved lower levels of arousal relative to rewards requiring equal effort but were associated with higher levels of arousal. One explanation of this observation could be that high arousal experiences are perceived as stressful, and as such are linked to negative affective states. Most people will try to avoid experiences leading to these states (e.g., Krieglmeyer et al., 2010; Rinck & Becker, 2007). Thus, the findings suggest that patients showed a tendency to prefer low-arousal rewards because it seems likely that these rewards were intrinsically associated with more positive affective states relative to high-arousal rewards.

In line with this, literature on positive emotions (Fredrickson, 1998, 2001) suggests that effort and arousal are two dimensions of basic positive emotions such as interest, joy, contentment, and love. Interest, characterised as a high-effort and high-arousal emotion (Fredrickson, 1998), is believed to motivate focused attention, receptivity to information, and learning across situations and throughout the life span (Dougherty et al., 1996). As such, it shows overlap with the outpatients' cluster 'future orientation', which captures items related to personal development, career opportunities and goal setting. Joy, described as a low-effort and high-arousal emotion (Fredrickson, 1998), is associated with the need to be playful, creative, and pushing the limits (Fredrickson, 2001) which parallels the characteristics of the rewards pertaining to the cluster 'experience seeking'. Contentment, a low-effort and low-arousal emotion (Fredrickson, 1998), has been described as a state of inner peace that is felt when people feel comfortable, at ease in, or at one with their situation (Fredrickson, 2013; Mitte & Kämpfe, 2008), which applies to the cluster 'relaxation'. In this theoretical framework (Fredrickson, 1998), love was originally described as overlapping the other emotions and as such was associated with variable levels of arousal and effort. However, when love is interpreted as a mixture of positive emotions in relation to other individuals (Mitte & Kämpfe, 2008), this applies to both the high-effort clusters 'maintaining intimate relationships' and 'general social recognition' of which the items represent low and intermediate levels of arousal, respectively. Thus, the pattern of results converges with the predictions made by the positive emotions framework to explain the link between positive affective states, effort, and arousal.

Moreover, the position of the reward items along the 'effort' dimensions appears related to the extent to which the rewards relate to the pursuit of hedonism and eudaimonia (Ryan & Deci, 2001). Hedonism can be described as a state of immediate, momentary pleasure, with an emphasis on physical stimulation, or a state of relaxation, whereas eudaimonia can be reached through personal growth and development. Stated differently, hedonism refers to a state of happiness, whereas eudaimonia can be explained as a higher state of well-being. Waterman (1993) found that eudaimonia was more associated with being challenged and exerting effort, whereas hedonic enjoyment was more related to being relaxed, away from problems, and happy. Our findings are in agreement with this dichotomy. Rewards related to autonomy, quality of social functioning, personal growth, and development, are in both concept maps on the high-effort level. Relaxing activities, substance use, and other stimulating experiences are more situated on the low-effort level.

However, it could be argued that criminal activity is often focused on immediate gratification of materialistic desires (e.g. Petry, 2002), or relates to an inability to control inappropriate emotional and sexual impulses (Gottfredson & Hirschi, 1990; Pratt & Cullen, 2000). From that perspective, one could expect that more hedonic rewards would hold higher values in forensic populations, as a hedonistic lifestyle focused on short-term immediate rewards has often contributed to the criminal careers of these individuals. In addition, long-term goals relating to the pursuit of self-fulfilment are often lacking in a large portion of offenders (Pratt & Cullen, 2000), especially in offenders with more severe antisocial tendencies and psychopathy (Hare, 2003b; Wiebe, 2003). However, our data show that, at least in these samples, individuals in forensic populations still prefer the achievement of personal growth or development over short-term materialistic rewards.

3.4.2 Clinical implications

It is important to keep in mind that determining which reinforcers to use during treatment of offenders with mental disorders is a complex undertaking. To illustrate, reinforcers can be classified as implicit (e.g., personal attention of the therapist) or explicit (e.g., vouchers), short-term (i.e., those effectuated during treatment) or long-term (i.e., the positive effects of successful treatment), and these dimensions will always interact and can even be in conflict. The reinforcers used in reinforcement-based treatments in correctional settings most often involve short-term, explicit, low-effort rewards (Gendreau et al., 2014). Contingency management programs that focus on short-term rewards help promote discipline and structure in prison settings (Webb, 2003), and are effective in the treatment of substance dependence in community settings (Secades-Villa et al., 2013). Regarding long-term behavioural change, our findings are in line with the GLM (Ward, 2002; Ward & Gannon, 2006) and suggest that it may be more beneficial to focus on rewards or goals that increase personal growth and social functioning, which will likely provide more opportunities for success in the future.

The potential of this approach is further highlighted by the fact that offenders released from incarceration are often unprepared for life outside, resulting in unemployment, housing problems, drug abuse, and family conflict (Travis et al., 2001). Similarly, forensic patients in community settings often experience problems in psychosocial and occupational functioning (Feitsma et al., 2010; Henrichs et al., 2014). In our samples, the rewards increasing eudaimonic well-being were rated as the most valuable, which suggests that forensic patients are willing to provide the effort required to achieve these goals. Therefore, individualised reinforcement programs should not only focus on low-effort, short-term rewards, but should be designed to also include higher-effort, long-term goals in order to further improve treatment success in forensic patients. One approach would be to move from low-effort to high-effort rewards in the course of treatment, as it is likely that while progressing through treatment stages, therapy commitment will increase and treatment goals will become more generalisable to everyday life (Willis et al., 2012). Another step toward the development of personalised reward-based interventions would be to determine the links between patient and offence characteristics, stage of treatment, and the identified reward preferences. It can be expected that different types of forensic patients (e.g., aggressive violent offenders and sex offenders) will differ in what they find rewarding, and that these preferences are also influenced by how responsive they have been to other treatment programs.

3.4.3 Limitations and recommendations

It is possible that the recruitment and inclusion process in this study has affected the generalisability of our results to forensic patients in general. Although we aimed to cover the complete range of patient characteristics in our samples, we were dependent on the judgment of the patients' head therapists regarding each patient's vulnerability and capacity to participate in ongoing scientific research in addition to their daily therapeutic routines. Consequently, our data may not reflect the reward preferences of psychotic, severely depressed, or intellectually impaired patients. More research focused specifically on vulnerable patient groups such as these could shed a light on their respective reward preferences. However, our samples covered a wide range of complex psychopathology, often including comorbid personality and axis-1 disorders, which in our opinion resulted in reasonably heterogeneous groups.

Regarding the item generation process, a limitation of our study is that the lists of rewards that were generated may not have been exhaustive. However, in order to minimise unnecessary strain on participants, a stopping rule was applied when the amount of overlap between items generated in an individual session and the total pool of items across sessions exceeded 70%. So, it could be argued that we did not identify all of the possible items that are experienced as rewarding in these populations. On the other hand, it seems unlikely that the results would have been significantly different given (a) the large amount of overlap in the items generated in the last sessions and (b) the fact that the number of items identified are similarly distributed across each of the clusters. The latter suggests that additional items would probably also fall within one of the identified clusters and that the concept mapping procedure yielded a relatively complete set of clusters.

A related limitation is that there is a possibility that procedural differences during the item generation stages may have affected the generative process in the two populations. Specifically, more item generation sessions were organised in the outpatient group, because it took longer to reach the stopping criterion. One explanation is that most sessions with outpatients included a lower number of participants, which was mostly due to participants not showing up. Also, whereas there are many parallels across the daily lives of inpatients with respect to, for instance, restrictions and structures, the lives of outpatients are considerably more diverse. Therefore, they may have generated more unique instances of rewarding items that showed less overlap with items from previous sessions.

Another potential issue is that although all three aspects of reward (affective, motivational, cognitive) were required to apply to each generated reward item, it is possible that the item rating procedure may have given unintended extra weight to the affective aspect. Moreover, we do not claim that the current results reflect the only possible outcome. It is possible that other samples of offenders will generate other reward items, even when recruited from the same locations. This is inherent to the subjective nature of the concept mapping process. In addition, the labelling of clusters and axes remains a subjective process and it is possible that we missed other interpretations that could have applied equally well or even better. However, we still found similar clusters (resulting from HCA) as well as one similar dimension (i.e., effort) when comparing the inpatient and outpatient data. This suggests that it is likely that a replication study will yield a similar set of clusters and axes, although the specific reward items may differ to a certain degree from those generated in the current study.

Since we did not include a social desirability measure, it is difficult to say to what degree socially desirable responding can account for the observed general preference for rewards related to personal growth over materialistic rewards. However, both inpatients and outpatients were engaged in intensive therapeutic programs in which personal development is essential to reach the behavioural change required to successfully finish therapy. Moreover, especially inpatients are confronted with severely constrained levels of autonomy and, often, a diminished social network. Consequently, these themes play a prominent role in everyday live, providing a further explanation for the relatively high ratings of related rewards related to these topics.

We did not directly determine whether our data violate the metric axioms that are also required for MDS (Tversky & Gati, 1982). Although the sorting task does not allow violations of minimality and symmetry, it is possible that violations of the triangle inequality principle occur when using similarity judgments. However, the clusters and dimensions were similar between the groups, which is an unlikely finding under severe violations of the triangle inequality assumption because the configuration of points in the MDS map would be highly distorted. This can be seen as an indication that triangle inequality did not have a large effect on our results. Nonetheless, it is important to consider the potential impact of triangle inequality in future studies, which may further aid reproducibility. Finally, the study did not include a healthy control group, which makes it difficult to determine the extent to which the identified clusters differ from what is found rewarding in the general community. It could be very useful to uncover differences in reward preferences between healthy individuals and outpatients, as they have access to similar resources and activities as healthy nonpatients in everyday life. Moreover, while this may be less informative for the inpatient population due to the restrictions imposed by institutionalisation, it would still be interesting to explore common factors in the preferences of forensic patients in general that differ from those of healthy individuals. In the future, identifying how these groups differ could provide a reference point for clinicians when determining the areas that need to be targeted through personalised treatment.

3.4.4 Conclusions

In summary, to our knowledge this is the first study investigating reward preferences in forensic in- and outpatient populations. Using a unique mixed-methods approach, we found that both inpatients and outpatients tend to rate rewards requiring greater effort (e.g., rewards related to autonomy, quality of social functioning, or personal growth and development) as more valuable than low-effort rewards (e.g., substances, material goods, relaxing activities, or stimulating experiences), especially when the rewards involve the direct environment of the patient or lower levels of arousal. The findings may foster the development of individualised treatment plans that incorporates a patient's reward preferences. One scenario is that clinicians could use (a subset of) the reward categories that emerged in the current study to aid in developing individualised reward schedules with their patients. For instance, helping their patients to think of examples in each of the reward categories may provide a structured framework to contemplate which elements in the patient's life are, or could be, rewarding. A next step could be to make the patient rate the items in terms of attractiveness (i.e., subjective reward value) and to determine together what would be needed to obtain these rewards; the feasibility, the conditions to be met, whether the rewards can be obtained on a short term or a longer term, and so on. Although the therapeutic impact of such an approach will need to be examined, the present study offers a first step toward achieving this goal.

3.5 SUPPLEMENTAL MATERIAL

S.3A Overview of clusters and reward items

TABLE 3A.1 Complete list of the eight clusters with the 98 reward items generated in the inpatient sample

CLUSTER NAME	ITEMS
General social recognition	• Being committed to something (e.g., to achieving a certain goal or objective) • Achieving goals or a diploma / Performing well • Experiencing a good cooperation with someone • Helping others • A good health • Receiving a compliment • Touching someone (e.g., as showing support or as a way of congratulating) • Intimacy and sexual contact • Receiving (mental and emotional) support • Promises, commitments and appointments being honoured • Feeling and receiving love • Having a good professional position • Having my own, save house • Receiving trust (and feeling trusted) • Having contact with family / social network • Autonomy / being independent from others • Receiving personal attention / being seen (as a person) • Receiving good advice • (A feeling of) security • Freedom • Receiving excuses / others admitting their mistakes • Having unexpected visitors
Leave	• Making supervised leave a fun activity • 'Shared' leave; going on leave with other patients • Going on leave • Extension of leave possibilities • Having more time during leave • Being paid for non-worked hours during leave • Meeting someone from outside during leave • Being able to go on leave during the evening • Going on leave without a pre-specified plan, or being able to deviate from the plan • Knowing good destinations to spend leave time

TABLE 3A.1 Continued

CLUSTER NAME	ITEMS
Autonomy	• Being able to use mobile phone • Taking care of pets • Pursuing (academic) studies • Going to a prostitute or having a prostitute visiting the clinic • Individually adjusted internet access in my room • Digital television in my room • An enjoyable way to spend my days (work, study, etc) • Larger and square rooms • Being able to stay in my room without being bothered • Doing my own shopping
Ward climate and restrictions	• Less controls in the clinic (cell control, urine control, control of visitors) • Treatment staff having and/or making time during the evening • Interacting with people from outside during social activities or sports inside the clinic • Possibilities to search for a partner outside the clinic • Permanent staff in the clinic • Informal, non-clinical, non-paranoid contact with staff members • A positively written legal record • Being able to use the apartment within the clinic (with my partner) • Possibilities to invest privately in an intimate relationship • Having volunteers visiting the clinic • Not being locked up (in my room) • Termination of TBS order • Attention to a lively atmosphere inside the clinic • Being able to let visitors sleep over in my room
Luxury and material rewards	• Salary raise • Winning (e.g., a game) • Having extra salary instead of holiday hours • Computer/I-pad/Tablet • Having my own stuff • Having my own cooking supplies and instruments (or my own kitchenette) • Good and tasty food • Keeping administrative records • Having high-quality music equipment and loudspeakers • Coffee • Money • A comfortable bed • Porn (both watching and not being punished for possession)

TABLE 3A.1 Continued

CLUSTER NAME	ITEMS
Active lifestyle	• Sports facilities inside the clinic • Being able to use sporting facilities in the clinic without planning • Swimming • Organizing and attending fun group activities within the clinic • Recreational (group) activities outside the clinic (e.g., amusement park, summer festival) • Visiting a museum • Open air and/or nature activities (hiking, MTB, walking the dog, working in the garden) • Dog training program in the clinic • Fishing (within the clinic) • Pursuing hobbies or sports outside the clinic
Relaxation	• Doing small craftwork (e.g., using wood, paper, fabric) • Solving puzzles (e.g., sudoku, crossword, jigsaw) • Reading books • Playing ball games, both individually or in a team (e.g., soccer, tennis) • Leisure time • Watching soccer • Singing and making music • Going out (movies, bowling, (house)party) • Going on a holiday • Playing a game • Cooking • Physical relaxation (massage, sauna) • Listening to music • Watching a movie
Substances	• Tobacco • (Medicinal) cannabis or hash • Alcoholic drinks • Party drugs / hard drugs (according to Dutch Opium Law) • Viagra

TABLE 3A.2 Complete list of the five clusters with the 115 reward items generated in the outpatient sample

CLUSTER NAME	ITEMS
Maintaining intimate relationships	• Being supported by my partner • Feeling safe and peaceful at home • My children being happy • Activities with my children or family (e.g., going to the zoo) • Enjoying myself at home • Being understood by my partner • Having contact with my children on a regular basis • Having a liveable home • Humour • Having good contact with my family • Being sociable with friends • Being able to control my anger • Openness • Sexual experiences • A quiet, peaceful relationship with my partner • A good health • Enjoying the small things in life together • Being able to keep the good things in my life • Being able to have and overcome arguments with my partner • Making my partner happy • Having a life partner • Having a good contact with my children • A quiet, peaceful life • Having time for myself • Feeling and receiving love • Enjoying life
General social recognition	• Social contact • Salary • Feeling and receiving interpersonal trust • Being judged on what I do instead of on how I look • Feeling and receiving empathy • Being taken seriously by others • Meeting new people • Being able to pay my bills • Doing my bit and feeling useful • Being appreciated for my efforts • Being able to be myself • Honesty (in myself as well as others) • Having good contact with my colleagues • Being able to express my aggression • Being accepted by my family and parents when doing things my own way

TABLE 3A.2 Continued

CLUSTER NAME	ITEMS
General social recognition (continued)	• Others giving me space • Receiving a compliment • Helping others • Having good contact with a fellow client in therapy • Having control over my own life • Having good conversations with friends • Being seen and acknowledged as a person • Real friendship • Feeling calm in my head • Being able to deal with situations in a relaxed and effective way
Future orientation	• A challenge to take on • Getting confidence and pride out of my work • Attending treatment • Having a job • Finishing treatment • Repairing something • Achieving something • Developing myself • Applying what I have learned during treatment • Setting and reaching goals; making a deadline • Good tools • Having security in my job • Money • Building or creating something • Gaining knowledge
Relaxation	• Having a phone • Swimming • Feeling freedom on the road (e.g., in a car, motorcycle or truck) • Listening to music • Watching a good movie or documentary • Taking a shower • Having a nice tattoo • Personal care (e.g., hairdresser, solarium) • Nice weather • Sleeping in and starting the day quietly and peacefully • A bed • Alcohol • A day of doing nothing and just hanging around • Walking the dog • Sitting outside during summer

TABLE 3A.2 Continued

CLUSTER NAME	ITEMS
Relaxation (continued)	• Relaxing on the couch at home • Having a day off • Coffee • Going out for dinner • Having a car • Having a television • Tasty food • A driving license • To barbecue • Fruit • Shopping
Experience seeking	• Tobacco • Smoking marijuana • Growing marijuana • Reading a good book • Partying without having to think of consequences • Quitting smoking • Gaming • Seeing new things • Learning about other countries and cultures during when traveling • Speeded activities (e.g., quad driving) • Going out • Enjoying a jacuzzi • Being away from home without email and telephone • Cocaine • Medication (e.g., benzodiazepines) • Holidays and traveling • Getting drunk • Going to a bar or concert • Long train rides • Hiking • Doing sports • Being surrounded by stretched plains of nature • A beautiful view

CHAPTER 4

So what'cha want?

The impact of individualised rewards on associative learning in psychopathy

ABSTRACT

Psychopathic individuals typically present with associative learning impairments under explicit learning conditions. The present study aimed to investigate whether the formation of stimulus-outcome associations as well as updating of these associations after changed contingencies could be improved by using rewards with sufficiently high subjective values. To this end, 20 psychopathic offenders, 17 non-psychopathic offenders and 18 healthy controls performed a passive avoidance task with a reversal phase under three motivational conditions, using naturalistic rewards. The subjective values of the rewards were assessed for each individual participant using a visual analogue scale. The correspondence of these values to their internal representation was confirmed by analyses of brain potentials. Psychopathic offenders performed worse during passive avoidance learning when a hypothetical reward was used ('neutral reward' condition), but performed similar to the other groups when naturalistic rewards could be obtained ('low reward' and 'high reward' conditions). No effects of group or condition were present in overall reversal learning performance. Analysis of win-stay and lose-shift behaviour showed that psychopathic offenders were less likely to stay with a rewarded response during passive avoidance learning in the neutral reward condition. In addition, regardless of experimental phase or condition, psychopathic offenders were less likely to stop responding to a particular stimulus after receiving negative feedback. Our findings suggest that psychopathic offenders have the ability to adapt their behaviour to environmental contingencies when positive reinforcers with sufficiently high subjective values are used.

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4.1 INTRODUCTION

Healthy social functioning relies on having a well-developed set of cognitive skills and functions that allows us to flexibly adapt our behaviour. Such functions include the capacity to learn from feedback, behavioural inhibition, the anticipation of behavioural consequences and evaluation of punishment and reward (Morgan & Lilienfeld, 2000; Ogilvie et al., 2011). Individuals that show impairments in these neurocognitive functions are more likely to engage in antisocial behaviour, which might eventually result in entering the criminal justice system. For these individuals it may be particularly difficult to benefit from the approach used in many correctional systems, in which offenders are expected to reflect on and learn from the negative outcomes of their choices, and to acquire new behavioural repertoires associated with (more) positive consequences.

As offenders are likely to show psychiatric symptoms (Gottfried & Christopher, 2017; James & Glaze, 2006), those afflicted would likely benefit more from psychiatric interventions to achieve this behavioural change. However, highly antisocial offenders, particularly those with psychopathy, are known to respond poorly to traditional therapeutic interventions (see Brazil et al., 2018a). Psychopathy is a personality disorder characterised by emotional abnormalities in combination with severe antisociality. Psychopathic individuals are known for their reckless and impulsive behaviour as well as a callous disregard for others, presenting with a lack of empathy and guilt (Hare, 2003a). Consequently, psychopathic offenders constitute one of the most difficult groups to treat and show high rates of recidivism, while they are often involved in extremely violent offences (Barbaree, 2005; Hare et al., 2000; Hildebrand et al., 2004; Salekin et al., 2010). These high reoffending rates suggest a relatively low sensitivity to corrective experiences, or an impaired ability to adapt and correct previously acquired antisocial behaviour.

The reduced ability to learn from negative behavioural consequences, like previous incarceration, has often been linked to a number of cognitive processing deficits that are typically observed in psychopathy. A well-established finding is that psychopathy is associated with maladaptive behaviour following negative feedback (e.g., Von Borries et al., 2010), as well as impaired learning from reward and punishment (e.g., Budhani et al., 2006; Newman & Kosson, 1986). Earlier studies on associative learning in psychopathy were focused on passive avoidance learning, during which individuals learn by trial and error which stimuli they should respond to in order to obtain rewards, and which stimuli require a response to be withheld as they do not yield any rewards or are even associated with punishment. Psychopathic individuals made more commission errors than healthy individuals during passive avoidance learning, but the groups had a similar number of omission errors (Newman & Kosson, 1986; Newman et al., 1985; Thornquist & Zuckerman, 1995). The findings indicated that, in conditions including both punishment and reward, the acquisition of stimulus-outcome associations based on punished responses was compromised.

Later studies also identified an impairment in reversal learning in psychopathy (e.g., Brazil et al., 2013; Budhani et al., 2006; Mitchell et al., 2002). During reversal learning, participants first learn which stimuli are associated with reward, and which stimuli are associated with punishment. After a predefined learning criterion has been reached, contingencies are reversed, so that previously rewarded stimuli should be avoided, and previously punished stimuli yield positive outcomes. The findings indicated that psychopathic individuals performed worse than controls in the reversal phase, suggesting that they had trouble updating the stimulus-outcome mappings (e.g., Baskin-Sommers et al., 2015; Brazil et al., 2013; Budhani et al., 2006; Mitchell et al., 2002).

It is likely that the learning impairments associated with psychopathy contribute to the limited capacity for behavioural change that is often seen during treatment of psychopathic individuals. However, facilitating adaptive behaviour also requires the use of reinforcers with sufficiently high motivational value (Bissonette & Roesch, 2016; Miendlarzewska et al., 2016; Schultz, 1998). An individual can assign a value to a reinforcer based on how motivationally relevant (i.e. attractive or unattractive) the reinforcer is for the individual, and individuals will vary in the value assigned to the same reinforcer. For example, an apple can have a relatively high value when a person is hungry, but the same apple will have a lower value if the person is already satiated. As the physical properties (e.g., caloric content) of the apple are equal in both situations, the assignment of value to the apple is subjective. Human and animal research has indeed shown that the subjective values assigned to rewards can guide a variety of cognitive processes, including associative learning and decision making (Gallagher et al., 1999; Medic et al., 2014; Padoa-Schioppa & Cai, 2011). However, the majority of studies on reinforcement learning in psychopathy used mere 'points' that could be earned or lost (e.g., Blair et al., 2004; Budhani et al., 2006; Dargis et al., 2017; Mitchell et al., 2002), without considering the role of subjective valuation. Only a handful of studies concerned other types of rewards that may be valued as being more rewarding, such as money, cigarettes, or snacks (Newman & Kosson, 1986; Newman et al., 1990; Newman & Schmitt, 1998). The latter category of studies yielded results indicating that such 'naturalistic' rewards do not influence learning in a manner different from merely earning or losing points. However, these studies did not provide any information on the extent to which the included rewards were experienced as being relevant and of high value for their participants. As such, experimental research focusing on reward-based learning in psychopathy may have used reinforcers with relatively low subjective value.

Importantly, evaluating and comparing different types of rewards require the values assigned to each reward to be placed on a common scale, and animal research has shown that the reward with the highest subjective value on this common scale is often chosen (Lak et al., 2014). There is compelling evidence that subjective reward values are represented by a common neural currency in (pre)frontal brain areas in humans as well (Levy & Glimcher, 2012; Peters & Büchel, 2010). These representations seem to be generated in the ventromedial prefrontal cortex (vmPFC), a region for which various neuroimaging studies in psychopathic individuals have reported reduced volume (Boccardi et al., 2011; de Oliveira-Souza et al., 2008; Tiihonen et al., 2008; Yang et al., 2010) and activity during task performance (Birbaumer et al., 2005; Finger et al., 2011; Rilling et al., 2007). Such findings support one of the predictions generated by the Integrated Emotion Systems (IES) model of psychopathy (Blair, 2004). This model assumes that impaired learning in psychopathy is partly driven by dysfunctions in generating representations of reinforcement (including reward) expectancies in the vmPFC (e.g., Blair, 2007), in addition to disturbances in establishing stimulus-outcome associations in the amygdala. Taken together, there are grounds to believe that the computation and representation of reward values might be compromised in individuals with psychopathy, which in turn could (partly) underlie their maladaptive tendencies and poor decision making.

However, while there is evidence for disturbances in the computation of reward value in psychopathy (see also Hosking et al., 2017), it is unknown how such impairment ultimately affects the learning process. The fact that each individual will subjectively assign a different value to a particular reward makes it even more challenging to unravel this relationship. One approach to studying the impact of individual differences in value assignment would be to study reinforcement learning using rewards that are matched on their subjective values across individuals. Thus, the attractiveness of the rewards can be manipulated and controlled for by letting each individual indicate which rewards they value most, and subsequently incorporating these rewards in the experimental paradigm. In addition, collecting neural responses indexing outcome processing can provide further insights into how value assignment affects learning in psychopathy.

The overarching aim of the present study was to explore how subjective valuation of rewards affects associative learning in psychopathic offenders. Specifically, we investigated to what extent self-reported, subjective reward values influence both initial learning and contingency updating, and whether these processes are different in psychopathic offenders compared to non-psychopathic offenders and healthy controls. In line with previous research, we expected both passive avoidance learning and reversal learning to be impaired in psychopathic offenders compared to non-psychopathic offenders and controls under low motivational conditions (i.e., using rewards with low subjective values), but we expected their performance to improve when rewards with high subjective values were incorporated in the task.

Win-stay and lose-shift percentages, reflecting the tendency to stay with a rewarded response and to shift away from a punished response, were also calculated for both acquisition and reversal to understand the relation between immediate feedback processing and general task performance. Previous investigations of contingency processing during associative learning in populations presenting with reversal learning deficits (e.g., individuals with psychopathy and patients with OFC-lesions) have focused on win-stay and lose-shift behaviour during reversal learning only (Berlin et al., 2004; Budhani et al., 2006). However, we were also interested in studying win-stay and lose-shift behaviour during acquisition, as this would allow for a more thorough investigation of whether impaired passive avoidance learning in psychopathy is mainly related to reduced processing of reward information, reduced processing of punishment information, or both. Since reward processing often seems to come at the cost of punishment processing in psychopathy, at least during passive avoidance learning (Blair et al., 2004; Newman et al., 1990), we expected psychopathic offenders to be less prone to shift away from a punished response but to be equally likely to stay with a rewarded response compared to the two other groups. In addition, similar to our general expectations regarding passive avoidance and reversal learning, we expected their win-stay and lose-shift behaviour to increase under conditions with high subjective reward values.

Finally, electrophysiological responses to feedback (as indexed by the feedback-related negativity; FRN) were collected to examine brain responses to rewards as a function of their subjective values. The FRN is an event-related potential (ERP) commonly used to study outcome processing in reinforcement learning tasks. The FRN has been found to be particularly sensitive to the valence and magnitude of external feedback representing performance-based outcome (i.e., gain or loss), and is generated in the anterior cingulate cortex (ACC) and other prefrontal areas associated with outcome evaluation (Gehring & Willoughby, 2002; Holroyd & Coles, 2002; San Martín, 2012; Yeung & Sanfey, 2004). The amplitude of the FRN is generally larger following losses than following gains, but it is also modulated by motivational significance. For example, one study found that the amplitude of the FRN increased as the level of personal relevance of the outcomes increased during joint action (Loehr et al., 2015). As such, the FRN could provide information on whether associative learning deficits in psychopathy stem from deficient coding of outcome value. We reasoned that higher subjective reward values would evoke stronger neural responses to negative feedback, and that the groups would not differ in this regard given prior findings indicating intact feedback processing in psychopathic offenders (Von Borries et al., 2010).

4.2 MATERIALS AND METHODS

4.2.1 Participants

Participants in the offender groups were recruited from the inpatient population of a maximum security forensic psychiatric institute in The Netherlands. Offenders were initially selected based on available information about clinical status and history obtained from their head therapists and patient files. Healthy controls were recruited via advertisements on social media, via research participant pools, and among employees in the facility. Subsequently, trained psychologists screened potential participants using the Dutch version of the MINI Psychiatric Interview (Van Vliet et al., 2000) and the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II; Weertman et al., 1996). Exclusion criteria were all major current Axis I and Axis II disorders (with exception of cluster B personality disorders), chronic use of intoxicating substances, and the use of psychotropic medication at the time of testing. All participants received written information about the experiment, gave written informed consent and received financial compensation. The experimental protocol was approved by the local ethics committee of the Radboud University Nijmegen (ECSW2016-2501-373).

Each participant's IQ was estimated using a combination of two subtests (*Information* and *Coding*) of the core Dutch Wechsler Adult Intelligence Scale–IV (WAIS-IV) subtests (Girard et al., 2015; Wechsler, 2012a, 2012b). For assignment to the group with psychopathic offenders, a cut-off score of 26 (Rasmussen et al., 1999) on the Hare Psychopathy Checklist — Revised (PCL-R; Hare, 2003a) was used, an instrument combining file information and a semi-structured interview to assess the core interpersonal, affective and behavioural attributes of psychopathy. The offender groups and healthy controls were matched for age and IQ. No PCL-R scores were available for the control group, as these participants did not have criminal records. Demographics of the three participant groups are presented in Table 4.1.

Statistical evaluation of these variables showed that psychopathic offenders had significantly higher PCL-R scores compared to non-psychopathic offenders, $t(34)=-9.42$, $p<.001$. Furthermore, the three groups did not differ in terms of age, $F(2,52)=0.11$, $p=.900$, =.004. However, there was a significant difference in IQ, $F(2,51)=5.59$, $p=.006$, $\eta_p^2=.180$. Post hoc analyses showed that psychopathic offenders had statistically significant lower IQ's than non-psychopathic offenders and controls ($t(51)=2.86$, $p=.017$ and $t(51)=2.86$, $p=.019$, respectively; see Table 4.1). No differences were observed between non-psychopathic offenders and controls ($t(51)=-.08$, $p=1.000$).

The sample size was similar to that of prior studies focused on feedback-based learning and/or error processing in offenders with psychopathy (e.g., Brazil et al., 2009; Budhani et al., 2006; Von Borries et al., 2010), and an a priori performed power analysis (G*Power 3.1;Faul et al., 2009) confirmed that our sample size would generate sufficient statistical power (>.80) to investigate our effects of interest (Cohen's $f=.25$, $\alpha=.05$, two-tailed).

TABLE 4.1 Participant characteristics

	GROUP		
	Healthy controls (n=18)	Non-psychopathic offenders (n=17)	Psychopathic offenders (n=20)*
Age (years)	43.3 (10.2)	44.9 (13.9)	44.7 (8.8)
FSIQ score	97.0 (17.3)	97.4 (14.3)	83.4 (11.3)
Years of education	15.4 (3.1)	13.1 (2.9)	10.5 (2.8)
PCL-R total score (mean [range])	N/A	18.7 (10-25)	30.2 (27-35)

*Note. Group data are mean (SD) unless stated otherwise. FSIQ=full-scale intelligence quotient. PCL-R=psychopathy checklist-revised. N/A=not applicable. *For one participant in the psychopathic offenders group, no exact PCLR-score was available. However, multiple legal documents in this participant's patient file stated that the PCL-R had been assessed, and that the resulting score indicated that this offender had (very) high levels of psychopathic traits. Mean PCL-R total score was therefore calculated with data from 19 psychopathic offenders. In addition, for one participant in the psychopathic offenders group, the IQ score that was obtained in the screening session could not be traced at the time of data analysis. Therefore, calculation of mean FSIQ score, as well as further analyses containing IQ, was performed with data from 19 psychopathic offenders.*

4.2.2 Task and design

First, participants sorted different items representing potential rewards based on their attractiveness using a Visual Analogue Scale (VAS), on which ratings could range from -25 (extremely unattractive) to +25 (extremely attractive). The reward items were selected from a larger pool of items we identified in a previous study on reward preferences in forensic samples (see Chapter 3; Glimmerveen et al., 2018), and could be roughly divided into three categories: material rewards, food-related rewards, and rewards related to personal development (e.g., attending workshops; see Supplement 4A, for an overview). Participants in the offender samples sorted 20 different items, and healthy controls were presented a subset of 10 items that were identical or comparable to the items presented to the offender groups. One reason for this difference was that a number of items related to personal development were difficult to arrange outside the clinical setting. In addition, the descriptions of some rewards differed in specificity between groups, resulting in multiple specific items in the offender groups versus a single more inclusive item for the healthy control group. For each participant, the two rewards with the lowest positive ratings and the two rewards with the highest positive ratings were selected. The negatively valued items were discarded, as they could not be considered as rewarding items. One of the two selected low-value rewards and one of the two selected high-value rewards were used in another task (described in Chapter 5) that was performed in the same session; allocation of the highest and lowest rated high-value and low-value rewards to each task occurred in counterbalanced order. In addition, task order was counterbalanced across participants.

The experiment consisted of an adapted version of the passive avoidance task developed by Newman and Kosson (1986), in which a reversal component was added based on the reinforcement contingency scheme used by Budhani et al. (2006). The experiment was run with OpenSesame v3.0 (Mathôt et al., 2012). Participants were seated in front of a 100 Hz computer screen on which events were presented against a black background (see Figure 4.1). A trial started with the presentation of a white fixation cross in the middle of the screen, followed by a go or a no-go stimulus. Stimulus presentation was terminated by a response, or by time-out. Participants made their responses by pressing the spacebar of a keyboard. After presentation of the stimulus, a blank screen was presented, followed by visual and auditory feedback on the response. Feedback consisted of the Dutch words *goed* (correct) or *fout* (incorrect), presented in green (correct) or red (incorrect) capitals, accompanied by a high or a low tone, respectively. When no response had been made (and stimulus presentation had timed-out), no feedback was presented.

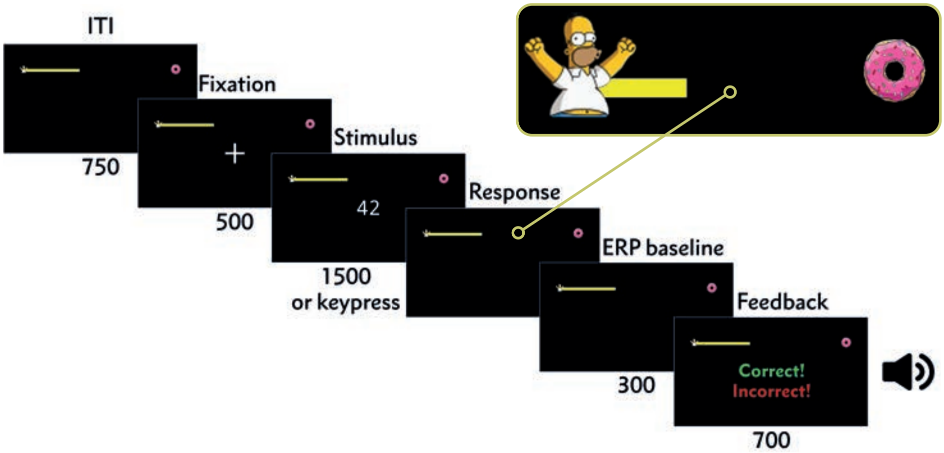

FIGURE 4.1 **Sequence of events and their timing (ms) during the experiment.** *ITI = Inter-trial interval. The figure depicts a trial in the neutral reward condition, with the cartoon character in the upper left corner of the screen, and a picture of the reward (i.e., a donut in the current (neutral reward) condition) in the upper right corner of the screen. In the low- and high reward conditions, pictures of the corresponding low-valued and high valued rewards were displayed in the upper right corner. The yellow bar between the cartoon character and the reward reflects the accumulated number of points and thus the progress towards obtaining the reward at the end of the current experimental run. In the figure can be seen that about 40% of the required number of points has been accumulated, as the yellow bar is almost halfway between the cartoon figure and the reward.*

In line with Newman and Kosson (1986), participants were presented with eight different two-digit numbers of which four were go stimuli and the other four were no-go stimuli. However, half of the go and no-go stimuli had probabilistic reinforcement contingencies, such that a response on the two probabilistic go stimuli would yield positive feedback on 80% of the trials and negative feedback on 20% of the trials, and, likewise, a response on the two probabilistic no-go stimuli would yield negative feedback on 80% of the trials and positive feedback on 20% of the trials. In addition, there was a go/no-go reversal for half of the stimuli, such that responses to previously correct stimuli (i.e., go stimuli) were followed by negative feedback indicating a wrong response, and responses to previously wrong stimuli (i.e., no-go stimuli) were followed by feedback indicating a correct response. This subset included each of the four stimulus types (non-probabilistic go, non-probabilistic no-go, probabilistic go, probabilistic no-go) and was gradually introduced throughout the experiment following a predefined schedule (see Table 4.2). Participants were not informed when these reversals would occur. For both non-reversing and reversing stimuli, there were 20 initial presentations, after which reversing stimuli had 20 additional presentations with reversed contingencies. One experimental run comprised of 240 trials, divided into five blocks of 40, 60, 40, 60, and 40 trials, respectively. Participants were unaware of this segmentation, but were offered self-paced pauses in the middle of the second and fourth blocks.

Each participant performed the task under three reward conditions, in counter balanced order using a Latin Square: 'neutral reward', involving a hypothetical reward (further explained below), 'low reward', involving the selected low-value reward, and 'high reward', involving the selected high-value reward. The neutral reward was considered as having a subjective value equalling zero. A horizontal bar representing the participant's performance during the task was displayed continuously on the top of the screen (see Figure 4.1). The bar increased and decreased in steps of 25 points, simultaneously with the presentation of positive and negative feedback, respectively. Since we wanted participants to be focused on the reward, and not on the number of points needed to gain the reward, they were not informed about this underlying point system. A cartoon figure (i.e., Homer Simpson) was placed at the beginning of the bar, and the upper right corner of the screen showed a picture of either the neutral, low or high rewards. The pictures representing low and high rewards were similar to the pictures that were used to rate the rewards on the VAS at the start of the experiment, and thus depended on the participants' individual choices. In the neutral (i.e., hypothetical) reward condition, the reward was represented by a donut. It was explained to the participants that they would not gain this donut themselves, but that Homer would be very grateful if they could help him to get it. Participants (or the cartoon figure, in the neutral reward condition) gained the reward when the horizontal bar reached (or crossed) the reward picture at the end of the task. To account for learning effects, the numbers of points to be earned for obtaining the reward were determined separately for each experimental run (first, second, or last), based on the median numbers of points participants earned in an (unpublished) pilot study (1410, 1550, or 1750 points, respectively). Material and food-related rewards (except the supervised dinner-preparing session to take place on the ward) were handed immediately at the end of the session; for the rewards related to personal development, appointments were arranged.

4.2.3 ERP acquisition and data processing

Electroencephalography (EEG) was recorded using 32 active electrodes (Acticap, Brain Products GmbH, Germany) arranged according to an extended version of the 10–20 system. All electrodes were referenced to the left earlobe. Vertical

TABLE 4.2 Gradual probabilistic reinforcement scheme

Reversal	Contingency (PF-NF)	BLOCK 1	2	3	4	5	Total
Non-reversing	100-0	10 (Go)	10 (Go)				20 trials
Reversing	100-0		10 (Go)	10 (Go)	10 (No-go)	10 (No-go)	40 trials
Non-reversing	80-20				10 (Go)	10 (Go)	20 trials
Reversing	80-20	10 (Go)	10 (Go)	10 (No-go)	10| (No-go)		40 trials
Non-reversing	20-80	10 (No-go)	10 (No-go)				20 trials
Reversing	20-80		10 (No-go)	10 (No-go)	10 (Go)	10 (Go)	40 trials
Non-reversing	0-100				10 (No-go)	10 (No-go)	20 trials
Reversing	0-100	10 (No-go)	10 (No-go)	10 (Go)	10 (Go)		40 trials
		40 trials	60 trials	40 trials	60 trials	40 trials	240 trials

Note. PF=Positive Feedback, NF=Negative Feedback. For each stimulus, the number of trials and expected (non-)response is given for each block. The order of presentation of the different stimuli was randomised within each block.

and horizontal eye movements were monitored using bipolar electrooculography (EOG) electrodes positioned above and beneath the right eye and at the outer canthi of both eyes. Impedance was kept below 10 kΩ and all signals were acquired with a sampling frequency of 500 Hz.

EEG data processing was performed offline using Brain Vision Analyzer software (V2.01.3931, Brain Products GmbH, Germany). The data were re-referenced to the mean of both earlobe electrodes. Ocular artefacts were removed using Independent Component Analyses (Jung et al., 2000). The data were filtered using high- and low-pass filters of 0.05 Hz (24 dB/oct) and 30 Hz (24 dB/oct), respectively. Next, the EEG data were segmented into epochs ranging from 200 ms before to 900 ms after feedback onset. The FRN was identified as the most negative peak relative to a 200 ms pre-feedback baseline period measured on the FCz electrode in the 150-400 ms interval after feedback onset. The choice for this interval was based on the time windows that are most commonly reported in the literature (Hajcak et al., 2006; Holroyd et al., 2003; Von Borries et al., 2013; Yeung & Sanfey, 2004). Finally, difference waves were calculated by subtracting FRN amplitude after win-feedback from FRN amplitude following loss-feedback. This subtraction procedure should isolate the components specifically related to differences in the processing of win and loss feedback (Hajcak et al., 2007; Holroyd & Coles, 2002). Hence, larger difference waves are thought to reflect stronger neural responses to losses.

4.2.4 Data analyses

Prior to analysis, hit rates and false alarm rates were calculated for each phase and contingency probability (both separately and combined), as well as for the total experiment (*hit rate = number of hits / number of go trials*; *false alarm rate = number of false alarms / number of no-go trials)*. Next, hit rates and false alarm rates were converted into d' discriminability values using a signal detection framework: *d' = Z(hit rate) – Z(false alarm rate)*.

In order to examine participants' behaviour after receiving reward or punishment, win-stay and lose-shift percentages were calculated based on trial-by-trial data. Win-stay percentage reflects the proportion of instances a participant repeats a rewarded response on the subsequent encounter with a specific stimulus, instead of (incorrectly) withholding a response to this stimulus (*win-stay percentage = number of win-stay trials / (number of win-stay trials + number of win-shift trials)* × *100*). Lose-shift percentage reflects the proportion of instances a participant withholds a response when confronted with a stimulus on which responding was punished during the previous encounter, instead of incorrectly responding to this stimulus again (*lose-shift percentage = number of lose-shift trials / (number of lose-shift trials + number of lose-stay trials)* × *100*).

ERP data were analysed using a 3 × 3 repeated measures analysis of variance (ANOVA) with Condition (neutral reward, low reward, high reward) as within-subject variable and Group (psychopathic offenders, non-psychopathic offenders, controls) as between-subjects factor. Response accuracy data were analysed by entering d' values into a 3 × 2 × 2 × 3 repeated measures ANOVA with Condition (neutral reward, low reward, high reward), Probability (100–0, 80 –20), and Phase (acquisition, reversal) as within-subject factors and Group (psychopathic offenders, non-psychopathic offenders, controls) as between-subjects factor. Win-stay and Lose-shift percentages were analysed using a 3 × 2 × 3 repeated measures ANOVA with Condition (neutral reward, low reward, high reward) and Phase (acquisition, reversal) as within-subject factors and Group (psychopathic offenders, non-psychopathic offenders, controls) as between-subjects factor. Since IQ was found to differ significantly between groups, and IQ was expected to contribute to inter-individual learning variability, it was added as a covariate in the behavioural analyses. Effect sizes are reported as partial eta-squared (η_p^2; small ≥ .01, medium ≥ .06, large ≥ .14 (Cohen, 1988)). Statistical analyses were performed in SPSS 23.0 (IBM Corp., 2015). An overview of all tested effects in primary analyses and post-hoc tests is presented in Supplement 4B and Supplement 4C, respectively.

4.3 RESULTS

4.3.1 ERP results

First, the mean peak amplitude of difference waves at FCz was compared between reward conditions. Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 6.29$, p=.043, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity (ε = .88). The results showed a main effect for reward level, $F(1.91, 82.11)=3.40$, p=.040, η_p^2=.073. Post hoc paired samples t-tests indicated stronger responses to negative feedback in the high reward condition (M=-8.58, SE=1.68) compared to the neutral reward (M=-4.76, SE=0.59) and low reward (M=-5.61, SE=1.09) conditions, $t(46)=-2.19$, p=.034 and $t(47)=-2.03$, p=.048, respectively (see Figure 4.2). This indicates that feedback processing was positively related to (subjective) reward value at the neural level. The analysis revealed no other statistically significant main and interaction effects.

4.3.2 Response accuracy

Analysis of accuracy data revealed that IQ was significantly related to d' values ($F(1, 50)=6.06$, p=.017, η_p^2=.108). Moreover, there was a significant three-way interaction between condition, phase and group (Wilk's Lambda=.812, $F(4, 98)=2.69$, p=.036, η_p^2=.099). Separate analyses for each condition, controlling for IQ, revealed that psychopathic offenders (M=1.46, SE=.18) performed worse than non-psychopathic offenders (M=2.21, SE=.18; B=.748, p=.005) and controls (M=1.98, SE=.17; B=.523, p=.044) during acquisition in the neutral reward condition. No group differences were observed in the reversal phase for the neutral reward condition (p=.891 and p=.177, respectively), nor in either phase of the low reward (acquisition: p= .786 and p=.955, respectively; reversal: p=.334 and p=.290, respectively) and the high reward conditions (acquisition: p= .267 and p=.311, respectively; reversal: p=.687 and p=.401, respectively; see also Figure 4.3a and 4.3b). To further investigate the three-term interaction effect, we ran subsequent analyses for each group separately, which did not reveal an effect of condition within acquisition (psychopathic offenders: $F(2, 34)=0.59$, p=.562, η_p^2=.033; non-psychopathic offenders: $F(2, 30)=1.00$, p=.378, η_p^2=.063; healthy controls: $F(2, 32)=0.90$, p=.416, η_p^2=.053).

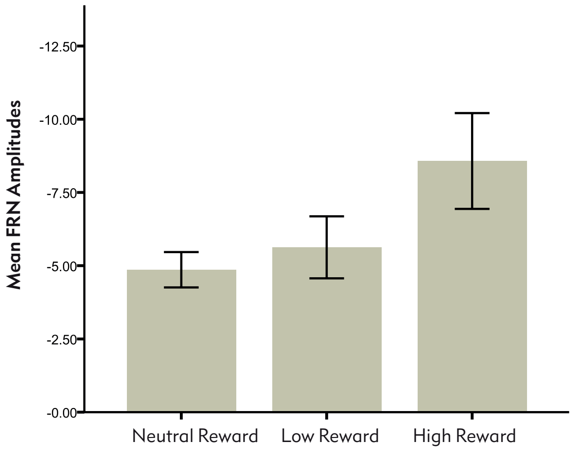

FIGURE 4.2 **Mean peak amplitude (μV) of FRN difference waves at FCz for each condition, across groups.** *Data are expressed as mean ± 1 standard error. Negative values are plotted upwards.*

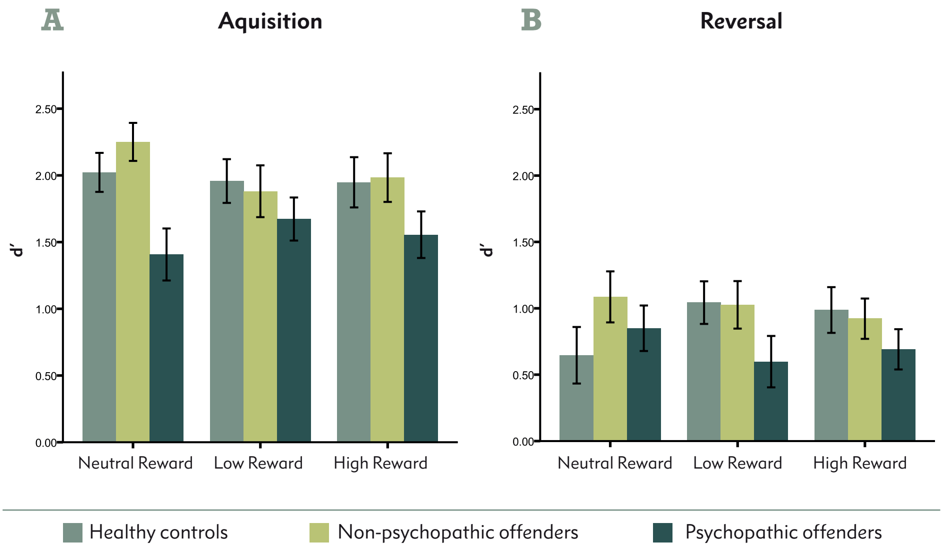

FIGURE 4.3 A. Response accuracy for each group in each condition during acquisition, as indexed by d-prime (d'). B. Response accuracy for each group in each condition during reversal, as indexed by d-prime (d'). *Data are expressed as mean ± 1 standard error.*

4.3.3 Win-stay and lose-shift behaviour

Analysis of win-stay percentages showed an interaction effect of group and condition, Wilk's Lambda=.78, $F(4,98)=3.24$, $p=.015$, $\eta_p^2=.117$. Separate univariate analyses revealed significant group differences in the neutral reward condition, $F(2,51)=4.63$, $p=.014$, $\eta_p^2=.154$. Pairwise comparisons showed that, in the neutral reward condition, psychopathic offenders were less likely to stay with a rewarded response than non-psychopathic offenders, (t(51)=3.01, *p*=.012), but no differences were observed between psychopathic offenders and controls (t(51)= 1.85, *p*=.210), or between non-psychopathic offenders and controls (t(51)=1.17, *p*=.743); *M*(psychopathic offenders)=94.1%, *SE*=.86%; *M*(non-psychopathic offenders)=97.9%, *SE*=.91%; *M*(controls)=96.4%, *SE*=.88%. No group differences regarding win-stay percentage were observed in the low reward and high reward conditions (see Figure 4.4).

Regarding lose-shift percentages, there was an interaction effect of group and phase, Wilk's Lambda=.88, $F(2,50)=3.35$, $p=.043$, $\eta_p^2=.118$. In order to examine this interaction effect, repeated measures ANOVAs were performed for acquisition and reversal separately (see Figure 4.5a and 4.5b, respectively). This revealed a main effect of group during acquisition, $F(2,51)=5.53$, $p=.007$, $\eta_p^2=.178$. Pairwise comparisons showed that, during acquisition, psychopathic offenders were less likely to shift away from a punished response compared to non-psychopathic offenders (t(51)=-2.66, *p*=.031) and controls (*t*(51)=-3.03, *p*=.012), but no differences were observed between non-psychopathic offenders and controls (*t*(51)=-0.32, *p*=1.000); *M*(psychopathic offenders)=33.7%, *SE*=2.88%; *M*(non-psychopathic offenders)=44.8%, *SE*=3.05%; *M*(controls)= 46.2%, *SE*=2.96%. During reversal, there was also an effect of group on lose-shift percentages, $F(2,51)=3.22$, $p=.048$, $\eta_p^2=.112$.

Psychopathic offenders were less likely to shift away from a punished response compared to controls (t(51)=-2.53, *p*=.044), but no differences were observed between psychopathic offenders and non-psychopathic offenders (*t*(51)=-1.00, *p*=.969), or between non-psychopathic offenders and controls (*t*(51)=-1.47, *p*=.443); *M*(psychopathic offenders)=28.3%, *SE*=2.72%; *M*(non-psychopathic offenders)=32.2%, *SE*=2.88%; *M*(controls)=38.1%, *SE*=2.80%. The analysis revealed no other statistically significant main and interaction effects.

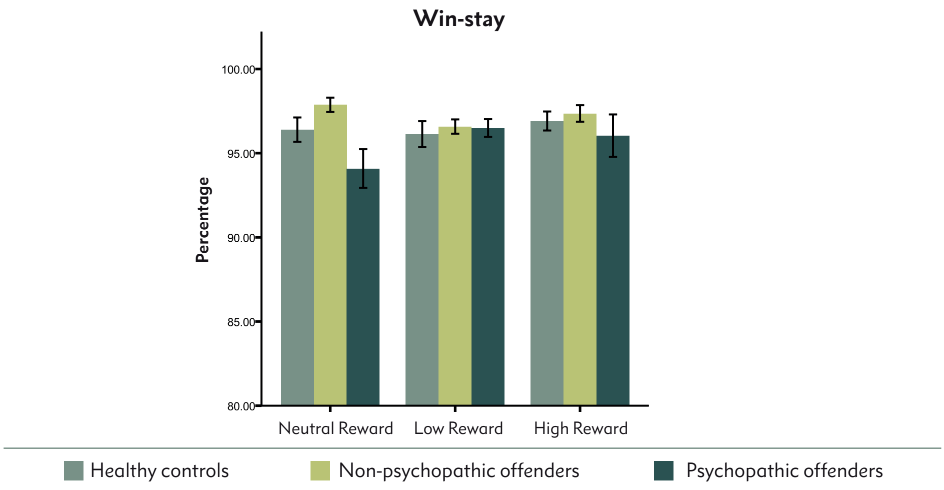

FIGURE 4.4 Win-stay behaviour for each group in each condition across phases. *Percentages reflect the proportion of instances participants repeated a rewarded response on the subsequent encounter with a specific stimulus. Data are expressed as mean ± 1 standard error.*

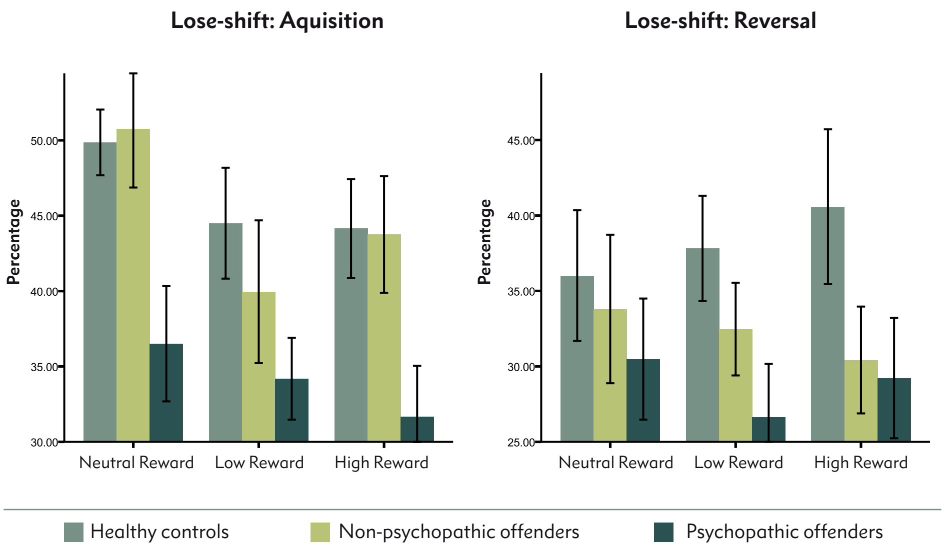

FIGURE 4.5 A: Lose-shift behaviour for each group in each condition during acquisition. B: Lose-shift behaviour for each group in each condition during reversal. *Percentages reflect the proportion of instances participants withheld a response when confronted with a stimulus on which responding was punished during the previous encounter. Data are expressed as mean ± 1 standard error.*

4.4. DISCUSSION

The aim of the present study was to explore to what extent the subjective valuation of rewards influences feedback-based associative learning in psychopathic offenders. Analyses of brain potentials showed that rewards with relatively high subjective values evoked stronger neural responses compared to neutral and low value rewards, providing evidence for consistency between the a priori assigned subjective values to the rewards and the internal representation of these reward values. In addition, the ERP analyses did not indicate any group differences, suggesting that the mechanisms involved in the computation of value and processing of feedback were unaffected in the offender groups.

4.4.1 Passive avoidance

On the behavioural level, psychopathic offenders performed worse during acquisition than the two comparison groups in the neutral reward condition. In other words, with no reward with sufficiently high subjective value to look forward to, psychopathic offenders learned less about the contingencies compared to non-psychopathic offenders and controls. This finding is in line with previous research reporting passive avoidance learning deficits in psychopathy when reinforcers with relatively neutral subjective value are used (Blair et al., 2004; Newman & Kosson, 1986; Newman et al., 1990; Newman & Schmitt, 1998). Interestingly, however, we found this deficit to be absent in conditions where rewards with sufficient subjective values could be earned, suggesting that the attractiveness of these rewards facilitated the acquisition of new stimulus-outcome relationships in psychopathic offenders.

This finding is in line with the notion of the IES model that the disturbances in reinforcement expectancies and stimulus-outcome associations can be modulated by saliency, such as reward level (Blair, 2007; Blair et al., 2004). Blair et al. (2004) indeed found performance of psychopathic offenders during passive avoidance learning to be positively related to the reward level of specific stimuli. Although our results do not reveal a clear improvement (or decrement) across conditions for any group, they do show that the passive avoidance deficit that our psychopathic participants displayed in the neutral reward condition was absent in the low and high reward conditions. In addition, our results can only partly be explained by the Response Modulation (RM) hypothesis (Gorenstein & Newman, 1980; Newman & Kosson, 1986; Patterson & Newman, 1993), which is another influential framework used to explain impaired associative learning in psychopathy. The RM hypothesis states that the impaired passive avoidance learning displayed by individuals with psychopathy is caused by an attentional deficit, directing too much attentional resources to reward-related information in conditions involving both reward and punishment (i.e., gains and losses). According to the RM hypothesis, this would result in a loss of attention for other contextual information, such as punishment, leading to impaired learning from negative feedback. However, the RM hypothesis can only explain our results in the neutral reward condition, suggesting that this holds exclusively for situations in which there is nothing at stake that is regarded as being sufficiently attractive. Apparently, the psychopathic offenders in our study were able to use information from both gains and losses effectively to learn new stimulus-outcome associations, provided that relevant rewards were used. One explanation could be that there is a critical threshold for subjective reward value, which determines whether psychopathic individuals are able to process both positive and negative performance feedback effectively to learn new associations. In conditions where rewards have sufficient subjective values, negative feedback (such as the experience of losses) may shift towards their goal-directed focus of attention, and consequently become relevant, non-ignored information. Although a few earlier studies on passive avoidance learning did use more or less naturalistic rewards (Newman & Kosson, 1986; Newman et al., 1990; Newman & Schmitt, 1998), they did not include measures of subjective reward value. Future research should therefore further elucidate whether the existence of such a threshold is plausible.

4.4.2 Reversal learning

All groups performed similarly in the reversal phase of each condition. This finding is contrary to expectations as reversal learning impairments in psychopathy have been shown before, at least under explicit learning conditions (e.g., Brazil et al., 2013; Budhani et al., 2006; Mitchell et al., 2002). However, there are indications that reversal learning impairments in offenders with psychopathy are less robust than previously believed (De Brito et al., 2013; Mitchell et al., 2006). The presence of the reversal learning deficits seems to be dependent on the learning context provided by the experimental task used (Brazil, 2015; Brazil et al., 2013). In addition, sample-specific cognitive and clinical variables, such as the level of processing of predictive information and childhood maltreatment history, also appear to play important roles in the severity of the reversal learning impairment in psychopathy (Dargis et al., 2017; Gregory et al., 2015). We cannot rule out that such factors may have affected task performance during reversal learning in our particular samples.

Another explanation might be that there could be a relation between task complexity and the locus of the learning impairments in psychopathy (Estrada et al., 2019). In relatively simple tasks including few stimuli, psychopathic offenders show intact acquisition and reversal (Brazil et al., 2013). However, in tasks including a more intermediate number of stimuli, they are still able to perform acquisition, but show impaired reversal (Budhani et al., 2006). Furthermore, in very complex tasks, including a large number of stimuli, they also show impaired acquisition (Von Borries et al., 2010). Importantly, in these studies, psychopathic offenders and comparison individuals were matched for (estimated) IQ or educational level, controlling for possible differences in intellectual abilities. Together, these data suggest that increased task complexity elicits a shift in the locus of impairment, but to date no studies have examined this hypothesis systematically. In our study, including eight (i.e., an intermediate number of) different stimuli, it would be expected that, like in the study of Budhani et al. (2006), they would at least present with impaired reversal. The fact that they showed intact reversal as compared with healthy controls and non-psychopathic offenders, highlights the need to further specify how task complexity may affect associative learning in psychopathy in future studies.

4.4.3 Win-stay behaviour

To investigate the immediate behavioural effects of reward or punishment, we also looked at participants' behaviour in every next encounter with each particular stimulus. Compared to non-psychopathic offenders, psychopathic offenders were less likely to stay with a rewarded response in the neutral reward condition. Although win-stay behaviour of controls did not differ from both offender groups, this suggests that the motivational drive of offenders with psychopathy to use positive feedback information to guide future decisions is lower than what is observed in other violent offenders when explicit rewards are lacking. Hence, their ability to use positive feedback depends on whether the feedback is linked to an explicit and attractive reward with a subjective value (e.g., the low and high value rewards used in our experiment) that is higher than that of neutral rewards (e.g., points). A practical implication of this could be that, in order to have psychopathic offenders using positive feedback to develop more adaptive behavioural repertoires, feedback should be explicitly linked to clear and attractive rewards that they are willing to pursue.

On the other hand, as previously noted, the IES model states that the formation and updating of expectancy representations may be compromised in psychopathic individuals because of abnormalities in (the connectivity between) the amygdala and the vmPFC. Indeed, Budhani et al. (2006) found reduced win-stay behaviour in psychopathic offenders during reversal (the authors did not report on win-stay and lose-shift behaviour during acquisition). However, the

IES model does not explain how differences in subjective reward value would influence feedback processing. Perhaps the neural processes involved in the formation and representation of stimulus-outcome associations and expectancies become more efficient when subjective reward values exceed a critical threshold. Interestingly, the findings obtained by Gregory et al. (2015) suggest that subjective value promotes associative learning in psychopathic offenders, although they found the neural processing of subjective value information to be highly atypical compared to non-psychopathic offenders and controls.

4.4.4 Lose-shift behaviour

Compared to non-psychopathic offenders and healthy controls, psychopathic offenders were less likely to shift away from a punished response during acquisition. In other words, psychopathic offenders seemed less likely to use negative feedback during passive avoidance learning than the two comparison groups, which is in agreement with the results obtained by Von Borries et al. (2010). During reversal learning, the likelihood of shifting away from punished responses only differed between psychopathic offenders and controls. Interestingly, in both phases, there was no effect of reward condition on this immediate measure of negative feedback processing, which suggests that a more general deficit underlies these impairments. This finding is in line with the RM hypothesis, which predicts limited attentional resources for negative feedback information processing in tasks involving both rewarded and punished responses. When evaluated from the neurocognitive perspective of the IES model, it suggests that the formation and updating of expectancy representations in the amygdala and vmPFC is especially compromised when negative feedback is being processed.

4.4.5 Limitations

One potential caveat of our study is that we were not able to test for effects of PCL-R factor scores, since for a number of participants factor scores were not available. We were dependent on file information and did not have permission nor resources to assess the PCL-R by ourselves in the present study. A second limitation of our study design is that we exclusively focused on subjective reward, without looking at subjective punishment. Investigating how varying levels of subjective punishment affect associative learning would be particularly relevant for understanding how behavioural change can be achieved in settings where it is difficult to implement the use of a wide array of subjective rewards (e.g., prison). Importantly, ethical aspects of research into subjective punishment in populations from the criminal justice system should be well-considered, both with respect to study design and the practical implications of its findings.

4.5 CONCLUSIONS

Our findings suggest that naturalistic rewards facilitate initial learning of new information in psychopathic offenders, as well as their ability to use positive feedback information to guide future decisions. Importantly, the attractiveness of each reward was tailored to the subjective preferences of each individual participant, but the observed effects were independent of the magnitude of the associated subjective reward values. Contrary to expectations, we did not find any group differences nor any effects of reward condition on reversal learning performance. However, in both phases, and irrespective of reward condition, psychopathic offenders were impaired in adapting their behaviour following negative feedback. Our findings suggest that psychopathic offenders, despite a more general deficit in negative feedback processing, have the ability to adapt their behaviour according to environmental contingencies when positive reinforcers with sufficiently high subjective values are used. These findings are the result of a novel approach to associative learning in psychopathy, and stress the importance of personalised methodologies when using reinforcement techniques in forensic treatment.

4.6 SUPPLEMENTAL MATERIAL

S.4A Overview of experimental rewards

TABLE 4A.1 Rewards available to participants

	PARTICIPANT GROUP	
Reward category	**Offenders**	**Healthy controls**
Material rewards	• A set of cosmetics and toiletries	• A set of cosmetics and toiletries
	• An 8-pack of batteries	• An 8-pack of batteries
	• A voucher for the in-house second-hand clothes shop	• A voucher for a large number of (online) clothing stores
	• A voucher for the rent of five DVD's	• A voucher for the cinema
Food-related rewards	• A package of crisps and peanuts	• A package of crisps and peanuts
	• A package of chocolate	• A package of chocolate
	• A package of cookies	• A package of cookies
	• Preparing a dinner together with other patients on the ward	
Personal development	• A workshop on preparing healthy bites and shakes	
	• A workshop on bee-keeping	
	• A workshop on painting on canvas	• A workshop on painting on canvas
	• Two piano or singing lessons	• A singing lesson
	• A (bass) guitar lesson	• A lesson on a musical instrument of choice
	• Three lessons to try out different musical instruments	
	• Preparing a song for a jam session under supervision of a music teacher	
	• One session to play with the inpatient rock band	
	• A fitness lesson	
	• A judo lesson	
	• A welding lesson	
	• A bike repair lesson	
	• An introductory computer lesson	

S.4B Overview of tested effects in primary analyses

TABLE 4B.1 ERP analyses

	DIFFERENCE WAVE AMPLITUDE AT FCZ		
Tested effect	*F*	*p*	η_p^2
Group	.601	.553	.027
Condition	3.402	.044	.073
Group × Condition	.126	.962	.006

TABLE 4B.2 Behavioural analyses

	RESPONSE ACCURACY			WIN-STAY PERCENTAGE			LOSE-SHIFT PERCENTAGE		
Tested effect	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
IQ	6.057	.017	.108	.331	.568	.007	.229	.635	.005
Group	.963	.389	.037	.919	.405	.035	4.339	.018	.148
Condition	.586	.560	.023	.657	.523	.026	.186	.830	.008
Probability	.472	.495	.009	-	-	-	-	-	-
Phase	2.760	.103	.052	3.238	.015	.117	2.757	.103	.052
Condition × IQ	.712	.496	.028	.657	.523	.026	.101	.905	.004
Condition × Group	1.154	.336	.045	3.238	.015	.117	.436	.782	.017
Condition × Probability	.283	.755	.011	-	-	-	-	-	-
Condition × Phase	.783	.462	.031	.508	.605	.020	.111	.895	.005
Probability × IQ	.191	.664	.004	-	-	-	-	-	-
Probability × Group	.394	.707	.014	-	-	-	-	-	-
Probability × Phase	2.637	.111	.050	-	-	-	-	-	-
Phase × IQ	.121	.729	.002	.089	.767	.002	.292	.591	.006
Phase × Group	.813	.450	.031	.089	.767	.002	.353	.043	.118
Condition × Probability × IQ	.301	.741	.012	-	-	-	-	-	-

TABLE 4B.2 Continued

	RESPONSE ACCURACY			WIN-STAY PERCENTAGE			LOSE-SHIFT PERCENTAGE		
Tested effect	*F*	*p*	η_p^2	*F*	*p*	η_p^2	*F*	*p*	η_p^2
Condition × Probability × Group	.173	.952	.007	-	-	-	-	-	-
Condition × Phase × IQ	.692	.505	.027	.508	.605	.020	.199	.820	.008
Condition × Phase × Group	2.689	.036	.099	1.516	.204	.058	.778	.542	.031
Condition × Probability × Phase	1.193	.312	.046	-	-	-	-	-	-
Probability × Phase × IQ	.601	.442	.012	-	-	-	-	-	-
Probability × Phase × Group	1.508	.231	.057	-	-	-	-	-	-
Condition × Probability × Phase × IQ	.958	.391	.038	-	-	-	-	-	-
Condition × Probability × Phase × Group	1.421	.233	.055	-	-	-	-	-	-

TABLE 4B.3 Hit & false alarm rates for all groups in each phase & condition

		ACQUISITION		REVERSAL	
		HiR	FaR	HiR	FaR
Condition	Group	M (SE)	M (SE)	M (SE)	M (SE)
Neutral reward	Healthy controls	.91 (.03)	.33 (.04)	.69 (.04)	.50 (.05)
	Non-psychopathic offenders	.91 (.03)	.33 (.05)	.79 (.04)	.48 (.06)
	Psychopathic offenders	.93 (.03)	.52 (.04)	.86 (.04)	.56 (.05)
Low Reward	Healthy controls	.90 (.02)	.35 (.05)	.77 (.04)	.46 (.05)
	Non-psychopathic offenders	.88 (.02)	.39 (.05)	.77 (.04)	.47 (.05)
	Psychopathic offenders	.96 (.02)	.47 (.05)	.83 (.04)	.60 (.05)
High Reward	Healthy controls	.91 (.03)	.36 (.05)	.77 (.04)	.47 (.06)
	Non-psychopathic offenders	.89 (.03)	.34 (.05)	.72 (.04)	.46 (.06)
	Psychopathic offenders	.96 (.03)	.54 (.05)	.84 (.04)	.63 (.06)

Note. HiR = Hit rate, FaR = False alarm rate, M = Mean, SE = Standard error.

TABLE 4B.4 Mean d' values for all groups in each phase and condition

		ACQUISITION	REVERSAL
Condition	Group	M (SE)	M (SE)
Neutral reward	Healthy controls	1.98 (.17)	0.59 (.20)
	Non-psychopathic offenders	2.21 (.18)	1.03 (.20)
	Psychopathic offenders	1.46 (.18)	0.99 (.20)
Low Reward	Healthy controls	1.87 (.17)	0.99 (.19)
	Non-psychopathic offenders	1.79 (.17)	0.97 (.19)
	Psychopathic offenders	1.86 (.17)	0.70 (.19)
High Reward	Healthy controls	1.92 (.19)	0.93 (.16)
	Non-psychopathic offenders	1.95 (.19)	0.86 (.16)
	Psychopathic offenders	1.63 (.19)	0.76 (.16)

Note. M = Mean, SE = Standard error.

S.4C Overview of post hoc tested effects

TABLE 4C.1 Response accuracy

CONDITION	TESTED EFFECT	*F*	*p*	η_p^2
Neutral reward	IQ	2.623	.112	.050
	Group	1.825	.172	.068
	Phase	2.621	.112	.050
	Phase × IQ	.113	.739	.002
	Phase × Group	4.732	.013	.159
Low reward	IQ	6.115	.017	.109
	Group	.260	.772	.010
	Phase	.153	.698	.003
	Phase × IQ	.734	.396	.014
	Phase × Group	.681	.511	.027
High reward	IQ	2.983	.090	.056
	Group	.727	.488	.028
	Phase	3.199	.080	.060
	Phase × IQ	.348	.558	.007
	Phase × Group	.234	.792	.009

TABLE 4C.2 Win-stay percentage

CONDITION	TESTED EFFECT	F	p	η_p^2
Neutral reward	Group	4.633	.014	.154
Low reward	Group	.232	.794	.009
High reward	Group	.764	.471	.029

TABLE 4C.3 Lose-shift percentage

PHASE	TESTED EFFECT	F	p	η_p^2
Acquisition	Group	5.533	.007	.178
	Condition	5.644	.006	.184
	Condition × Group	1.175	.327	.045
Reversal	Group	3.216	.048	.112
	Condition	.135	.874	.005
	Condition × Group	.462	.763	.018

CHAPTER 5

(Not) against the odds:

Short-term gains overrule outcome probabilities during risky decision making in psychopathic offenders

ABSTRACT

In daily life, psychopathy is associated with suboptimal and maladaptive decision making, which often leads to substance abuse, criminal behaviour and imprisonment. However, experimental findings regarding risky decision making in psychopathy have been inconclusive. The present study investigated whether rewards with varying subjective values affected risky decision making in psychopathic offenders. To this end, 20 psychopathic offenders, 17 non-psychopathic offenders and 18 healthy controls performed a decision-making task involving explicit gain and loss probabilities under three reward conditions. The rewards used were tailored to the subjective preferences of each participant. The results showed no effects of subjective reward value on risky decision making in any group. However, irrespective of reward condition, both offender groups made more risky decisions than healthy controls when large gains were available, despite the low probabilities of these large gains. Psychopathic offenders also gambled more often than healthy controls when low-probable small gains were available. Furthermore, psychopathic offenders made more risky decisions than both other groups when the expected values of options were relatively similar and a large possible gain with low probability was involved. The current findings suggest that psychopathic individuals tend to base their decisions on the prospect of short-term attractive outcomes, regardless of the associated risks, whereas longer-term rewards seem to have little effect on risky decision making.

AUTHORS

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5.1 INTRODUCTION

Each day, we encounter numerous situations that require fast decision making. Decisions may lead to social, monetary or health outcomes, to name a few, and some have more impactful consequences than others. There are individuals who have the tendency to consistently make poor choices that have a negative impact on own and others' well-being (e.g., Blair, 2007; Pletti et al., 2017). This is particularly the case for individuals with high levels of psychopathy, whose sub-optimal decision-making strategies often lead to criminal behaviour and imprisonment (e.g., Beszterczey et al., 2013). Psychopathy is a personality construct defined by severe emotional and interpersonal impairments in combination with antisocial behaviour and an impulsive and reckless lifestyle (Hare, 2003a). Psychopathic individuals often show, for example, a reduced capacity to form sincere social bonds, emotional bluntness, a strong need for stimulation and engaging in risky behaviour, and their offences often reflect a propensity towards immediate gains despite potential losses.

On the phenotypical level, psychopathic individuals share a number of affective and behavioural characteristics with patients with damage to the ventromedial prefrontal cortex (vmPFC), such as impulsivity, reduced empathy, antisocial behaviour, and impaired learning from aversive outcomes (Damasio et al., 1990; Koenigs & Tranel, 2006). The learning impairment seen in vmPFC patients has often been studied with the Iowa Gambling Task (IGT; Bechara et al., 1994), which involves probabilistic learning using reward and punishment information. In this task, participants are offered four decks of cards, of which two are 'risky decks' (high reward and punishment magnitudes) and two are 'non-risky decks' (low reward and punishment magnitudes). In the long run, consistently choosing cards from the non-risky decks will result in better outcomes. Patients with lesions to the vmPFC show impaired decision making throughout the task, and, whereas healthy individuals show increased electrodermal responses prior to making risky decisions on the IGT, these responses have been found to be attenuated or even absent in vmPFC patients. Such reductions in physiological responses to aversive events have also been observed in relation to increased levels of psychopathy (for a review, see Hoppenbrouwers et al., 2016) but published studies using the IGT in psychopathic populations did not include indices of autonomic physiological responses. Behavioural results of studies using the IGT in psychopathic offenders are mixed, with studies showing no relation with psychopathy (Kuin & Masthoff, 2016; Lösel & Schmucker, 2004; Schmitt et al., 1999), impaired performance (Beszterczey et al., 2013; Boulanger et al., 2008; Broom, 2011; Mitchell et al., 2002), and even enhanced performance in psychopathic individuals (Hughes et al., 2015). With some exceptions (e.g., Miranda Jr et al., 2009; Takahashi et al., 2014), studies in community samples generally point to a negative relation between psychopathic traits and IGT performance (e.g., Mahmut et al., 2008; Morgan et al., 2011; Vassileva et al., 2007), although there is evidence that this relation may be linked to the antisocial and lifestyle component of psychopathy rather than to affective and interpersonal impairments (Dean et al., 2013).

However, although impaired performance on the IGT is often associated with real-life suboptimal decision making (Buelow & Suhr, 2009), it should be noted that similar patterns of poor performance across individuals could result from different sources of impairment in neuropsychological functioning (e.g., learning ability, cognitive flexibility, working memory, or reward and punishment sensitivity). Other tasks that have been used to assess risk taking in psychopathy are the Balloon Analogue Risk Task (BART; Lejuez et al., 2002) and the Cambridge Gambling Task (CGT; Rogers et al., 1999). Unlike the IGT, both the BART and the CGT do not involve a learning component. In the BART, participants accumulate points in a temporal bank by inflating a virtual balloon with button presses. Accumulated points can be transferred to a permanent bank at any time during the task, after which a new balloon is presented. However, pumping too many times will make the balloon pop and will, thereby, result in a loss of the accumulated points in the temporal bank. BART performance generally correlates with real-world risk behaviour (Lejuez, Aklin, Jones, et al., 2003; Lejuez, Aklin, Zvolensky, et al., 2003; Lejuez et al., 2002), but findings regarding its relation with psychopathy are mixed. Hunt et al. (2005) found a positive relation between self-reported psychopathy and risk taking on the BART in a community sample, in contrast to Crysel et al. (2013). Offender studies also either did not find a direct association (Swogger et al., 2010), or the association was attributed to psychopathy-related boldness (referring to stress tolerance, emotional resiliency, and social dominance) rather than to affective impairments and antisocial tendencies (Snowden et al., 2017).

In the CGT, a token is hidden in a row of ten coloured boxes, and participants guess the location of this token by betting a proportion of their earned points on one of the two colours. The ratio between the two colours varies between trials. De Brito et al. (2013) did not find a relation between psychopathy and risk taking on the CGT, but both non-psychopathic offenders and psychopathic offenders performed worse than healthy controls with respect to decision-making quality (i.e., their choices were less beneficial). This suggested that both offender groups were aware of the associated risks, but failed to adjust their behaviour accordingly. In sum, risk-taking studies suggest that psychopathic individuals may be more prone to risky decision making than healthy individuals, but findings are mixed and seem to at least partly rely on the psychopathy construct that is used to define experimental groups.

Another cause of the mixed findings across studies could be that the impact of the motivational significance of the rewards involved in the different tasks has been systematically overlooked. In both humans and animals, the subjective valuation of rewards is a key element in decision-making processes (Medic et al., 2014; Padoa-Schioppa & Cai, 2011). Importantly, the same reward can be assigned a different value both within and across individuals, depending on variations in individual preferences and contextual states (Levy & Glimcher, 2012). This implies that similar rewards may elicit different motivational states, and, hence, differences in perceived risks during decision making. Likewise, individuals can assign the same subjective value to rewards of different types or with different properties. Since factors like motivation and perceived risk should be kept as equal as possible when assessing propensity to risk taking in the lab setting, this suggests that incorporating the subjective valuation of rewards in risk-taking studies would result in a more realistic approach to real-life risky decision making.

Despite the impact that subjective valuation has on motivating risk taking, prior studies in psychopathy did not account for this factor and employed similar rewards for all participants, without assessing how these rewards were valued by individual participants. This implicates that the used rewards may not have had equal subjective values across participants, and the task may not have been maximally motivating for psychopathic offenders. Fairchild et al. (2009) used the Risky Choice Task (RCT; Rogers et al., 2003) to study risky decision making in boys and adolescents with disruptive behavioural disorders under different motivational conditions. In the RCT, participants choose between two gambles with explicit gain and loss magnitudes and probabilities. One gamble is the risky option, in which magnitudes and probabilities of outcomes are varied across trials. The other gamble is the safe option with stable outcome magnitudes and probabilities. The results showed that boys with conduct disorder made more risky choices than healthy controls, but that increased motivation and stress, as operationalised by a standardised laboratory stressor combined with a monetary incentive, decreased risky decision making in all groups.

Importantly, the term 'disruptive behavioural disorders' is an umbrella construct for integrating developmental disorders that are considered to be the precursors of antisocial and psychopathic personality disorders in adulthood (Fairchild et al., 2019), and it remains to be shown whether the effects of subjective valuation of reinforcement is also visible in adult antisocial offenders. Therefore, the goal of the current study was to investigate decision making under risk in adult offenders with and without psychopathy. Motivation was manipulated using different types of reward based on the subjective values assigned to each reward by each participant. We hypothesized that both offender groups would show increased risky decision making compared to healthy controls, as reflected by higher gamble ratios (i.e., the proportion of trials in which the experimental gamble was chosen). However, since individuals generally become more risk averse when there are more valuable outcomes at stake (Bornovalova et al., 2009; Ruggeri et al., 2020; Tversky & Kahneman, 1981), rewards with high subjective values were expected to promote more risk-averse behaviour in all groups. These results would be in line with the findings of Fairchild et al. (2009) concerning risky decision making under increased motivational conditions. Considering the mixed findings from earlier studies with respect to risk taking in psychopathy, we were also interested in possible differences in risk taking between offender groups with and without psychopathy, respectively. In addition, prior performance is another factor that seems to affect decision making in the RCT (Fairchild et al., 2009). Our hypotheses concerning the effect of the outcome of the previous trial were largely based on the findings of Fairchild et al. (2009). As such, we expected that, under low motivational conditions, the experience of a loss would promote risky decision making on the next trial in all groups. However, we also expected that psychopathic offenders would gamble more frequently after a small gain relative to the other groups. Under high motivational conditions, we expected the reduced tendency for risky decisions to also attenuate the effects of the previous trial in all groups. Finally, we were interested in the effect of framing on response bias. In healthy individuals, comparing possible gains is associated with risk aversion, whereas choosing between possible losses is associated with more risk seeking behaviour. We expected group differences to be more pronounced in negatively framed trials, with psychopathic individuals making more risky decisions than the other groups, and non-psychopathic offenders also taking more risks than healthy controls. In addition, we expected framing effects to be less prominent under high motivational conditions in controls, but not in offenders.

5.2 METHODS

5.2.1 Participants

A total of 20 psychopathic and 17 non-psychopathic offenders[1] were recruited from the inpatient population of a maximum security forensic psychiatric institute in The Netherlands. Selection was based on available information about clinical status and history obtained from their head therapists and patient files. 18 healthy control participants were recruited via advertisements on social media, via research participant pools, and among employees in the facility. Subsequently, all potential participants were screened by trained psychologists using the Dutch version of the MINI Psychiatric Interview (Van Vliet et al., 2000) and the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (SCID-II; Weertman et al., 1996). They were excluded in case of any major current Axis I and Axis II disorders (with exception of cluster B personality disorders), chronic use of intoxicating substances, and the use of psychotropic medication at the time of testing. The experimental protocol was approved by the local ethics committee of the Social Sciences Faculty at Radboud University Nijmegen, the Netherlands (ECSW2016-2501-373). All participants received written information about the experiment, gave written informed consent and received financial compensation. The sample was identical to the sample described in Chapter 4.

Each participant's IQ was estimated using a combination of two subtests (*Information* and *Coding*) of the core Dutch Wechsler Adult Intelligence Scale–IV (WAIS-IV) subtests (Girard et al., 2015; Wechsler, 2012a, 2012b). The group with psychopathic offenders was composed of individuals with a score of 26 or higher on the Hare Psychopathy Checklist-Revised (PCL-R; Hare, 2003a), which is the customary threshold in Europe (Cooke & Michie, 1999; Rasmussen et al., 1999). The PCL-R is a 20-item instrument assessing the affective, interpersonal and behavioural characteristics associated with psychopathy, based on a file review and a semi-structured interview. The offender groups and healthy controls were, as far as possible, matched for age and IQ. No PCL-R scores were assessed in the control group, as these participants did not have criminal records.

For one participant in the psychopathic offender group, no exact PCLR-score was available. However, multiple legal documents in this participant's patient file stated that the PCL-R had been assessed, and that the resulting score

1 Our sample sizes were above the required thresholds according to an a priori power analysis based on the effect sizes obtained in similar prior studies (power =.80, Cohen's f=.25, α=.05, two-tailed).

indicated that this offender had (very) high levels of psychopathic traits. Mean PCL-R total score was therefore calculated with data from 19 psychopathic offenders. PCL-R scores were significantly higher in psychopathic offenders (*M*=30.2; range=27-35) compared to non-psychopathic offenders (*M*=18.7; range=10-25), $t(34)=-9.42$, $p<.001$. The three groups did not differ in terms of age (psychopathic offenders: *M*=44.7, *SD*=8.8; non-psychopathic offenders: *M*=44.9, *SD*=13.9; healthy controls: M=43.3, SD=10.2), $F(2,52)=0.11$, $p=.900$, $\eta_p^2=.004$. For one participant in the psychopathic offender group, the IQ score that was obtained in the screening session could not be traced at the time of data analysis. Therefore, calculation of mean IQ score, as well as further analyses containing IQ, was performed with data from 19 psychopathic offenders. There was a significant group difference in IQ, $F(2,51)=5.59$, $p=.006$, $\eta_p^2=.180$, with significantly lower IQ's in psychopathic offenders (M=83.4, SD=11.3) compared to non-psychopathic offenders (*M*=97.4, *SD*=14.3; $t(51)=2.86$, $p=.017$) and controls (M=97.0, SD=17.3; $t(51)=2.86$, $p=.019$). No differences in IQ were observed between non-psychopathic offenders and controls ($t(51)=-.08$, $p=1.000$).

5.2.2 Task and design

The experiment started with the collection of reward attractiveness ratings. This was the same procedure as described in Chapter 4. Each participant sorted items representing potential rewards, extracted from a larger pool of items that were identified in an earlier study (see Chapter 3; Glimmerveen et al., 2018), on a Visual Analogue Scale (VAS), ranging from -25 (extremely unattractive) to +25 (extremely attractive). The items could be characterised as representing food rewards, material rewards, or rewards related to personal development (see Supplement 4A, for an overview). Offenders sorted a larger number of potential rewards (20) than controls (10). One important reason for this difference concerned feasibility of the rewards in the facility versus 'the outside world'. For instance, a number of items offered to offenders were formulated more specific (e.g., "guitar lessons", "piano lessons", "singing lessons") than those offered to controls ("lessons on a musical instrument"). Moreover, a number of items in the offender group were restricted to the clinical setting (e.g., "Preparing a dinner together with other patients on the ward"). For each participant, the two rewards with the lowest positive ratings and the two rewards with the highest positive ratings were selected. One of the two low-value rewards and one of the two high-value rewards were selected for the current study; the other low- and high-value rewards were used in another task (described in Chapter 4) that was performed in the same session. Both task order and allocation of the highest and lowest rated high- and low-value rewards to each task occurred in counterbalanced order.

To study risky decision making, we used a modified version of the Risky Choice Task (RCT) developed by Fairchild et al. (2009). Participants were seated in front of a 100 Hz computer screen on which events were presented against a black background, and made their response by pressing the m or z key on a keyboard (see Figure 5.1). On each trial, participants chose one of two options, both associated with different outcomes and probabilities of these outcomes. The options were displayed as two 'roulette wheels' that were divided into eight segments displaying the associated numbers of points. After choosing a wheel, a white triangle moved around quickly in clockwise direction for 2000-4000 ms, accompanied by a rattling sound, to successively highlight each possible outcome and ultimately stopping on one of the possible outcomes. Feedback was provided for 3500 ms, by keeping the white triangle on the final segment (displaying the gained or lost number of points), accompanied by a sound with increasing pitch (gain), decreasing pitch (loss), or stable pitch (zero points). The experiment was run with OpenSesame v3.0 (Mathôt et al., 2012).

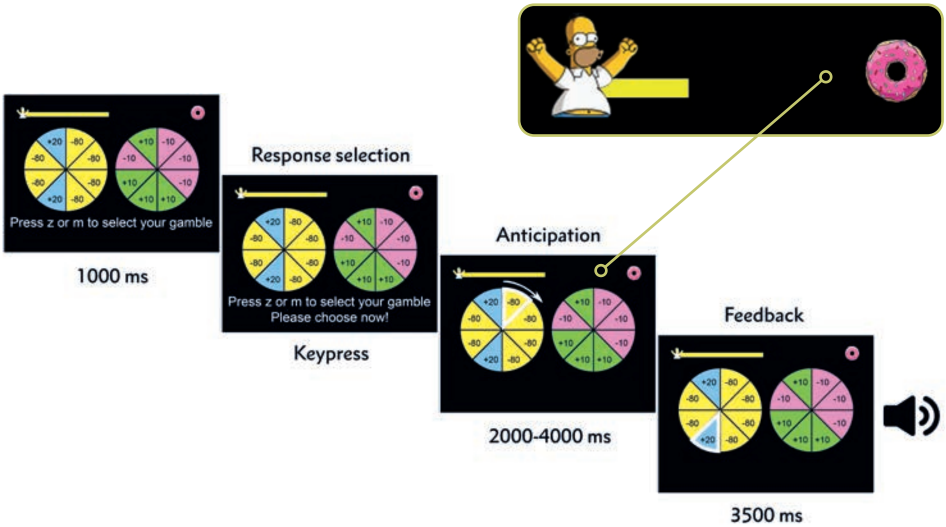

FIGURE 5.1 **Sequence of events and their timing (ms) during the experiment.** *ITI = Inter-trial interval. The figure shows a ΔEV-55 trial type in the neutral reward condition, with the experimental wheel on the left and the control wheel on the right side of the screen. The cartoon character is placed in the upper left corner of the screen, and a picture of the reward (i.e., a donut in the current condition) in the upper right corner of the screen. The yellow bar reflects the accumulated number of points and thus the progress towards obtaining the reward at the end of the current experimental run. In the figure can be seen that about 50% of the required number of points has been accumulated, as the yellow bar is almost halfway between the cartoon figure and the reward.*

One of the two options (the 'control wheel') was always less risky than the other, and was on most trials (except on framing trials) associated with a .5 probability of gaining 10 points and a .5 probability of losing 10 points. The other ('experimental') wheel varied in terms of magnitude (80 or 20 points) and probability (.75 or .25) of gaining and losing. Combining these variables resulted in eight different trial types varying in the difference of expected values (EV) of the two options, referred to as delta expected value (ΔEV = EV experimental option – EV control option). The control wheel always had an EV of 0 (.5 x 10 + .5 x -10), but the EV of the experimental wheel depended on the combination of both the magnitude and probability of obtaining each possible number of points on the wheel. For instance, a .75 probability of gaining 20 points and .25 probability of losing 80 points resulted in an EV of -5 (i.e., .75 x 20 + .25 x -80). Hence, in this trial type, ΔEV would be -5. See Table 5.2 for an overview of ΔEVs and the associated gain and loss magnitudes and probabilities.

Two additional trial types, in which ΔEV was 0, were included to assess the effect of framing on response bias. In the positively framed trial (+0 frame), the control wheel was associated with a certain gain of 40 points, and the experimental wheel provided a .5 probability of gaining 80 points and a .5 probability of gaining 0 points. In the negatively framed trial (-0 frame), the control wheel was associated with a certain loss of 40 points, and the experimental wheel provided a .5 probability of losing 80 points and a .5 probability of losing 0 points (see also Table 5.1). There was a total of 60 trials, in which all 10 trial types were presented six times in randomised order. The experimental wheel and the control wheel appeared pseudo-randomly on the left and right side of the screen.

Each participant performed the task under three reward conditions (hypothetical reward, low reward and high reward), in counter balanced order using a Latin Square. Participants could monitor their performance with a horizontal bar that was displayed continuously on the top of the screen (see Figure 5.1), increasing and decreasing according to the valence and magnitude of the outcome of each trial. A gain of 80 points resulted in the largest possible increase and a loss of 80 points resulted in the largest possible decrease of the bar. A cartoon figure (i.e., Homer Simpson) was placed at the left start point of the bar. The upper right corner of the screen displayed a picture of the reward. The low and high rewards were represented by the same pictures that were used to sort the items on the VAS and thus depended on the individual participants' choices. The hypothetical reward was always represented by a donut. Participants were explained that they would not gain the donut themselves, but that it would be appreciated if they would help Homer to get this donut.

TABLE 5.1 **Overview of trial types with corresponding gain/loss magnitudes and probabilities for both gambles**

TRIAL TYPE	EXPERIMENTAL GAMBLE			CONTROL GAMBLE		
ΔEV-55	0.25	20	-80	0.50	10	-10
ΔEV-40	0.25	80	-80	0.50	10	-10
ΔEV-10	0.25	20	-20	0.50	10	-10
ΔEV-5	0.75	20	-80	0.50	10	-10
ΔEV-0	0.50	0	-80	0.00	0	-40
ΔEV+0	0.50	80	0	1.00	40	0
ΔEV+5	0.25	80	-20	0.50	10	-10
ΔEV+10	0.75	20	-20	0.50	10	-10
ΔEV+40	0.75	80	-80	0.50	10	-10
ΔEV+55	0.75	20	-20	0.50	10	-10

Note. For each trial type, gain probability and gain and loss magnitudes are given for both gambles. ΔEV-0 and ΔEV+0 refer to negative and positive framing trials, with both gambles having the same EV (-40 and +40, respectively).

The reward was gained when the horizontal bar reached or crossed the reward picture at the end of the task. To account for learning effects, the numbers of points to be earned for obtaining the reward were determined separately for each experimental run (first, second, or last), based on the median numbers of points participants earned in an (unpublished) pilot study (470, 575, or 575 points, respectively). The accumulated number of points at any point in the experiment, as well as this criterion, were unknown to the participants, whose only reference was the length of the yellow bar and its distance to the reward.

5.2.3 Data analyses

Decision-making data were first analysed by entering gamble ratios (i.e., the proportion of trials in which the experimental wheel was chosen) into a 3 × 10 × 3 repeated measures ANOVA with Condition (neutral reward, low reward, high reward) and Trial type (ΔEV-55, ΔEV-40, ΔEV-10, ΔEV-5, ΔEV-0, ΔEV+0, ΔEV+5, ΔEV+10, ΔEV+40, ΔEV+55) as within-subject factors and Group (psychopathic offenders, non-psychopathic offenders, controls) as between-subjects factor.

To investigate the immediate effect of gamble outcome on subsequent decision making, gamble ratios were also calculated over trials immediately following either a large loss (-80), a small loss (-20), a small gain (+20) or a large gain (+80). Data from five participants (three controls, one non-psychopathic offender, and one psychopathic offender) were excluded, since they never experienced a small or large loss. For these analyses, gamble ratios were entered into a 3 × 2 × 2 × 3 repeated measures ANOVA with Condition (neutral reward, low reward, high reward), Outcome (loss, gain) and Magnitude (small, large) as within-subject factors and Group (psychopathic offenders, non-psychopathic offenders, controls) as between-subjects factor.

Since IQ was found to differ significantly between groups, and IQ was expected to contribute to inter-individual decision-making variability, it was added as a covariate in the analyses. Effect sizes are reported as partial eta-squared (η_p^2; small ≥ .01, medium ≥ .06, large ≥ .14 (Cohen, 1988)). Statistical analyses were performed in SPSS 23.0 (IBM Corp., 2015). An overview of all tested effects in primary analyses and post-hoc tests is presented in Supplement 5A and 5B.

5.3 RESULTS

First, and most importantly, there were no significant main or interaction effects concerning condition on gamble ratio (all *p*s > .5; see Supplement B). However, there was an effect of group on gamble ratio, $F(2,50)=6.44$, $p=.003$, $\eta_p^2=.205$. Pairwise comparisons showed that controls were less likely to choose the experimental wheel than psychopathic offenders ($t(50)=-3.46$, $p=.001$) and non-psychopathic offenders (t(50)=-2.44, $p=.018$), but no statistically significant difference was observed between the two offender groups ($t(50)=-1.11$, $p=.272$); *M*(controls)=47.2%; *M*(psychopathic offenders)=57.1%; *M*(non-psychopathic offenders)=53.9%; all *SE*s=2.0%.

Concerning trial type, Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(44) = 328.63$, $p<.001$, therefore degrees of freedom were corrected using Huynh-Feldt estimates of sphericity ($\varepsilon = .506$). This revealed an effect of trial type on gamble ratio, $F(4.55,227.61)=7.38$, $p<.001$, $\eta_p^2=.129$. As expected, participants showed relatively low gamble rates when confronted with highly negative expected values (see Table 5.2; ΔEV-55, ΔEV-40, and ΔEV-10), and high gamble rates when confronted with highly positive expected values (see Table 5.2; ΔEV+10, ΔEV+40, and ΔEV+55). However, relatively small differences in expected values between choices had a dramatic effect on the gradual increase of gamble ratio with expected value (see Table

5.2; ΔEV-5 and ΔEV+5). This resulted in significantly higher gamble ratios in the ΔEV-5 trial type compared to the ΔEV-10 trial type, $F(1,50)=14.26$, $p<.001$, $\eta_p^2=.222$, and significantly lower gamble rates in the ΔEV+5 trial type compared to the ΔEV+10 trial type, $F(1,50)=10.50$, $p=.002$, $\eta_p^2=.174$. Interestingly, post hoc analysis of ΔEV-5 and ΔEV+5 trial types showed that participants chose the experimental wheel more often in the ΔEV-5 trial type compared to the ΔEV+5 trial type, $F(1,50)=8.09$, $p=.006$, $\eta_p^2=.139$. This suggests that participants relied primarily on the probability of gaining or losing in these trial types, regardless of the actual magnitude of the gains and losses. In addition, as expected, participants showed higher gamble ratios in the negatively framed trials compared to the positively framed trials (see Table 5.2; ΔEV-0 and ΔEV+0), $F(1,50)=3.96$, $p=.052$, $\eta_p^2=.073$.

In addition, there was a significant trial type × group interaction, $F(9.10, 227.61)=2.23$, $p=.021$, $\eta_p^2=.082$. Assessing group effects for each trial type independently revealed that psychopathic offenders selected the experimental wheel significantly more frequently than controls on the ΔEV-55, ΔEV-40, ΔEV-10, ΔEV+0, and ΔEV+5 trial types (see Figure 5.2; $p=.041$, $p=.003$, $p=.004$, $p=.007$, and $p=.001$, respectively). Non-psychopathic offenders chose the experimental wheel also more often than controls on the ΔEV-40 and ΔEV+0 trial types (see Figure 5.2; $p=.049$ and $p=.003$, respectively), but less often than psychopathic offenders on the ΔEV+5 trial type (see Figure 5.2; $p=.047$). Finally, analyses revealed that IQ was negatively related to gamble ratio ($F(1, 50)=4.13$, $p=.047$, $\eta_p^2=.076$). However, IQ did not significantly interact with any of the other factors.

Analyses of the immediate effect of gamble outcome on subsequent decision making showed an effect of group on gamble ratio, $F(1,45)=7.89$, $p=.001$, $\eta_p^2=.260$. Pairwise comparisons showed that controls were less likely to choose the experimental wheel after a gamble trial than psychopathic offenders ($t(45)=-3.91$, $p<.001$) and non-psychopathic offenders, (t(45)=-2.43, $p=.019$), but no differences were observed between the two offender groups ($t(45)=-1.47$, $p=.148$); *M*(controls)=47.4%, *SE*=2.3%; *M*(psychopathic offenders)=60.2%, *SE*=2.3%; *M*(non-psychopathic offenders)=55.2%, *SE*=2.2%. However, this effect can be explained by the finding that controls overall chose the experimental wheel less frequently than offenders. No other main effects or interactions were observed, indicating that our participants' choice behaviour was not influenced by their experience on the previous trial.

TABLE 5.2 Gamble ratios across trial types for total sample

TRIAL TYPE	GAMBLE RATIO (SE)
ΔEV-55	7.1 (1.3)
ΔEV-40	13.2 (2.4)
ΔEV-10	10.4 (1.8)
ΔEV-5	75.1 (3.6)
ΔEV-0	64.2 (3.6)
ΔEV+0	39.0 (3.0)
ΔEV+5	31.8 (3.6)
ΔEV+10	95.1 (1.0)
ΔEV+40	94.6 (1.3)
ΔEV+55	96.8 (0.7)

Note. SE= Standard Error. Gamble ratio and SE values are percentages (%).

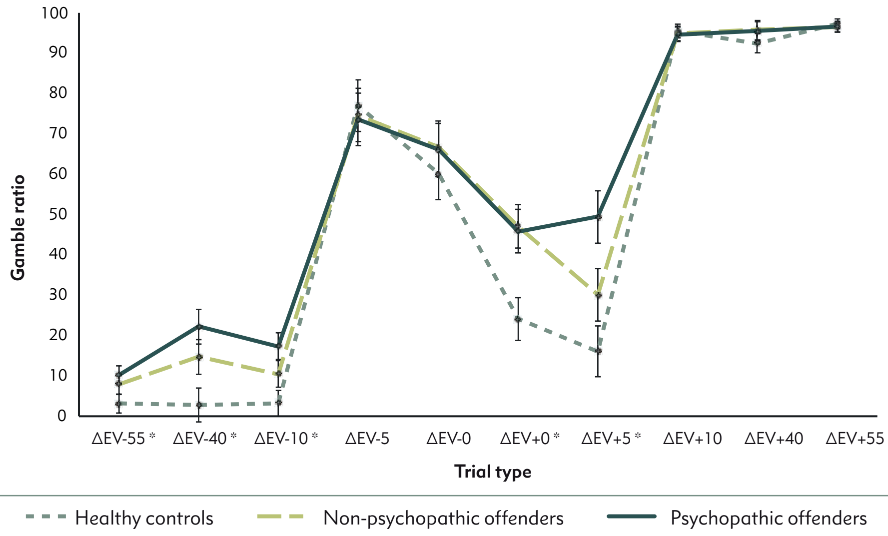

FIGURE 5.2 Mean proportion of instances the experimental wheel was chosen for each participant group. *Trial types are defined as the difference in expected value between options (ΔEV). Gamble ratios are expressed as percentages. Error bars represent standard errors. An * indicates group differences in the respective trial types. The ΔEV-0 and ΔEV+0 trial types refer to the negative and positive framing trials, respectively.*

5.4 DISCUSSION

The present study was focused on systematically examining the effect of the subjective experience of reward on risky decision making in antisocial offenders with and without psychopathy, respectively. However, contrary to expectations, no effects of reward were observed. It seems unlikely that the rewards lacked motivational relevance to induce behavioural change, given that an identical operationalization of reward was used in another study with the same participants and this study did yield both electrophysiological and behavioural effects related to the level of subjective reward. Instead, the lack of effects of reward on decision making may be attributed to either task design or the underlying cognitive mechanisms involved in task performance. One possibility is that the task itself was already maximally motivating; 'winning the game' may have been a primary goal for our participants, regardless of the associated reward. Another explanation could be that there were too many ambiguous variables in the task for participants to also take the actual rewards (in addition to the points to be gained or lost) into account in their decisions. In particular, considering the varying expected values may have placed a large demand on cognitive resources.

5.4.1 Overall effects of expected value

In correspondence with the previous explanation, we found that expected values were not linearly associated with risk aversion. In line with expectations, participants showed rational and effective decision-making patterns when differences in expected values between choices were evident. In these trials, the outcomes associated with the experimental gamble were either highly favourable or highly unfavourable. However, in trials with relatively similar expected values, where it was less apparent which option was the most beneficial, participants used more straightforward rules of thumb to guide decision making. Looking at the pattern of gamble ratios across expected values, they seem to have particularly considered the probability of gaining or losing points when expected values were close to zero, regardless of the magnitude of these gains and losses. This probability heuristic is often used when individuals are faced with complex gamble situations in which outcomes involve both gains and losses, since it maximises the overall probability of winning with reduced mental effort (Payne, 2005; Venkatraman et al., 2014). In addition, participants were highly susceptible to framing, showing higher gamble ratios in the negative decision frame compared to the positive decision frame. Both the tendency to use heuristics under ambiguous circumstances and the observed sensitivity to framing are robust findings in human decision-making research (see Kahneman & Frederick, 2002; Kahneman & Tversky, 1979).

5.4.2 Group comparisons

In line with expectations, we found that offenders were more likely to make risky decisions than healthy controls. Interestingly, the higher gamble ratios of psychopathic offenders compared to healthy controls could be mainly attributed to trials with high loss probabilities. In general, controls tended to 'play on safe' and chose the control wheel in these trials, but psychopathic offenders were more inclined to select the risky gamble in an attempt to obtain some points. In particular, they decided to gamble more often than controls in these trials when a large gain was available, regardless of its low probability. This result can be related to the general finding of increased reward seeking behaviour in psychopathic individuals and their deficient responding to (potential) punishment in the face of reward (e.g., Blair et al., 2004; Newman et al., 1990). Moreover, in healthy individuals, decision making in a gamble context is more highly correlated with gain and loss probabilities than with payoff sizes (Lichtenstein & Slovic, 1971; Slovic & Lichtenstein, 1968; Tversky et al., 1988). Our findings suggest that this does not hold for individuals with psychopathy. In addition, both offender groups gambled more than controls when large gains were available in trials where large losses were highly probable. The relation between antisociality and enhanced risk taking in a context with high loss probabilities has been shown before (Maes et al., 2018). However, this finding is also attributable to the fact that the majority of controls *never* gambled in this particular trial type.

We were also interested in possible differences between offenders with and without psychopathy. In trials involving a large gain and a highly probable small loss, with a positive though close-to-zero expected value (EV=+5), psychopathic offenders gambled more often than non-psychopathic offenders. In trials involving a highly probable small gain and a low-probable large loss, with a negative but close-to-zero expected value (EV=-5), all groups displayed similar risky decision making. In situations that do not allow fast comparing of different options (because their outcomes are highly similar), psychopathic individuals thus seem to rely on the availability of large gains, whereas non-psychopathic offenders and healthy individuals show more risk-averse behaviour. These situations may be described as having an increased level of uncertainty, since the difference between the two options is not immediately evident. Impaired processing and reduction of uncertainty has already been associated with psychopathy during threat conditioning (Brazil et al., 2017).

In the same line of reasoning, the positively framed trials could be described as offering large gains with maximum uncertainty, since both options have equal EV's. Although all groups displayed the generally found risk aversion in these trials, both offender groups showed higher rates of risky decisions compared to healthy controls. Previous research has shown that interpersonal and affective features of psychopathy are positively related to risk taking in gain contexts (Maes et al., 2018). However, in the current study this effect was also present in non-psychopathic offenders, who display primarily antisocial features. An explanation of this finding could be that the higher rates of risky decisions of both offender groups in positive framing trials are related to the uncertainty associated with these trials, as insensitivity to ambiguous uncertainty has been related to antisocial features in general (Buckholtz et al., 2017). In this context it is important to note that decision making under ambiguity relies on different neural processes than decision making under risk (Krain et al., 2006), and the literature generally uses the term ambiguity in decision making to refer to situations with unknown a priori probabilities, which does not apply to the current study. As such, our data suggest that processing of non-ambiguous uncertainty during decision making may also be largely similar between non-psychopathic and psychopathic individuals.

5.4.3 Effects of the previous trial

Finally, for all three participant groups, decision making was not guided by the outcome of the previous trial. Offenders chose the experimental gamble more often than controls after a gamble trial, but this was independent of the outcome of the previous gamble and most likely reflected the overall higher gamble frequency of the offender groups compared to controls. This is contrary to the findings of Fairchild et al. (2009), who found boys with early-onset conduct behaviour disorder to more frequently select the experimental gamble in trials following a small gain compared to control participants. As they needed higher levels of immediate reinforcement to supress risky decision making, it was hypothesised that these boys had altered levels of reward sensitivity compared to control participants. Although our adult participants did not display any effects of gamble outcome on subsequent decisions, our offenders, particularly those with psychopathy, did show increased reward seeking behaviour, whereas their tendency to be guided by payoff sizes more than by probabilities suggests a reduced punishment sensitivity. Future research may shed more light on the development of reward and punishment sensitivity from adolescence to adulthood in populations with antisocial tendencies, and how these mechanisms affect (risky) decision making.

5.4.4 Limitations

Our task design has a few limitations. As previously noted, the task may have included too many parameters to assess the effect of reward without the impact of other variables. Future studies using a less complex task may further elucidate the effect of personalised rewards on risky decision making in psychopathic offenders. Second, in everyday decision making, the exact probabilities of the outcomes of our choices are generally unknown. The current study may therefore not be an optimal ecologically valid reflection of problematic risk behaviour associated with psychopathy. Using individualised rewards in studies focused on decision making in psychopathy that do not include explicit outcome probabilities, such as the IGT, could therefore further elucidate the processes underlying decision making under ambiguity in psychopathic individuals.

5.4.5 Conclusion

The current study did not reveal an effect of subjective reward value on risky decision making in psychopathic offenders. However, the results did show that offenders are more guided by payoff sizes than probabilities, in contrast to healthy controls. This holds especially for situations in which large gains are available. Moreover, psychopathic offenders are less inhibited to make risky decisions when high loss probabilities are involved, as long as there is something to gain. They also make more risky decisions than non-psychopathic offenders when two options are relatively similar and a large possible gain with low probability is involved. In daily life, the probabilities of the outcomes of our choices are not evident, but healthy individuals generally do take the available information into account in their decisions. The current findings suggest that psychopathic individuals are more inclined to be guided by the prospect of attractive outcomes, regardless of the associated risk of their decisions. A longer-term attractive reward, linked to overall behavioural performance, seems to have little effect on risky decision making, even when gain and loss probabilities are made explicit.

5.5 SUPPLEMENTAL MATERIAL

S.5A Overview of tested effects in primary analyses

TABLE 5A.1 Gamble ratios

	GAMBLE RATIO		
Tested effect	*F*	*p*	η_p^2
IQ	4.133	.047	.076
Group	6.442	.003	.205
Condition	.620	.540	.012
Trial type	7.375[1]	.000[1]	.129[1]
Condition × IQ	.489	.615	.010
Condition × Group	.589	.671	.023
Condition × Trial type	.584[1]	.888[1]	.012[1]
Trial type × IQ	1.685[1]	.146[1]	.033[1]
Trial type × Group	2.230[1]	.021[1]	.082[1]
Condition × Trial type × IQ	.571[1]	.898[1]	.011[1]
Condition × Trial type × Group	.891[1]	.636[1]	.034[1]

[1] *Degrees of freedom corrected using Huynh-Feldt estimates of sphericity (ε = .506)*

TABLE 5A.2 Effects of gamble outcome on subsequent decision making

	GAMBLE RATIO		
Tested effect	*F*	*p*	η_p^2
IQ	2.207	.144	.042
Group	7.520	.001	.231
Outcome	.219	.642	.004
Condition × Outcome	1.938	.149	.037
Outcome × IQ	.305	.583	.006
Outcome × Group	.129	.879	.005
Outcome × Magnitude	.806	.373	.016
Condition × Outcome × IQ	1.649	.197	.032
Condition × Outcome × Group	1.237	.300	.047
Condition × Outcome × Magnitude	1.128	.328	.022
Outcome × Magnitude × IQ	1.120	.295	.022
Outcome × Magnitude × Group	1.838	.170	.068
Condition × Outcome × Magnitude × IQ	1.306	.275	.025
Condition × Outcome × Magnitude × Group	.817	.517	.032

S.5B Overview of post hoc tested effects

TABLE 5B.1 Comparison of gamble ratios between selected trial types

TRIAL TYPES	*F*	*p*	η_p^2
ΔEV-5 vs ΔEV-10	14.263	.000	.222
ΔEV+5 vs ΔEV+10	10.500	.002	.174
ΔEV-5 vs ΔEV+5	8.085	.006	.139
ΔEV-0 vs ΔEV+0	3.955	.052	.073

TABLE 5B.2 Group contrast results for each trial type independently

TRIAL TYPE	TESTED CONTRAST	*p*
ΔEV-55	C vs PP	.041
	Non-PP vs PP	.503
	C vs Non-PP	.146
ΔEV-40	C vs PP	.003
	Non-PP vs PP	.241
	C vs Non-PP	.049
ΔEV-10	C vs PP	.004
	Non-PP vs PP	.161
	C vs Non-PP	.108
ΔEV-5	C vs PP	.719
	Non-PP vs PP	.906
	C vs Non-PP	.801
ΔEV-0	C vs PP	.533
	Non-PP vs PP	.952
	C vs Non-PP	.474
ΔEV+0	C vs PP	.007
	Non-PP vs PP	.885
	C vs Non-PP	.003
ΔEV+5	C vs PP	.001
	Non-PP vs PP	.047
	C vs Non-PP	.123
ΔEV+10	C vs PP	.755
	Non-PP vs PP	.933
	C vs Non-PP	.812
ΔEV+40	C vs PP	.419
	Non-PP vs PP	.927
	C vs Non-PP	.346
ΔEV+55	C vs PP	.668
	Non-PP vs PP	.985
	C vs Non-PP	.639

Note. C = Healthy controls; PP = Psychopathic offenders; Non-PP = Non-psychopathic offenders.

CHAPTER 6

General discussion

Psychopathy and its associated violence have been widely acknowledged as a societal burden, reaching far beyond the consequences of individual victims (Kiehl & Hoffman, 2011). A lack of empathy, a lack of remorse, irresponsibility and diminished behavioural control, among others, are factors that contribute to the disruptive outcomes of the behaviour of psychopaths (Hare, 2003a). Moreover, psychopathy is associated with impairments in cognitive mechanisms that are also involved in (social) learning, such as learning from feedback, and predicting aversive outcomes (e.g., Baskin-Sommers et al., 2015; Brazil et al., 2013; Budhani et al., 2006; Newman et al., 1990). Considering the complicated nature and societal impact of the disorder, evidence obtained from both fundamental and applied research is needed to effectively design interventions targeted at psychopathic offenders.

Criminal justice systems are traditionally focused on punishment, primarily functioning as retribution for victims, incapacitation to protect society, as well as discouragement for future crimes (Carlsmith, 2006). However, avoiding continued involvement in criminal behaviour when offenders return into society after a period of punishment requires sufficient attention to rehabilitation and behavioural change, which has become increasingly recognised over the last decades (Day et al., 2006; Lipsey & Cullen, 2007). In both forensic and non-forensic populations, interventions aimed at establishing behavioural change often incorporate the use of reinforcers (e.g., Timmerman & Emmelkamp, 2005; Wodahl et al., 2011; Wong et al., 2007). Considering the importance of individual differences in treatment responsivity (Brazil et al., 2018b; Insel & Cuthbert, 2015), in addition to the low treatment responsivity in individuals with psychopathy (Howells & Day, 2007; Ogloff et al., 1990), it is important to find and use reinforcers that are relevant for individual patients. This individualised approach is central to the studies described in this thesis, focusing on individual reward preferences and taking these into account when studying learning and decision making in psychopathic offenders.

6.1 SUMMARY OF MAIN FINDINGS

In **Chapter 2,** an overview was provided of research directed at aversive conditioning, instrumental learning and risky decision making in offenders with psychopathy. This showed that psychopathy is associated with reduced responsivity to aversive cues, which has been related to diminished learning from punishment. Furthermore, psychopathy has been associated with impaired passive avoidance learning, at least when tasks require processing of both reward and punishment cues, and with deficient updating of learned contingencies, such as in reversal learning tasks.The literature is less consistent about risky decision making in relation to psychopathy. Although many studies do show increased risky decision making in psychopathic offenders compared to healthy controls, when compared to individuals with ASPD, the findings are far from conclusive. This suggests that increased risk taking may be primarily related to the behavioural aspects of psychopathy, and that the core personality characteristics, particularly those related to affective processing, have less impact on risk-taking tendencies. Nonetheless, it is important to note that there is evidence that the processes underlying maladaptive behaviour in psychopathy compared to non-psychopathic antisocial personality structures are distinct (Brazil et al., 2012; Moreira et al., 2019; Pasion et al., 2018), which may also apply to mechanisms underlying risk-taking behaviour. In addition, one factor that is overlooked in many of these studies is how the rewards and punishers (which were often mere points or small amounts of money) were subjectively valued by participants, but studies focused on which rewards are considered attractive in offenders are lacking.

In **Chapter 3**, this topic was approached with an exploratory study in forensic in- and outpatients, using a mixed-methods design also known as concept mapping. We found that both in- and outpatients rated rewards requiring greater effort as more attractive than low-effort rewards. High-effort rewards were, for instance, rewards related to autonomy, quality of social functioning, or personal development. Examples of low-effort rewards were those related to substance use, material goods, and relaxing or stimulating experiences. In inpatients, rewards were especially valued when they involved their direct environment. In outpatients, rewards with higher values were often associated with lower levels of arousal. Although these findings are in line with reward preferences of healthy individuals, they also may seem somewhat counterintuitive in relation to the low-effort, hedonistic goals often associated with offending (Felson et al., 2018) and what has been found in relation to psychopathy in community samples (Glenn et al., 2017). Socially desirable responding and the mixed composition of our samples regarding offence types and psychopathology are factors that may have contributed to this discrepancy.

In **Chapters 4 and 5**, the findings of this study were used in two experimental tasks targeted at instrumental learning and risky decision making. Of specific interest was whether the subjective values of naturalistic rewards, that were tailored to the subjective preferences of each individual participant, would affect performance in these tasks more than 'typical' experimental rewards and punishers (i.e., earning points).

The results of the study described in **Chapter 4** showed that psychopathic offenders were impaired in passive avoidance learning compared to non-psychopathic offenders and healthy controls when mere points could be earned, which is in correspondence with the literature on passive avoidance learning in psychopathy (Blair et al., 2004; Newman & Kosson, 1986). In addition, they were less able to use positive feedback to guide future decisions. However, when 'real', naturalistic rewards could be earned, no group differences were observed. Contrary to expectations, there were no group differences, nor effects of reward value with respect to reversal learning performance. However, a more general deficit in negative feedback processing was observed in psychopathic offenders, as they were impaired in adapting their behaviour following negative feedback.

The study described in **Chapter 5** revealed no effects of reward value on risky decision making. Instead, offenders, particularly those with psychopathy, made more risky decisions than healthy controls when large gains were available, and those with psychopathy also made more risky decisions than healthy controls when small gains were available. This tendency of offenders to base their decisions on the availability of gains was irrespective of outcome probabilities. These findings suggest both increased reward-seeking behaviour and reduced punishment sensitivity in our offender samples. Moreover, low-probable large gains also promoted risky decisions in psychopathic offenders compared to non-psychopathic offenders when expected values of outcomes were relatively similar. Considering our central research questions, our findings suggest that psychopathic individuals are guided by the prospect of short-term attractive outcomes, regardless of the associated risks, whereas longer-term rewards have little effect on risky decision making.

6.2 DISCUSSION OF MAIN FINDINGS

A central finding in the experimental studies described in this thesis is the reduced processing of predictive information, particularly related to aversive outcomes. As explained in the general introduction of this thesis, these characteristics can (partly) explain the development of antisocial behaviour (see Blair, 2013), but it also offers insights considering appropriate legal responding to offences. Importantly, the results support existing evidence that punishment has limited ability to prevent maladaptive behaviour in individuals with psychopathy (Ling & Raine, 2018; see also Jurjako & Malatesti, 2016), including future offending (Hare, 2003a; Hemphill, Hare, et al., 1998; Leistico et al., 2008). On the other hand, our findings suggest that psychopathic offenders have the ability to adapt their behaviour to environmental contingencies when positive reinforcers with sufficiently high subjective values are used. This highlights the potential of individualised treatment programs using personalised reinforcements to achieve behavioural change in forensic psychiatric settings.

As already outlined in Chapter 3, our findings suggest that such programs should include long-term goals that are, for instance, related to personal development and improved social functioning. However, especially for incarcerated offenders, the attractiveness of rewards and goals increases when they are related to their current environment. This environment, in turn, also depends on treatment stage, as patients will gain more liberties when showing progression, which also implies that treatment goals will become more generalisable to everyday life in later stages of treatment (Willis et al., 2012). As such, the characteristics of the reinforcers used could be adapted to treatment stage, with a focus on more short-term rewards that require less effort earlier in therapy, but longer-term goals to establish persistent change in later treatment stages, which would also be in line with the GLM (Ward, 2002; Ward & Gannon, 2006).

It is important to note that the findings presented in Chapter 3 covered the preferences of the total group of offenders, without distinguishing patient or offence characteristics. As such, we do not know to what extent these findings hold specifically for psychopathic individuals. In community samples, high levels of psychopathic traits have been related to hedonistic goals and values, such as pleasure seeking and material possessions, but also to social dominance (Glenn et al., 2017). Importantly, the findings presented in Chapter 5 suggest that offenders with psychopathy tend to base their decisions on the prospect of short-term attractive outcomes, regardless of the associated risks, whereas longer-term rewards seem to have little effect on risky decision making. These results are important from a clinical point of view as well, as they highlight the need to also consider short-term goals or intermediate reinforcers in forensic treatment of offenders with psychopathy, while being aware of other short-term incentives that may interfere with the therapeutic goals.

Considering the experimental findings (Chapters 4 and 5) in the light of the prominent theoretical frameworks regarding reward and punishment processing in relation to psychopathy, the predictions of these theories could be regarded as somewhat opposing. The RM hypothesis (Gorenstein & Newman, 1980; Hamilton & Newman, 2018; Newman & Baskin-Sommers, 2016) predicts that rewards cause a loss of attention for other contextual information, such as punishment, leading to impaired learning from negative feedback. With respect to instrumental learning, the RM hypothesis can therefore only explain our passive avoidance results in the neutral reward condition, suggesting that its prediction holds exclusively for situations in which the outcomes at stake may not be regarded as being sufficiently attractive. On the other hand, the RM hypothesis could be used to explain the results of the risky decision-making task, where psychopathic offenders often seemed to neglect contextual information concerning magnitude and probability of the outcomes in the face of possible gains.

According to the IES model, disturbances in reinforcement expectancies and stimulus-outcome associations in psychopathic individuals can be modulated by saliency, such as reward level (Blair, 2007; Blair et al., 2004), which would explain our results in the passive avoidance study. Using stimuli that were linked to specific reward or punishment levels, Blair et al. (2004) indeed showed that participants were better able to adapt their responses to the contingencies of high-reward stimuli compared to low-reward stimuli. With respect to the risky decision-making findings, it could be argued that psychopathic offenders' behaviour reflected a compromised representation of within-trial reinforcement expectancies, irrespective of the overarching reward condition. This would be in line with the predictions of the IES model concerning dysfunctional representations of outcomes in the vmPFC in individuals with psychopathy.

Recently, there has been reported neuroscientific evidence for impaired signalling of subjective value in relation to maladaptive decision making in psychopaths (Hosking et al., 2017). Specifically, psychopathic offenders were found to have weaker intrinsic functional connectivity between the nucleus accumbens (NAcc) and vmPFC, while there was stronger subjective value-related activity within the NAcc. Our ERP results reported in Chapter 4 suggest that representation of subjective value in a common neural currency is at least partly intact in psychopathic individuals. However, these results were obtained within a learning context. Our findings of the risky decision-making study (i.e., a non-learning context) described in Chapter 5 could be explained by the findings of Hosking et al. (2017), suggesting that subjective value of reward has differential effects on learning versus decision making in psychopathy.

Support for this differentiation could be found in the underlying structure of psychopathy, particularly pertaining to the distinction between an affective-interpersonal component and an antisocial lifestyle component. It is likely that coding for subjective reward is most strongly related to affective functioning, which is reflected in Factor 1 of the PCL-R. Impairments in associative and instrumental learning also rely on mechanisms captured by Factor 1, specifically regarding deficient affective functioning, whereas risky decision making is a form of aberrant behavioural functioning and thus more strongly related to mechanisms associated with Factor 2. Unfortunately, we were not able to incorporate PCL-R factor scores in our analyses, since factor scores were missing from a number of patient files and leaving out these participants would have critically affected statistical power. Looking at the impact of factor scores in future studies may help to further understand which mechanisms could be responsive to variations in subjective reward value.

6.3 METHODOLOGICAL CONSIDERATIONS

Importantly, attention should be given to possible caveats in our task design and interpretation of our results. First, some caution should be taken in the interpretation of the effects of reward in the passive avoidance study. Although the passive avoidance impairment found in the neutral reward condition was not present in the low and high reward conditions, we did not find an effect of reward value *per se*. However, our findings suggest that reward value does, to a certain extent, facilitate initial learning of contingencies in psychopathic offenders. Further research is needed to capture under which circumstances subjective reward value will positively affect learning and decision making in psychopathy.

Second, there may have been too many parameters in the risky choice task to be able to distinguish the effects of reward. Increased motivation and stress in the original Fairchild et al. (2009) study was operationalised by a standardised laboratory stressor with a monetary incentive, in which frustration and antagonism between the participant and a videotaped opponent was induced. This stress procedure has been found to significantly affect autonomic stress responses (Van Goozen et al., 2000). Our operationalisation of motivation (i.e., reward) required deeper cognitive processing, with information concerning immediate gains and losses as well as longer-term rewards to be processed in parallel. On the other hand, it could be argued that our approach was a realistic reflection of everyday life, in which impulses often have to be suppressed by keeping a relatively better (though longer-term) outcome in mind. Future risk-taking studies using other paradigms with less parameters but the same operationalisation of reward could shed more light on this possibility.

Finally, research suggests that offenders differ greatly in what they experience as particularly punishing (van Ginneken & Hayes, 2016). As implementing a wide array of subjective rewards in non-treatment settings can be difficult, research into how subjective punishment facilitates adaptive behaviour in psychopathic individuals would be another relevant topic for investigation. Importantly, as also outlined in the limitations section of Chapter 4, such research requires thorough consideration of design-related ethical standards as well as those related to the practical and clinical implications, especially when involving participants who fall under the jurisdiction of the criminal justice system.

6.4 CONCLUSION

The work presented in this thesis was aimed at the question whether rewards with sufficient subjective value would be able to reduce learning and decision-making deficits often observed in psychopathic offenders. Although not unequivocal, our results are promising with respect to facilitative effects of rewards for learning new stimulus-outcome associations. Regarding the updating of learned contingencies, it is unclear whether psychopathic offenders would benefit from reward value, since they did not show a reversal-learning deficit in our study. However, irrespective of reward condition, they made less use of (particularly negative) feedback to guide future decisions during reversal learning, suggesting that subjective reward may specifically enhance the learning of new associations. Furthermore, psychopathic offenders did show increased risky decision making, but, possibly also due to task design, no effects of reward were observed. In sum, our data suggest that using rewards with sufficiently high subjective values may promote adaptive behaviour in psychopathic individuals, but further research is needed to investigate which mechanisms should be targeted for behavioural change to occur. Ultimately, both society and offenders themselves would benefit from the stronger embedding of empirical findings into clinical forensic practice. This would facilitate the journey towards a future with personalised therapy programs that can better accommodate individual differences in order to achieve positive behavioural change.

ADDENDUM

References

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Nederlandse samenvatting

Waar denkt u aan bij het horen van de termen 'psychopathie' of 'psychopaat'? In de media worden hiermee meestal koelbloedige moordenaars aangeduid die vaak ook sadistisch zijn en zonder enige vorm van mededogen te werk gaan. Ook in het dagelijks taalgebruik komen de termen nog wel eens voorbij, waarbij dan meestal iemand wordt bedoeld die weinig empathie toont en voornamelijk vanuit eigenbelang handelt. Zoals bij zoveel termen die uit de psychiatrie afkomstig zijn en in populair taalgebruik zijn overgenomen, hebben deze 'betekenissen' wel enige raakvlakken met de daadwerkelijke stoornis, maar is de werkelijkheid genuanceerder en, bovendien, gevarieerder. Vast staat wel dat mensen met psychopathie voor een substantieel deel van ernstige geweldsdelicten verantwoordelijk zijn en het aandeel van deze mensen binnen gevangenissen en andere onderdelen van het justitiële system is vele malen hoger dan in de samenleving als geheel.

Binnen de psychiatrie wordt psychopathie gedefinieerd als een constellatie van persoonlijkheids- en gedragskenmerken die in grofweg twee dimensies zijn te onderscheiden: tekorten in het sociaal-emotioneel functioneren, en een impulsieve, antisociale levensstijl. De meningen over de precieze definitie van psychopathie zijn echter nog steeds verdeeld, maar dat is ook te wijten aan het feit dat de stoornis zoveel uitingen kan hebben en er grote onderlinge verschillen zijn in het niveau waarop men binnen de samenleving functioneert. Dit proefschrift richt zich op een zeer specifieke groep personen met psychopathie, namelijk zij die ernstige (gewelds)delicten hebben gepleegd en in verband hiermee onder forensisch psychiatrische behandeling zijn. De definitie die hierbij gehanteerd wordt is dan ook dezelfde als gangbaar binnen het forensische systeem en is gebaseerd op het model van Robert Hare, die tevens een instrument heeft ontwikkeld om (de ernst van) psychopathie meetbaar te maken: de Psychopathy Checklist-Revised (PCL-R). De persoonlijkheidskenmerken die binnen het model van Hare worden gedefinieerd, hebben betrekking op emotionele en interpersoonlijke tekorten, zoals een beperkte emotionele belevingswereld, een oppervlakkige charme ('gladheid'), pathologisch liegen, manipulatief gedrag, en een gebrek aan empathie en schuldgevoelens. Gedragskenmerken die binnen dit model worden genoemd zijn onder andere impulsiviteit, een sterke behoefte aan prikkels, een gebrek aan lange-termijn doelen, reeds op jonge leeftijd aanwezige gedragsproblemen en aanrakingen met justitie, en een breed spectrum aan criminele activiteiten. Psychopathie vertoont overlap met de antisociale persoonlijkheidsstoornis, maar dat is met name op de gedragsdimensie, en minder op het persoonlijkheidsvlak. Bovendien is er bewijs dat de processen die ten grondslag liggen aan maladaptief gedrag bij psychopathie verschillen van die bij non-psychopathische antisociale persoonlijkheidsstructuren.

Naast de hierboven genoemde kenmerken van psychopathie, worden bij mensen met psychopathie vaak beperkingen gezien in cognitieve mechanismen die tevens betrokken zijn bij (sociaal) leren, zoals het leren van feedback en het voorspellen van aversieve uitkomsten (zoals straf) op basis van eerdere ervaringen. Juist doordat de stoornis zo gecompliceerd is en maatschappelijk veel teweegbrengt, is zowel fundamenteel als toegepast onderzoek nodig om interventies te kunnen ontwerpen die specifiek gericht zijn op psychopathische geweldplegers. Van belang hierbij is dat juridische systemen traditioneel over het algemeen gericht zijn op straffen, waarbij gevangenisstraf primair functioneert als vergelding van leed voor slachtoffers en maatschappij, ter bescherming van de samenleving, en ter ontmoediging van toekomstige delicten. Wanneer iemand echter na een periode van detentie terugkeert in de maatschappij, dient er mede daaraan voorafgaand voldoende aandacht te zijn voor rehabilitatie en gedragsverandering om te voorkomen dat iemand terugvalt in crimineel gedrag.

Bij de gangbare interventies gericht op gedragsverandering, zowel in forensische als non-forensische populaties, staat bekrachtiging van gewenst gedrag vaak centraal. Dit houdt in dat gewenst gedrag positieve consequenties voor het individu heeft (en hiermee beloond wordt), en dat ongewenst gedrag het missen van deze beloning (en hiermee indirect een negatieve consequentie) tot gevolg heeft. Gezien de grote individuele verschillen in behandelrespons, alsmede de lage behandelrespons en hoge recidivecijfers bij patiënten met psychopathie, is het van belang om bekrachtigers te vinden die voor individuele patiënten relevant zijn. Deze individu-gerichte benadering staat centraal in de studies die in dit proefschrift worden beschreven, waarbij ik mij heb gericht op individuele beloningsvoorkeuren en deze voorkeuren heb meegenomen bij mijn onderzoek naar hoe patiënten met psychopathie leren van feedback en beslissingen nemen op basis van voorspellende informatie.

In hoofdstuk 2 beschrijf ik een overzicht van de literatuur gericht op aversief conditioneren, instrumenteel leren en het omgaan met risico tijdens het nemen van beslissingen bij patiënten met psychopathie. Uit studies gericht op aversief conditioneren blijkt dat psychopathie geassocieerd is met een verminderde respons op aversieve *cues*. In deze studies werd gebruik gemaakt van bijvoorbeeld (lichte) elektrische schokken, vervelende auditieve prikkels, of sociale afwijzing, waarbij patiënten met psychopathie minder goed in staat waren om van herhaaldelijke aanrakingen met deze aversieve prikkels te leren dan een controlegroep. Zij bleven bijvoorbeeld langer dezelfde respons geven die tot deze aversieve uitkomst leidde, waardoor onderzoekers ook de link hebben gelegd met een verminderde gevoeligheid voor straf en de hoge recidivecijfers binnen deze groep.

Daarnaast blijkt uit de literatuur dat psychopathie geassocieerd is met beperkingen in *passive avoidance learning*. Bij passive avoidance learning leert iemand door middel van *trial-and-error* op welke stimuli gereageerd moet worden, en welke stimuli vermeden dienen te worden. Meestal is het dan zo dat reageren op de 'correcte' stimulus een beloning oplevert (bijvoorbeeld het verdienen van punten), en reageren op een 'incorrecte' stimulus heeft straf tot gevolg (bijvoorbeeld verlies van punten). Uit onderzoek blijkt dat patiënten met psychopathie vaker blijven reageren op incorrecte stimuli dan mensen zonder psychopathie wanneer er inderdaad sprake is van zowel beloning als straf binnen de taak. Wanneer er alleen sprake is van straf bij incorrecte responsen, maar geen beloning bij een correcte respons, presteren ze hetzelfde als mensen zonder psychopathie. Dit lijkt erop te wijzen dat er niet primair sprake is van een verstoorde verwerking van aversieve prikkels, maar dat de manier waarop beloning-gerelateerde informatie wordt verwerkt hiermee sterk verband houdt.

Voorts blijkt uit de besproken studies dat patiënten met psychopathie tekorten hebben in hun vermogen om geleerde contingenties te updaten, zoals bij *reversal learning* gevraagd wordt. Tijdens reversal learning worden eerst associaties aangeleerd, waarbij het geven van een correcte respons wordt beloond, en het geven van een incorrecte respons wordt bestraft. Na enige tijd worden deze associaties omgedraaid, waarbij de voorheen beloonde respons voortaan wordt bestraft, en de voorheen bestrafte respons voortaan wordt beloond. Uit onderzoek blijkt dat patiënten met psychopathie moeite hebben om de eerst aangeleerde beloningsgerichte associatie te veranderen, waardoor ze een respons blijven geven die uiteindelijk steeds straf oplevert.

De literatuur is minder eenduidig over de relatie tussen psychopathie en het nemen van risicovolle beslissingen. Hoewel veel studies wijzen op een verhoogde mate van risicovolle beslissingen bij patiënten met psychopathie in vergelijking met een gezonde controlegroep, zijn de bevindingen een stuk minder duidelijk wanneer zij vergeleken worden met patiënten met een antisociale persoonlijkheidsstoornis. Dit suggereert dat verhoogd risicogedrag bij psychopathie primair gerelateerd is aan de gedragsmatige aspecten van de stoornis, en dat de persoonlijkheidskenmerken die aan de kern van psychopathie liggen, met name de kenmerken die betrekking hebben op de emotionele informatieverwerking, minder invloed hebben op risicogedrag.

Een belangrijke factor die in veel van deze studies niet is meegenomen, is hoe de beloningen en straffen (die meestal de vorm hadden van te verdienen punten of kleine geldbedragen) subjectief werden gewaardeerd door de deelnemers aan deze onderzoeken. Er zijn echter ook nog geen studies gedaan naar welke soorten beloningen als aantrekkelijk worden beschouwd door plegers van ernstige delicten, waaronder zij met psychopathie.

In hoofdstuk 3 wordt dit onderwerp benaderd met een exploratieve studie bij patiënten die onder forensisch-psychiatrische behandeling zijn. Zowel patiënten uit een gesloten (TBS) als ambulante behandelsetting hebben aan deze studie deelgenomen. Hierbij werd gebruik gemaakt van een combinatie van kwalitatieve en kwantitatieve onderzoeksmethoden, een techniek genaamd *concept mapping*. In focusgroepen met patiënten werden items gegenereerd die door henzelf als belonend werden ervaren. Daarna werden al deze items individueel door patiënten gewaardeerd en gesorteerd in groepjes van bij elkaar passende items. Op deze data werden uiteindelijk kwantitatieve analysemethoden toegepast om tot een aantal hoofdcategorieën van beloningen, de dimensies waarlangs ze variëren, en hun relatieve waarden te komen.

We vonden dat beide groepen patiënten beloningen die meer inzet of moeite kosten als aantrekkelijker beoordeelden dan beloningen die weinig moeite kosten. Beloningen die veel inzet kosten waren bijvoorbeeld beloningen gerelateerd aan autonomie, kwaliteit van sociaal functioneren, of persoonlijke ontwikkeling. Beloningen die weinig moeite kosten waren bijvoorbeeld gerelateerd aan middelengebruik, materiële goederen, en ontspannende of juist stimulerende ervaringen. Bij TBS-patiënten werden beloningen met name gewaardeerd wanneer deze betrekking hadden op hun directe omgeving, wat hiermee ook implicaties heeft voor de behandelfase (met meer of minder vrijheden) waarin een patiënt op dat moment verkeert. Bij ambulante patiënten werden beloningen met hogere waarden vaak geassocieerd met lagere niveaus van *arousal* ('opwinding'). Ondanks dat deze bevindingen overeenkomen met de beloningsvoorkeuren van gezonde individuen, lijken ze enigszins contra intuïtief in vergelijking met het 'snelle geld' en de hedonistische doelen die vaak met crimineel gedrag geassocieerd zijn, maar ook in vergelijking met wat is gevonden in relatie tot psychopathie in de algemene populatie. Sociaal wenselijke antwoorden en de gemengde samenstelling van onze steekproeven met betrekking tot delict-type en psychopathologie hebben mogelijk bijgedragen aan deze discrepantie.

In hoofdstuk 4 en 5 zijn de bevindingen van deze studie gebruikt in twee experimentele taken die gericht zijn op instrumenteel leren en het nemen van risicovolle beslissingen. We waren specifiek geïnteresseerd in de vraag of de subjectieve waarde van 'natuurlijke' beloningen, die aangepast waren aan de subjectieve voorkeuren van iedere individuele deelnemer, meer invloed zouden hebben op de prestaties van patiënten met psychopathie in deze taken dan de meer gebruikelijke experimentele beloningen en straffen (zoals het verdienen van punten). We vergeleken in deze studies TBS-gestelden met psychopathie, TBS-gestelden zonder psychopathie, en een gezonde controlegroep. Hierbij beoordeelden de deelnemers eerst een aantal beloningen die ze met hun prestatie op de experimentele taken zouden kunnen verdienen. Ze voerden deze taken vervolgens onder drie verschillende condities uit: eenmaal voor alleen punten, eenmaal voor de door hen laagst gewaardeerde beloning, en eenmaal voor de hoogst gewaardeerde beloning. De te verdienen beloningen varieerden dus tussen de deelnemers.

In de studie die in hoofdstuk 4 is beschreven, voerden de deelnemers een taak uit waarmee zowel passive avoidance learning als reversal learning werd onderzocht. Hieruit bleek dat patiënten met psychopathie, vergeleken met de andere twee groepen, inderdaad tekorten laten zien in passive avoidance learning wanneer er in de taak alleen punten kunnen worden verdiend of verloren. Dit is in overeenstemming met wat er in de literatuur over psychopathie en passive avoidance learning wordt beschreven. Daarnaast waren ze in die conditie minder goed in staat om positieve feedback te gebruiken voor toekomstige beslissingen. Er waren echter geen groepsverschillen in prestatie wanneer er 'echte', natuurlijke beloningen op het spel stonden. Uit gemeten hersenactiviteit door middel van *event-related potentials* bleek dan ook dat negatieve feedback in alle groepen een sterkere respons in het brein tot gevolg had wanneer een beloning met hoge subjectieve waarde op het spel stond in vergelijking met de twee andere condities (lage subjectieve waarde en alleen punten). Met andere woorden: de subjectieve waarde die door de deelnemers aan de beloningen was toegekend, werd ook als zodanig door het brein vertaald. In deze studie werd ook onderzocht of verschillen in beloningswaarde invloed zouden hebben op de prestatie tijdens reversal learning. Er kwamen echter geen effecten van groep, noch van beloningswaarde naar voren. Wel was er hierbij een meer algemeen tekort in het verwerken van negatieve feedback bij patiënten met psychopathie; zij waren minder goed in staat hun gedrag direct aan te passen op basis van negatieve feedback, al leidde dit dus niet tot een lager overall niveau van reversal learning dan bij de andere groepen.

In de studie die in hoofdstuk 5 is beschreven, deden dezelfde drie groepen deelnemers een taak gericht op het nemen van risicovolle beslissingen. Hierbij kregen ze steeds de keuze uit twee varianten van 'het Rad van Fortuin': een veilige optie en een risicovolle optie. De veilige optie gaf altijd 50% kans op winst en verlies van hetzelfde lage aantal (10) punten, en had dan ook altijd een *expected value* van 0. Expected value wordt hier gedefinieerd wordt als de som van alle verwachte uitkomsten vermenigvuldigd met hun waarschijnlijkheden. De risicovolle optie varieerde in het aantal te winnen en te verliezen punten (20 vs. 80), alsmede in de waarschijnlijkheid van de twee uitkomsten (75% vs. 25%). De expected value van de risicovolle optie varieerde hierdoor van zeer negatief tot zeer positief. Uit deze studie kwamen geen effecten naar voren van subjectieve beloningswaarde op het nemen van risicovolle beslissingen. Wel vonden we dat alle patiënten, maar met name die met psychopathie, meer risicovolle beslissingen namen dan mensen uit de gezonde controlegroep wanneer er in de risicovolle optie een hoog aantal punten te behalen was. Patiënten met psychopathie namen ook meer risicovolle beslissingen dan mensen uit de gezonde controlegroep wanneer er binnen de risicovolle optie een relatief laag aantal punten te behalen viel. Deze neiging van de patiënten om hun beslissingen te baseren op de beschikbaarheid van puntenwinst was onafhankelijk van de waarschijnlijkheid van deze uitkomsten.

Deze resultaten wijzen op zowel verhoogd beloning-zoekend gedrag als een verminderde gevoeligheid voor straf in onze steekproef van patiënten. Daarnaast leidden grote winsten met lage waarschijnlijkheid ook tot een verhoogde mate van risicovolle beslissingen in patiënten met psychopathie in vergelijking met patiënten zonder psychopathie wanneer de expected values van de twee opties relatief gelijk waren en de opties daardoor lastig in een oogopslag te vergelijken waren. Wanneer we de centrale onderzoeksvragen in ogenschouw nemen, suggereren deze bevindingen dat patiënten met psychopathie geleid worden door het vooruitzicht van aantrekkelijke korte-termijn uitkomsten, ongeacht de ermee geassocieerde risico's, terwijl langere-termijn beloningen weinig effect op risicovolle beslissingen lijken te hebben.

Samengevat kan uit dit proefschrift geconcludeerd worden dat het gebruik van subjectieve beloningen het leren van nieuwe associaties bij patiënten met psychopathie kan verbeteren, en daarmee het leren van nieuwe responsen, maar dit werd niet gevonden voor het aanpassen van deze eenmaal geleerde associaties. Verder lijken patiënten met psychopathie geneigd om risicovolle beslissingen te nemen en hierbij primair gestuurd te worden door uitkomsten op de korte termijn, waarbij kans-gerelateerde predictieve informatie en langere-termijn uitkomsten (zoals beloningen voor de algehele prestatie) een beperkte rol lijken te spelen. Deze bevindingen wijzen erop dat het gebruik van beloningen met voldoende subjectieve waarde adaptief gedrag in mensen met psychopathie zou kunnen faciliteren, maar er is meer onderzoek nodig naar de mechanismen die het sterkst betrokken zijn bij zulke gedragsverandering. Vervolgstudies naar de invloed van subjectieve beloningen op gedragsadaptatie bij psychopathie zouden zich dan meer specifiek op deze mechanismen kunnen richten. Uiteindelijk zouden zowel de maatschappij als patiënten zelf profiteren van een sterkere inbedding van empirische bevindingen in de klinische forensische praktijk, waarmee een toekomst met verder ontwikkelde gepersonaliseerde therapieprogramma's, gericht op duurzame positieve gedragsverandering en rekening houdend met individuele verschillen, dichterbij zou kunnen komen.

Curriculum Vitae

Johanna Glimmerveen was born on September 8, 1979 in the city of Uithoorn. In 2006, she obtained her master's degree in Biological and Cognitive Psychology at Erasmus University Rotterdam, where she stayed for about two years to fulfil several teaching and research positions. She then started to work as a teacher at the Developmental Psychology department of Tilburg University, where she also obtained her University Teaching Qualification. After three years, she started her PhD project at the Neuropsychology and Rehabilitation Psychology department at Radboud University Nijmegen, also being affiliated to the Donders Institute for Brain, Cognition and Behaviour. While finishing the writing of her thesis, she worked as a psychologist at the Institute for Neuropsychiatry at Vincent van Gogh, Venray. Currently, she works as a student advisor and pre-master's programme coordinator at the Artificial Intelligence department of Radboud University.

Dankwoord

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Research data management

This research followed the applicable laws and ethical guidelines. Research Data Management was conducted according to the FAIR principles. The paragraphs below specify in detail how this was achieved.

ETHICS

This thesis is based on the results of human studies, which were conducted in accordance with the principles of the Declaration of Helsinki. The Ethical Committee of the faculty of Social Sciences (ECSS) has given a positive advice to conduct these studies to the Dean of the Faculty, who formally approved the conduct of these studies (Chapter 3: ECG2012-3008-044; Chapters 4 and 5: ECSW2016-2501-373). This research is supported by a VENI grant (451-15-014) from the Netherlands Organisation for Scientific Research (NWO), awarded to Inti A. Brazil.

FINDABLE ACCESSIBLE

The table below details where the data and research documentation for the chapters reporting empirical findings can be found on the Donders Repository (DR). All data are archived as a Data Sharing Collection and remain available for at least 10 years after termination of the studies.

Chapter	DSC	DSC License
3	https://doi.org/10.34973/a2yh-k268	CC-BY-NC-ND-4.0
4	https://doi.org/10.34973/qqr5-9s48	CC-BY-NC-ND-4.0
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DSC = Data Sharing Collection; Informed consent was obtained on paper following the Centre procedure. The forms are archived in the central archive of the Centre for 10 years after termination of the studies.

Interoperable, Reusable

The DSC contains the raw data in their original as well as their pre-processed form (on which the reported analyses have been conducted). The appropriate pre-processing and statistical analysis scripts are also provided. Results are reproducible by providing a description of the experimental setup (including experiment files), raw data, and analysis scripts.

Privacy

The privacy of the participants in this thesis has been warranted using random individual subject codes. A pseudonymization key linked this random code with the personal data. This pseudonymization key was stored on a network drive that was only accessible to members of the project who needed access to it because of their role within the project. The pseudonymization key was stored separately from the research data. The pseudonymization keys have been destroyed after finalization of these projects. All data are not identifiable and shared without restrictions.

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For a successful research Institute, it is vital to train the next generation of young scientists. To achieve this goal, the Donders Institute for Brain, Cognition and Behaviour established the Donders Graduate School for Cognitive Neuroscience (DGCN), which was officially recognised as a national graduate school in 2009. The Graduate School covers training at both Master's and PhD level and provides an excellent educational context fully aligned with the research programme of the Donders Institute.

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