A Neurophysiological Dissociation Between Monitoring One's Own and Others' Actions in Psychopathy

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Background: Psychopathy is a severe personality disorder often leading to violent and disruptive antisocial behavior. Efficient and proper social behavior crucially relies on monitoring of one's own as well as others' actions, but the link between antisocial behavior in psychopathy and action monitoring in a social context has never been investigated.

Methods: Event-related potentials were used to disentangle monitoring of one's own and others' correct and incorrect actions in psychopathic subjects ($n = 18$) and matched healthy control subjects ($n = 18$). The error-related negativity (ERN) was investigated following own and other's responses in a social flanker task.

Results: Although both groups showed similar event-related potentials in response to own actions, amplitudes after the observation of others' action-outcome were greatly reduced in psychopathy. More specifically, the latter was not unique to observed errors, because the psychopathic group also showed reduced brain potentials after the observation of correct responses. In contrast, earlier processing of observed actions in the motor system, as indicated by the lateralized readiness potential, was unimpaired.

Conclusions: Monitoring of own behavior is not affected in psychopathy, whereas processing of the outcome of others' actions is disturbed. Specifically, although psychopathic individuals do not have a problem with initial processing of the actions of others, they have problems with deeper analyses of the consequences of the observed action, possibility related to the reward value of the action. These results suggest that aspects of action monitoring in psychopathy are disturbed in social contexts and possibly play a central role in the acquisition of abnormal social behavior.

Key Words: Action monitoring, error observation, error-related negativity (ERN), lateralized readiness potential, observed error-related negativity (oERN), psychopathy

Psychopathy is a personality disorder characterized by distortions in emotional processing and antisocial behavior (1). Psychopathic individuals are known to show an almost total lack of empathy, guilt, or remorse combined with antisocial behavior fueled by impulsivity, poor planning skills, and frequently criminal intents. In clinical practice, psychopathy is often labeled as highly resistant to treatment. The antisocial lifestyle of psychopathic offenders indicates that they have experienced severe problems in acquiring social norms and rules (2). One way of acquiring social norms and rules and appropriate behavior is by observing others. More specifically, we learn by monitoring other individuals' performance and imitating behavior leading to desired outcomes, while avoiding others' behavior ending in undesired outcomes (3). This implies that we need to be susceptible to errors committed by others to learn appropriately.

Research on performance monitoring has predominantly focused on processing of one's own errors. The detection of error commission by oneself is associated with the generation of the error-related negativity (rERN) (4–6), an event-related brain potential (ERP) in posterior medial frontal cortex (7). This component has been linked to the processing of the reward value of the action and subsequent behavioral adjustments (8,9). Previous results on monitoring of own actions in psychopathy are mixed, although there seems to be a dissociation between studies using students with psychopathic traits (10,11) and actual psychopathic offenders (12,13). Although the former studies reported reduced error-related negativity (ERNs) in tasks consisting of affectively neutral stimuli, these deficiencies were not demonstrated in diagnosed psychopathy.

More recently, investigations of ERPs during action monitoring in social contexts have been initiated, focusing on two aspects of processing others' actions. First, components related to initial processing of the action. Studies on motor resonance have shown that the observation of movements activates brain systems in the motor cortices similar to those activated by the self-generation of the same actions (14–16). Motor activation can be measured with the lateralized readiness potential (LRP), a marker for automatic motor preparation, visible before the execution of a movement over the contralateral hemisphere. During observation, the development of the LRP seems to be susceptible to the correctness of the observed response. The LRPs for both correct and incorrect responses start to develop in the same direction before the onset of the observed response ("anticipation") and continue to increase in amplitude after the observation of a correct response but will decrease if the observed response was incorrect (17). Thus, motor resonance during action observation extends further than only making copies of observed movements by showing differential activation susceptible to response correctness, a function that might play an important role in observational learning (18).

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The second component identified during observation of others' actions is a later ERN-like component, which is generated when participants observe other individuals commit errors, the so-called "observed ERN" (oERN) (17,19,20). The source of the oERN has been localized in the same medial frontal areas as the traditional rERN, suggesting that both waveforms are a reflection of the same underlying mechanism (17). This was confirmed by functional magnetic resonance imaging data showing that both the detection of own and others' errors activate the same networks (21,22).

The aim of the present study is to investigate error-monitoring during the observation of actions in psychopathy. We hypothesized that deeper processing of others' erroneous outcomes is compromised in psychopathy, made evident by reduced oERN amplitudes in the psychopathic group. We expected, in contrast and in line with earlier research, normal ERNs to own errors, reflecting unaffected monitoring of own actions (13). Additionally, we investigated the onset and course of the LRP as a marker for differential involuntary motor activation during the commission and observation of correct and erroneous responses.

Methods and Materials

Subjects

The psychopathic group was recruited from the in- and outpatient population of the Pompestichting Forensic Psychiatric Institute in The Netherlands, a treatment facility for mentally disordered offenders. Stay in the clinic is designed to resemble everyday life outside of detention, requiring patients to follow treatment, schooling, work, practice sports, and the like.

Patients were selected on the basis of available information about clinical status and prior history. An estimation of the IQ level of each participant was obtained with the Dutch version of the National Adult Reading Test (23) (Table 1). The patient group consisted of 18 male violent offenders diagnosed with psychopathy, as assessed with the Hare Psychopathy Checklist–Revised (PCL-R) (1). Patients scoring above the cutoff score (PCL $>$ 25), according to European standards, were considered suitable for inclusion in the psychopathic group (24,25).

The control group consisted of 18 healthy male volunteers without criminal records and no history of psychiatric disorders recruited by use of advertisements. They were matched with the patients on age and IQ. The Dutch version of MINI Psychiatric Interview (26) and the Structured Clinical Interview for DSM-IV Axis II Personality Disorders (27) were used in both groups to determine compliance with the inclusion criteria. Exclusion criteria included all major Axis-I and Axis-II disorders, somatic disorders, any form of (self-)reported or documented head trauma, chronic use of intoxicating substances, use of psychotropic medication up to 5 days before the test session, pretest use of alcohol or tobacco, and for the patient group, a positive result on any of the unannounced randomly administered urinal drug tests. All assessments were conducted by trained psychologists on the basis of interviews with the participants and on available information from the clinical files of each patient.

The protocol was approved by the local medical ethics committee. All participants received written information about the experiment, gave written informed consent, and received a financial reward.

Table 1. Demographic Data of Control and Psychopathic Groups

	Control Group (n = 18)	Psychopathic Group (n = 18)
Age	36 (8)	39 (8)
IQ	101 (6)	98 (9)
PCL-R	—	31 (3)

No significant group differences. Means are reported with SDs between parentheses.

PCL-R, Hare Psychopathy Checklist–Revised.

Task and Procedure

All clinical assessments were conducted during a screening session. In a second session, behavioral and electroencephalography data were collected during the execution of a modified version of the arrowhead Eriksen flanker task (17,28). Participants were seated across the table facing the experimenter. A light-emitting diode (LED) device was situated at the center of the table with a custom-made joystick device in front of it at a distance of approximately 25 cm on both the right and the left side of the LED device. The LED device had two display sides, one facing the participant, and the other toward the actor at a viewing distance of approximately 75 cm. Stimuli consisted of arrowheads pointing to the left or to the right in four arrays (<<<<<,>>>>>,<<><<,>><>>) occurring randomly with equal probabilities.

The experiment was divided into two conditions. In the first condition (Perform condition), participants were instructed to respond as quickly and accurately as possible by using their thumb to push the lever on the joystick in the same direction indicated by the arrowhead in the center of the array displayed.

In the second condition (Observe condition), participants received instructions to observe the actor (experimenter) while he performed the same flanker task and to count and report the amount of errors committed by the actor after each block. The counting provided an accuracy measure for the engagement of the observer in the task. Only the center arrowhead was displayed to the observers, to ensure that error detection was not compromised by the presence of flankers. Observers were able to see both the LED device and the actor's responses without moving their eyes and were instructed to stay focused on the fixation point and to identify responses without making eye movements (cf. van Schie *et al.*) (17). All subjects participated in the Perform condition first, establishing their understanding of the task, before participating in the Observe condition (17,21,22).

The experimental conditions started with a practice block of 40 trials. Each condition consisted of six blocks of 100 trials. A trial started with the presentation of a fixation point presented at the center of the LED device for 200 msec, followed by a stimulus-free interval of 200 msec. In succession, one of the four stimulus arrays was displayed for 300 msec followed by a response window of 900 msec. An error-check was added to the task to ensure participants committed enough errors. After 15 consecutive correct trials an array of hash marks (#####) was presented, indicating that the performer had to increase his response speed. In the observe condition, subjects were instructed to write down the amount of errors they had observed at the end of each block.

Data Acquisition

Scalp potentials were collected with 27 active electrodes (ActiCap, Brain Products, Munich, Germany) arranged according to an extended version of the 10–20 system. All electrodes were referenced to the left ear during recording and were re-referenced to the linked earlobes during analysis. Electro-oculography recordings were also collected for vertical and horizontal eye movements by placing electrodes above and below the left eye and at the outer canthi. The recorded signals were digitized with a sampling rate of 500 Hz with a QuickAmp amplifier (Brain Products) and filtered