



Contents lists available at ScienceDirect

Personality and Individual Differences

journal homepage: www.elsevier.com/locate/paid



Short Communication

Closing one's eyes to reality: Evidence for a dopaminergic basis of Psychoticism from spontaneous eye blink rates

Lorenza S. Colzato^{a,*}, Heleen A. Slagter^b, Wery P.M. van den Wildenberg^c, Bernhard Hommel^a

^aLeiden University, Department of Psychology, Cognitive Psychology Unit, Institute for Psychological Research and Leiden Institute for Brain and Cognition, Postbus 9555, 2300 RB Leiden, The Netherlands

^bUniversity of Wisconsin, Waisman Laboratory for Brain Imaging and Behavior, Madison, USA

^cUniversity of Amsterdam, Amsterdam Center for the Study of Adaptive Control in Brain and Behaviour (ACaCia), Psychology Department, Amsterdam, The Netherlands

ARTICLE INFO

Article history:

Received 22 July 2008

Received in revised form 13 October 2008

Accepted 16 October 2008

Available online 28 November 2008

Keywords:

Psychoticism

Dopamine

Spontaneous eye blink

Striatum

ABSTRACT

We tested the idea that Psychoticism, a major personality dimension, is rooted in individual differences in dopamine functioning. To this end, we related the spontaneous eye blink rate (EBR), a marker of striatal dopaminergic activity, to scores in the Eysenck Personality Questionnaire Revised Short Scale (EPQ-RSS) in adult healthy subjects. The level of Psychoticism was indeed predicted by EBR: people with higher scores on the Psychoticism scale showed higher EBRs. No relationship was found between EBR and other major personality dimensions, such as Neuroticism, Extraversion, or social conformity. These findings point to a central role of dopamine in Psychoticism.

© 2008 Elsevier Ltd. All rights reserved.

1. Introduction

In 1952, Eysenck proposed, in addition to Neuroticism and Introversion–Extraversion, a third major dimension of personality, called Psychoticism (Eysenck, 1952). These three major personality dimensions are found in different cultures and across race (Eysenck & Eysenck, 1983), which according to Eysenck and Eysenck (1985) implies a shared neurobiological basis. With regard to Psychoticism, Lester (1989) suggested individual variability in dopamine (DA) functioning as the neurochemical basis.

This idea is in line with prior work that has linked DA functioning to psychosis in humans. For example, the DA hypothesis of schizophrenia, which has received a lot of empirical support, attributes symptoms of schizophrenia, like psychosis, to a disturbed and hyperactive dopaminergic system (for a review, see Davis, Kahn, Ko, & Davidson, 1991). In addition, Seeman et al. (2006) proposed that psychoses caused by amphetamine, phencyclidine, steroids, ethanol, and brain lesions, all lead to dopamine hypersensitivity and increase the high-affinity states of dopamine D2 receptors. Evidence for the idea that DA functioning represents the neurobiological basis for the Psychoticism personality dimension comes from Gray, Pickering, and Gray (1994). They found a significant correlation between DA/D2 binding in the basal ganglia

and Psychoticism, in the absence of such an association with other personality dimensions, including Extraversion, Neuroticism and Lie (a measure of social conformity). Unfortunately, the results from this study must be considered preliminary because of its small sample size ($n = 9$). Further evidence is provided by studies that point to an association between Psychoticism and activation patterns in the striatum, a subcortical structure of the brain innervated mainly by DA/D2 receptors (Camps, Kelly, & Palacios, 1990). In particular, significant correlations were observed between Psychoticism scores and resting-state fMRI signals in putamen and global pallidus (Kumari, Ffytche, Williams, & Gray, 2004), perfusion in the basal ganglia and thalamus (O'Gorman et al., 2006), and activation states in putamen and parahippocampal gyrus (Kumari, Antonova, & Geyer, 2008).

The present study sought to provide converging evidence for the hypothesis that individual difference in DA functioning represents a neurobiological substratum for Psychoticism (Lester, 1989). Our measure of DA functioning was the spontaneous eye blink rate (EBR), a well established clinical indicator (Shukla, 1985) thought to index dopamine production in the striatum (Blin, Masson, Azu-lay, Fondarai, & Serratrice, 1990; Karson, 1983; Kleven & Koek, 1996; Taylor et al., 1999). The idea that EBR reflects striatal dopaminergic functioning is first of all supported by clinical observations in patients with DA-related dysfunctions. For example, EBRs are elevated in schizophrenic patients, who show increased dopaminergic activity in the striatum (Freed, 1980), but reduced in recreational cocaine users (Colzato, van den Wildenberg, & Hommel, 2008a)

* Corresponding author.

E-mail address: colzato@fsw.leidenuniv.nl (L.S. Colzato).

and Parkinson's patients (Deuschel & Goddemeier, 1998)—two populations suffering from severe losses of nigrostriatal dopaminergic cells. In addition, pharmacological studies in nonhuman primates have shown that DA agonists and antagonists increase and decrease EBRs, respectively (Kleven & Koek, 1996). Further, albeit more indirect, evidence for the idea that EBR reflects dopaminergic activity comes from studies showing that EBR reliably predicts behavioral performance on cognitive tasks that have been associated with dopaminergic functioning (e.g., Colzato, Slagter, Spapé, & Hommel, 2008; Colzato, van den Wildenberg, & Hommel, submitted for publication b; Colzato, van Wouwe, & Hommel, 2007; Dreisbach et al., 2005). Taken altogether, the available evidence suggests that EBR provides a reliable measure of dopaminergic functioning.

To examine the hypothesis that Psychoticism is associated with individual DA levels (Lester, 1989), we investigated whether Psychoticism can be predicted from spontaneous EBR in healthy individuals. The Eysenck Personality Questionnaire Revised Short Scale (EPQ-RSS) was used to measure Psychoticism as well as several other personality traits, including Neuroticism, Extraversion and Lie (Eysenck, 1992; Eysenck & Eysenck, 1991). Based on previous work (Gray et al., 1994; Kumari et al., 2004, 2008; Lester, 1989; O'Gorman et al., 2006), we expected to find a positive correlation between Psychoticism and EBR, that is, participants with higher EBR (reflecting higher basal dopaminergic activity) should show higher Psychoticism scores.

2. Materials and methods

2.1. Participants

Twenty-eight young healthy adults served as participants for partial fulfilment of course credit or a financial reward (6 €). The sample was drawn from adults in the Leiden metropolitan area, who were recruited via notices posted on community bulletin boards and by word of mouth.

Following Colzato, Kool, and Hommel (2008), participants were selected by means of a phone interview by a research assistant with the Mini International Neuropsychiatric Interview (M.I.N.I.; Lecrubier et al., 1997), a diagnostic tool that screens for several psychiatric disorders including, among others, schizophrenia, depression, mania, and obsessive–compulsive disorder. Individuals with a history of psychopathology and/or under medication were excluded from participation.

Participants were asked to refrain from all caffeine containing foods and beverages for 12 h prior to the experiment. They were also instructed not to consume alcohol on the night before the experimental session and to have a normal night of sleep (cf. Colzato et al., 2008, 2007). Subjects' compliance with the instruction was encouraged by taking a saliva sample (not further analyzed) at the beginning of the session (cf., Colzato, Fagioli, Erasmus, & Hommel, 2005). Also, given that spontaneous EBR is supposed to be stable during daytime but generally increases in the evening (8:30 p.m., as reported by Barbato et al., 2000), data were never collected after 5 p.m.

Demographic statistics are provided in Table 1. Written informed consent was obtained from all participants after a detailed explanation of the study procedures. The study was approved by the institutional review board (Leiden University, Institute for Psychological Research).

2.2. Procedure and design

Participants filled out the EPQ-RSS (Eysenck & Eysenck, 1991) before the eye blink data were recorded.

Table 1

Demographic characteristics. Standard errors are presented within parentheses.

Sample	
N (M:F)	28 (14:14)
Age (years)	20.7 (1.9)
Psychoticism	2.9 (1.5)
Extraversion	9.0 (2.4)
Neuroticism	4.7 (3.3)
Lie	5.4 (2.5)

Personality traits measured by means of the Eysenck Personality Questionnaire Revised Short Scale.

2.3. Eysenck Personality Questionnaire Revised Short Scale (EPQ-RSS)

The EPQ-RSS measures four major personality dimensions: Psychoticism, Extraversion, Neuroticism and Lie. It contains 48 statements (12 per dimension) requiring a 'yes' or a 'no' answer, and is designed for people aged 16 and older (Eysenck & Eysenck, 1991; Gregory, 2004). The higher one scores on the 12 items of a given personality scale, the more one tends to exhibit that personality trait.

2.4. Eye blink rate

A BioSemi ActiveTwo system (BioSemi Inc., Amsterdam, The Netherlands) was used to record the EBR. Eye blinks and movements were recorded with two vertical (one upper, one lower) and two horizontal (one left, one right) Ag–AgCl electrodes, for 6-min eyes-open segments under resting conditions (cf. Colzato et al., 2008, 2007). The vertical electrooculogram (EOG), which records the voltage difference between two electrodes placed above and below the left eye, was used to detect eye blinks. The horizontal EOG, which records the voltage difference between electrodes placed lateral to the external canthi, was used to measure horizontal eye movements. Participants were comfortably sitting in front of a blank poster with a fixation cross in the centre, located about 1 m from the participant. They were alone in the room and were asked to look at the fixation cross in a relaxed state.

2.5. Statistical analysis

To test our main hypothesis that dopamine modulates Psychoticism, but not any of the other major personality dimensions, we ran four Pearson correlation tests examining the association between EBR and Psychoticism, Extraversion, Neuroticism and Lie. A significance level of $p < .05$ was adopted for all statistical tests.

3. Results

3.1. EPQ-RSS

Our sample of participants had Psychoticism scores ranging from 1 to 7 (MEAN = 2.9; standard deviation (SD) = 1.5), and thus showed a wide range of Psychoticism levels.

3.2. Eye blink rate measurement

EOG data were analyzed using Brain Vision Analyzer (Brain Products™ GmbH, Munich, Germany). An eye blink was defined as a voltage change of 100 μ V in a time interval of 500 ms (Colzato et al., 2007, 2008). Our sample of participants had EBRs ranging from 2.4 to 39.2 per minute (standard deviation (SD) = 10.5), and thus represented a wide range of tonic dopaminergic functioning.

As predicted, EBR correlated positively with Psychoticism, $r(28) = .452$, $p = .016$. As can be seen in Fig. 1, individuals with a rel-

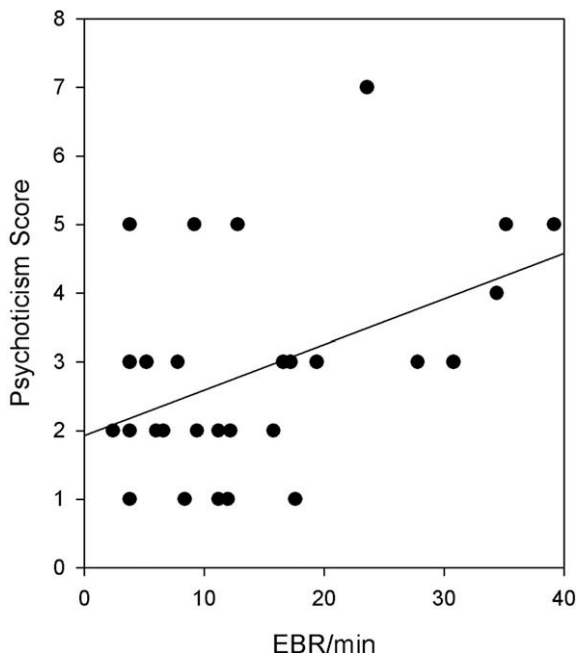


Fig. 1. Relationship between level of Psychoticism and EBR (in minutes). Note that participants with higher EBRs tend to show higher levels of Psychoticism.

atively high EBR generally showed elevated scores on the Psychoticism scale. In contrast, EBR did not correlate significantly with Extraversion, $r(28) = -.26$, $p = .19$, Neuroticism, $r(28) = .16$; $p = .42$ nor with Lie, $r(28) = .05$; $p = .78$. Thus, EBR was selectively associated with Psychoticism.

4. Discussion

Our findings show that the spontaneous EBR, a functional marker of striatal dopaminergic functioning (Blin et al., 1990; Karson, 1983; Kleven & Koek, 1996; Taylor et al., 1999), selectively predicts the level of Psychoticism in a non-clinical sample. As expected, participants with higher EBRs showed higher Psychoticism scores, corroborating the idea that variations in DA functioning represent a neurobiological substratum for the personality dimension Psychoticism (Lester, 1989). These observations fit with the observed correlations between Psychoticism and DA/D2 binding in the left and right basal ganglia (Gray et al., 1994) and activation states in putamen, basal ganglia, thalamus, global pallidus, and parahippocampal gyrus (Kumari et al., 2004, 2008; O'Gorman et al., 2006).

Notably, schizophrenic patients, who exhibit psychotic symptoms, show higher EBRs compared to healthy control subjects (Freed, 1980). This raises the interesting possibility that individual differences in dopaminergic activity represent a continuum with schizophrenia at one end and low Psychoticism scores at the other end. It should be noted that since participants were screened for several psychiatric disorders in the current study, we can rule out an account in terms of pre-existing psychiatric disorders (such as schizophrenia, ADHD, and obsessive compulsive disorder) that have been associated with dopaminergic abnormalities (Davis et al., 1991; Pooley, Fineberg, & Harrison, 2007; Tripp & Wickens, 2007).

Taken together, the current observations provide additional evidence for the idea that Psychoticism is related to activity of the dopaminergic system (Lester, 1989). Clearly, a more systematic investigation in particular of the underlying nature of differences in dopaminergic functioning is necessary. An important pointer to these roots may be the DRD2 TaqIA polymorphism, which affects DA availability in the striatum.

Acknowledgments

This research was supported by VENI grants from the Netherlands Organization for Scientific Research (NWO) to LSC and WPMvdW. We thank Wouter Kool for his enthusiasm and invaluable assistance in recruiting, testing the participants of this study and collecting the data.

References

- Barbato, G., Ficca, G., Muscettola, G., Fichelle, M., Beatrice, M., & Rinaldi, F. (2000). Diurnal variation in spontaneous eye-blink rate. *Psychiatry Research*, 93, 145–151.
- Blin, O., Masson, G., Azulay, J. P., Fondarai, J., & Serratrice, G. (1990). Apomorphine-induced blinking and yawning in healthy volunteers. *British Journal of Clinical Pharmacology*, 30, 769–773.
- Camps, M., Kelly, P., & Palacios, J. (1990). Autoradiographic localization of dopamine D1 and D2 receptors in the brain of several mammalian species. *Journal of Neural Transmission: General Section*, 80, 105–127.
- Colzato, L. S., Slagter, H. A., Spapé, M. A., & Hommel, B. (2008). Blinks of the eye predict blinks of the mind. *Neuropsychologia*, 46, 3179–3183.
- Colzato, L. S., van den Wildenberg, W., & Hommel, B. (2008a). Reduced spontaneous eye blink rates in recreational cocaine users: Evidence for dopaminergic hypoactivity. *PLoS ONE*, Available from: <<http://dx.plos.org/10.1371/journal.pone.0003461>>.
- Colzato, L. S., van den Wildenberg, W., & Hommel, B. (submitted for publication b). When the eye is quicker than the hand: Evidence for the dopaminergic modulation of inhibitory action control.
- Colzato, L. S., Fagioli, S., Erasmus, V., & Hommel, B. (2005). Caffeine, but not nicotine enhances visual feature binding. *European Journal of Neuroscience*, 21, 591–595.
- Colzato, L. S., Kool, W., & Hommel, B. (2008). Stress modulation of visuomotor binding. *Neuropsychologia*, 46, 1542–1548.
- Colzato, L. S., van Wouwe, N. C., & Hommel, B. (2007). Spontaneous eye-blink rate predicts the strength of visuomotor binding. *Neuropsychologia*, 45, 2387–2392.
- Davis, K., Kahn, R., Ko, G., & Davidson, M. (1991). Dopamine in schizophrenia: A review and reconceptualization. *American Journal of Psychiatry*, 148, 1474–1486.
- Deuschel, G., & Goddemeier, C. (1998). Spontaneous and reflex activity of facial muscles in dystonia, Parkinson's disease and in normal subjects. *Journal of Neurology, Neurosurgery and Psychiatry*, 64, 320–324.
- Dreisbach, G., Müller, J., Goschke, T., Strobel, A., Schulze, K., Lesch, K., et al. (2005). Dopamine and cognitive control: The influence of spontaneous eye-blink rate and dopamine gene polymorphisms on perseveration and distractibility. *Behavioral Neuroscience*, 119, 483–490.
- Eysenck, H. J. (1952). *The scientific study of personality*. London: Routledge and Kegan Paul.
- Eysenck, H. J. (1992). The definition and measurement of Psychoticism. *Personality and Individual Differences*, 13, 757–785.
- Eysenck, H. J., & Eysenck, S. B. G. (1983). Recent advances in the cross-cultural study of personality. In J. N. Butcher & C. D. Spielberger (Eds.), *Advances in personality assessment* (Vol. 2, pp. 41–69). Hillsdale, NJ: Erlbaum.
- Eysenck, H. J., & Eysenck, M. W. (1985). *Personality and individual differences*. New York: Plenum Press.
- Eysenck, H. J., & Eysenck, S. B. G. (1991). *Manual of the Eysenck personality scales (EPS adult)*. London: Hodder and Stoughton.
- Freed, W. (1980). Eye-blink rates and platelet monoamine oxidase activity in chronic schizophrenic patients. *Biological Psychiatry*, 15, 329–332.
- Gray, N. S., Pickering, A. D., & Gray, J. A. (1994). Psychoticism and dopamine D2 binding in the basal ganglia using SPET. *Personality and Individual Differences*, 17, 431–434.
- Gregory, R. J. (2004). *Psychological testing: History, principles, and applications* (4th ed.). Boston, MA: Pearson Education Group, Inc.
- Karson, C. N. (1983). Spontaneous eye-blink rates and dopaminergic systems. *Brain*, 106, 643–653.
- Kleven, M. S., & Koek, W. (1996). Differential effects of direct and indirect dopamine agonists on eye blink rate in cynomolgus monkeys. *Journal of Pharmacology and Experimental Therapeutics*, 279, 1211–1219.
- Kumari, V., Antonova, E., & Geyer, M. A. (2008). Prepulse inhibition and "psychosis-proneness" in healthy individuals: An fMRI study. *European Psychiatry*, 23, 274–280.
- Kumari, V., Ffytche, D. H., Williams, S. C. R., & Gray, J. A. (2004). Personality predicts brain responses to cognitive demands. *Journal of Neuroscience*, 24, 10636–10641.
- Lecrubier, Y., Sheehan, D. V., Weiller, E., Amorim, P., Bonora, I., & Sheehan, K. H. (1997). The Mini-International Neuropsychiatric Interview (M.I.N.I.): A short diagnostic structured interview: Reliability and validity according to the CIDI. *European Psychiatry*, 12, 224–231.
- Lester, D. (1989). A neurotransmitter basis for Eysenck's theory of personality. *Psychological Reports*, 64, 189–190.
- O'Gorman, R. L., Kumari, V., Williams, S. C. R., Zelaya, F. O., Connor, S. E. J., Alsop, D. C., et al. (2006). Personality factors correlate with regional cerebral perfusion. *Neuroimage*, 31, 489–495.

- Pooley, E. C., Fineberg, N., & Harrison, P. J. (2007). The met158 allele of catechol-O-methyltransferase (COMT) is associated with obsessive-compulsive disorder in men: Case-control study and meta-analysis. *Molecular Psychiatry*, 12, 556–561.
- Seeman, P., Schwarz, J., Chen, J. F., Szechtman, H., Perreault, M., et al. (2006). Psychosis pathways converge via D2 high dopamine receptors. *Synapse*, 60, 319–346.
- Shukla, D. (1985). Blink rate as clinical indicator. *Neurology*, 35, 286.
- Taylor, J. R., Elsworth, J. D., Lawrence, M. S., Sladek, J. R., Jr., Roth, R. H., & Redmond, D. E. Jr., (1999). Spontaneous blink rates correlate with dopamine levels in the caudate nucleus of MPTP-treated monkeys. *Experimental Neurology*, 158, 214–220.
- Tripp, G., & Wickens, J.R. (2007). Dopamine transfer deficit: A neurobiological theory of altered reinforcement mechanisms in ADHD. *Journal of Child Psychology and Psychiatry*. doi:10.1111/j.1469-7610.2007.01851.