The neuropsychology of the human reward system : impaired gambling performance in ADHD children and adults with psychopathic tendencies

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SUMMARY

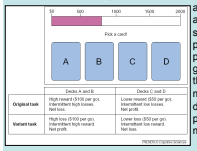
Since the seminal work of the Damasio's group, reward processing has been explored using gambling tasks in which people have to make their decision by choosing between four card decks providing either small but durable rewards or immediate larger rewards but leading to more risky and finally less advantageous outcomes. Here we present evidence of impaired decision-making measured with the gambling task in two neurobehavioral conditions previously suspected of entailing a reward system dysfunction: children with Attention deficit with Hyperactivity (ADHD: N=22), and young adults with psychopathic tendency (N=20), both populations being compared to carefully selected normal controls. In both cases, performance on the gambling task was clearly impaired, with a tendency for both children and adults to prefer less advantageous decks and to fail to improve their behavior throughout the task duration. For ADHD children, failure to perform the task was unrelated to any of two versions of the Stroop test. For psychopaths, gambling performance was marginally correlated to Stroop performance, but was very significantly correlated to the degree of psychopathy (assessed by the Hare's psychopathy check list). Interestingly, these correlations were found in the control group as well. Taken together, these results suggest that ADHD children as well as adults with psychopathy tendencies have a dysfunction in brain reward mechanisms.

INTRODUCTION / RATIONALE

While ADHD and conduct disorders in children are classically viewed as two frequently comorbid conditions, the relationship between children behavioural disorders and adult psychopathy is unclear [1]. Psychopathy itself remains a loose and debated concept, where, in addition to aggressive and deceitful behaviours, persons are reported as showing shallow affect, manipulativeness, selfishness, and lack of empathy, guilt or remorse [2]. Some of these personality traits are also found in children with conduct disorders, in particular tendencies to deceit and manipulate, and more generally to break rules, but also cruel behaviours, emotional dysregulation and lack of empathy [3]. Finally, all these conditions share common neuropsychological features, especially impulsivity, defective selection and inhibition strategies [4], and finally defective decision making [5-7].
A neural circuitry, centred on the nucleus accumbens and related parts of the striato-pallidum, is thought to entail the function of processing the reward value of current or expected situations [8], in association with medial frontal cortex, which is involved in reward-based action selection and evaluation of action-outcome contingencies [9]. Such circuitry is believed to subserve the process of decision making in tasks such as the **Iowa gambling task.**

The *Iowa gambling task* [10; 11]]

The task requires participants to select from one of four decks of cards that are identical in physical appearance for 100 trials. Each card choice leads to either a variable financial reward or a combination of a variable financial reward and penalty. Unknown to participants, the rewards and punishments on the decks have been fixed by the experimenter. For each selection from decks A and B participants win $100 and from each selection from decks C and D participants win $50. Every so often variable punishment is also given. Overall, the high reward decks (A and B) give higher levels of punishment whereas the low reward decks (C and D) give lower levels of punishment. Thus, successful task performance relies on sampling more from decks C and D than from decks A and B. It is argued that the reward/punishment schedule is opaque, such that participants are unlikely to be able to perform an exact calculation of net gains and losses. To do well, it is therefore claimed that participants must rely on more 'intuitive' decision-making processes, in particular the activation of somatic marker biasing signals.



STUDY 1 : ADHD PATIENTS

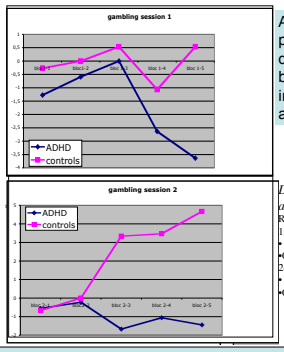
POPULATION AND METHOD

•22 successive children with a diagnosis of ADHD
• (19 M, 7;9 to 14;4 y-o; μ=11)
•15 normal controls, matched on age, sex and socio-economic status.
•All normal IQ
•17/22: hyperactive-impulsive type (Conners);
•5/22 : inattentive type, unmedicated

Diagnosing conduct disorder :
- qualitative : DSM-IV criteria : 12/22 TDAH, 0/15 controls
- **quantitative: extended Conners' questionnaire :** answers to 6 specific questions

Cognitive assessment of inhibition: 2 forms of the Stroop Test

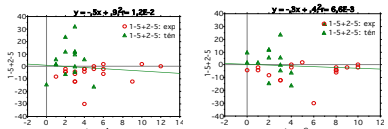
IOWA GAMBLING TASK



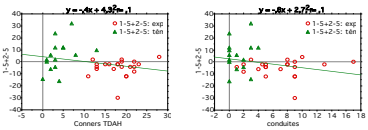
ADHD children show persistent disadvantageous behaviour, while controls increase their advantageous drawings

Dependant variable : nb drawing from advantageous minus disadvantageous decks
Repeated measure ANOVA
1st session:
• group p=0.066
•Group x block p =0.083
2d session:
• group p=0.0508
•Group x block p =0.0011

CORRELATIONS



No correlation with either form of the Stroop task



No correlation with either ADHD or conduct disorder rating

STUDY 2 : PSYCHOPATHY

POPULATION AND METHOD

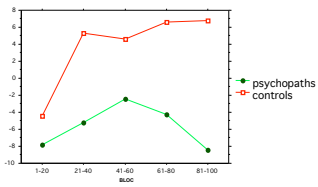
•Twenty young adults (18-40y) with DSM-IV axis II diagnosis of antisocial personality disorder (SCID II)

•20 age- and sex-matched controls

Clinical assessment: PCL-R, Stroop interference index, TMT, WCST
Emotional assessment: Alexithymia (TAS-20)
Level of Empathy: cognitive (LEAS), **emotional** (RME)

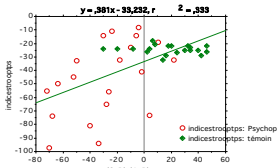
PCL-R: Psychopathy Checklist-Revised; TAS-20: Toronto Alexithymia Scale TMT : trail-making test, WCST : Wisconsin card sorting test LEAS: Level of emotional Awareness Scale; RME: Reading the Mind in the Eyes

IOWA GAMBLING TASK

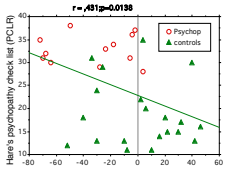


Disadvantageous gambling behaviour in psychopaths compared to controls
F(1,38)=35,521, p<0,0001

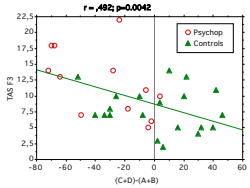
CORRELATIONS



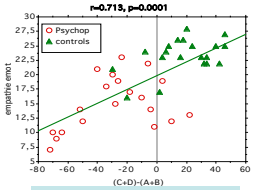
Correlation between the rate of disadvantageous choice on gambling task and an index of sensitivity to interference on Stroop Test.



Correlation with severity of psychopathy (PCR-L)



Correlation with alexithymia score (Toronto Alexithymia Score)



Correlation with empathy questionnaire

DISCUSSION - CONCLUSIONS

- Notwithstanding uncertainty about its ecological validity, the tendency to make risky choices observed in both ADHD children and psychopath young adults on the Iowa Gambling task can be taken as a marker of impairment of the brain mechanisms of reward in these two populations. More specifically, both populations perform on the Iowa gambling task in a way very similar to that of neurological patients with orbital frontal lesions [12; 13]. Whereas the degree of such impairment seems independent from cognitive (Stroop test) and behavioural (Conners rating scales) data in ADHD children, in adults with psychopathic tendencies, disadvantageous gambling strategy seems to relate to the severity of psychopathy (as assessed on the Hare's psychopathy Check List), and to a lesser extent to the degree of dysexecutive functioning [14].
- Moreover, impaired reward mechanisms seem to correlate with scores of emotional control, especially alexithymic traits and deficient empathy, suggesting some common underlying mechanisms.
- Interestingly, many of these correlations were also found among the control group, suggesting a continuum between normality and pathology.
- Finally, further exploring the relationship between pleasure seeking behaviours and awareness of emotional status and/or experience, for oneself and for other persons, may prove an important objective for future research [15].

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