Cognitive and neuroimaging findings in pathological gambling

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Overview

General overview on cognitive and neuroimaging findings in PG (van Holst et al., 2010)

Three studies that target cognitive distortions:

– Overconfidence (Goodie, 2005)

– Control vs. No-control (Goodie, 2005; Clark et al., 2009; Chase and Clark, 2010)

– Near-miss effect (Clark et al., 2009; Chase and Clark, 2010)
Van Holst et al, 2010

«Why gamblers fail to win: A review of cognitive and neuroimaging findings in pathological gambling»

Reviews papers between 2003 and 2008 in 4 domains:

• Reward and punishment processing
• Attentional bias and cue reactivity
• Impulsivity
• Decision making and executive function
Reward and Punishment - Behavior

- Problem gambling characterized by increased reward seeking and/or increased insensitivity to loss in behavioral tasks (Cavedini et al., 2002; Petry, 2001b; Vitaro et al., 1999).

- PG do not stop playing (Card playing task) even if probabilities of getting reward worsen over time (Goudriaan, 2005).

  ➔ PG are more reward seeking.

- However, no reward seeking difference in a different study (Leiserson and Phil, 2007).
• PG show smaller brain responses to reward in ventral striatum and VMPFC (Reuter et al, 2005).

• Another study showed less activation in VLPFC for PG compared to HC in both win and loss trials (de Ruiter et al, 2009).

→ Reward sensitivity seems to be smaller in PG, i.e. similar amounts of reward result in smaller neuronal reward signals.
Attentional bias and cue reactivity - Behavior

- D-amphetamine increases the desire to gamble in PG (Zack and Poulos, 2004; same result with alcohol dependency).

- D-amphetamine increases reading speed on gambling related words, but decreases on others, compared to an overall increase in HC (Zack and Poulos, 2004).

- Haloperidol (D2 antagonist) in PG enhances desire to gamble during game, but not before (Zack and Poulos, 2007).

- Haloperidol increases reading speed on gambling related words (Zack and Poulos, 2007).

→ DA function seems to play a role in pathological gambling.
Attentional bias and cue reactivity - fMRI

- PG show less activity in ventral and dorsal ACC and right IPL when viewing gaming related scenes (Potenza et al, 2008).
- Less activation in PG (while watching gambling video) in CC, OFC, caudate, basal ganglia and thalamic areas (Potenza et al, 2003).
- Higher response (gambling video) in right DLPFC, right IFG, MFG, left parahippocampal region (Crockford et al, 2005).

→ Inconclusive and highly uncontroled paradigms.
Impulsivity - Behavior

- How to measure impulsivity?
  - Response inhibition as suppression of prepotent response (GO/NOGO, Stop Signal Task, Stroop task etc.)
  - Delay discounting
  - Measures of cognitive impulsivity (e.g. IGT, CGT, etc.) → but this is also decision making, and will be treated there.
Impulsivity - Behavior

- PG make more errors in choice reaction tasks (Fuentes et al, 2006).

- Delay gratification and Stop Signal task are more strongly impaired in PG-ADHD patients compared to PG and HC. (Rodriguez-Jimenez et al, 2004).

  ➔ potential confounds of comorbidity


- Stroop task performance is worse in PG (Kertzman et al, 2006).
Impulsivity - Behavior

- PG respond slower (!) in CPT and GO/NOGO but make more commission errors. Problems in task switching (Kertzman et al, 2008).

- Delay discounting reliably differs between PG, PPG and HC. No difference in future time perspectives (MacKillop, 2006).

→ PG consistently show signs of impulsivity in cognitive tasks. However, comorbidity factors are often not taken into account (ADHD example).
• In color-word Stroop task PG show less activation in VLPFC (Potenza et al, 2003). However, behavior was inconsistent with other findings (PG=HC).

→ Difficult to interpret because of conflicting behavioral results.
Decision making and executive function - Behavior

- The Iowa Gambling Task
  - 4 decks with cards.
  - 2 decks have higher wins and fewer, but even higher losses.
  - On the long run it is favorable to go for the decks with the frequent but small losses.
  - Normal people usually learn after about 50 trials.

Other gambling tasks: Georgia Gambling Task (GGT), Cambridge Gambling Task (CGT).
Decision making and executive function
- Behavior

- Performance of PG is worse on IGT (Goudriaan et al, 2006, Linnet et al., 2006, Lakey et al., 2007, Roca et al., 2008).

- Overconfidence and bet acceptance in GGT predict gambling severity (Lakey et al., 2007).

- No correlation between go/nogo and IGT results. (Roca et al., 2008).

- Cognitive flexibility is impaired in PG (Ruff Figural Fluency Test, Trail Making Task Part B) (Kalechstein et al., 2007).

- Large battery of tests (cognitive flexibility, working memory, inhibition) with PG results worse then HC (Forbush et al., 2008, Marazziti et al., 2008).
Decision making and executive function - Behavior

- Performance in a Game of Dice task correlates with executive function measures (Brand et al., 2005).

- No salivary cortisol or alpha-amylase difference compared to HC during Game of Dice task (Labodda et al., 2007).

- Working memory deficits (Leiserson and Pihl, 2007).

→ Consistent deficits in decision making are observed. In many studies, effects of comorbidities can not be excluded.
Decision making and executive function - fMRI

• Modified IGT in comorbid PG and SD: lowered VMPFC activity compared to HC (Tanabe et al, 2007).

→ So far, inconclusive. Too few studies, non with PG without comorbidity.
Van Holst – overall summary

- There are many differences in many cognitive aspects.
- However, only few are very consistent across studies, e.g. stop signal, IGT performance.
- Except for 2 fMRI studies that look at reward coding in PG, there is no conclusive neuroimaging study.
The effect of near misses and perceived control

• The role of perceived control and overconfidence in pathological gambling. (Goodie, Journal of Gambling Studies, 2005)

• Gambling near-misses enhance motivation to gamble and recruit win-related brain circuitry (Clark et al., Neuron, 2009)

• Gambling severity predicts midbrain responses to near-miss outcomes (Chase and Clark, Journal of Neuroscience, 2010)
Role of perceived control and overconfidence

- Participants: University students that like to gamble.

- Scores: SOGS and a PG status directly derived from SOGS
  - SOGS > 5 → PG = 1 Probable PG
  - SOGS = [3,4] → PG = 0.5 problem gambling
  - SOGS < 3 → PG = 0, non-problem gambling

- Run 2 studies to compare SOGS with cognitive measures.

Goodie et al., Journal of Gambling Studies, 2005
Example of measures

- Accuracy of confidence estimates
- Total win on gambles
- Bet acceptance ➔ Betting slope

Goodie et al., Journal of Gambling Studies, 2005
Calculation of payoff for gambles and manipulations

Study 1: Replication of earlier study. Win on gamble = 100/confidence → equal payoff over many trials, if confidence estimates are correct.

Goodie et al., Journal of Gambling Studies, 2005
Results Study 1

Gamblers are overconfident and thus earn less, because they get offered less favourable bets. The acceptance slope is flater in PPG.
But, probable PG do not accept more gambles over all \(\rightarrow\) Study 2

Goodie et al., Journal of Gambling Studies, 2005
Calculation of payoff for gambles and manipulations

Study 1: Replication of earlier study. Win on gamble = 100/confidence → equal payoff over many trials, if confidence estimates are correct.

Study 2: Win on gamble = 100 / accuracy, where accuracy is the average accuracy of all questions with the same confidence. → equal payoff over many trials. Gamble can be either on the question (Control) or on a random gamble. (No-Control: Random number between 1 and 100, if smaller than e.g. 75%, you win.)

Goodie et al., Journal of Gambling Studies, 2005
Role of perceived control

- PPG accept more bets
- Control increases the number of bets and decreases betting slope.
- Control has less impact on gamblers betting frequency.
- Slope is affected more strongly in PPG.

Goodie et al., Journal of Gambling Studies, 2005
Summary

• Probable pathological gamblers are more overconfident.

• PG is associated with gamble acceptance if payoffs are equal.

• Control affects PG differently from non-PG.

• PPG weigh probabilities differently from non PPG (acceptance slope).

Considerations: No payout (points only), real facts vs. random outcomes,

Goodie et al., Journal of Gambling Studies, 2005
The effect of near misses

Participants: University students
Subjective Ratings: Gambling Related Cognition Scale, 3 questions after each choice (every third choice in fMRI).

Second column is random $\rightarrow$ 1/6 hits, 2/6 near misses, 3/6 misses

First column: set by computer or set by participant $\rightarrow$ «Influence on the game?»

Clark et al., Neuron, 2009
(A) Chances of winning are estimated higher when participant chooses the object in the left column.
(B) Subjects want to continue the game more strongly, at near-misses, when they themselves choose the object.

Clark et al., Neuron, 2009
Win vs. miss and near-miss vs. full-miss

(A) $p < 0.05$ FWE corrected

(B) $p < 0.05$ FWE corrected (masked with A). Map: $p < 0.001$ unc.

Clark et al., Neuron, 2009
Differential effect of control in near-misses vs. full-misses

(A) $p \sim 0.05$ FWE corrected (masked with A). Map: $p < 0.001$ unc.

Clark et al., Neuron, 2009
Gambling-related cognitions scale (GRCS)

23 questions that seem to display a high variance also in healthy controls (compared to SOGS). SOGS = South Oaks Gambling Screen

5. Relating my winnings to my skill and ability makes me continue gambling.
6. Gambling makes things seem better.
7. It is difficult to stop gambling as I am so out of control.
8. Specific numbers and colours can help increase my chances of winning.
9. A series of losses will provide me with a learning experience that will help me win later.
10. Relating my losses to bad luck and bad circumstances makes me continue gambling.
11. Gambling makes the future brighter.
12. My desire to gamble is so overpowering.
13. I collect specific objects that help increase my chances of winning.
14. When I have a win once, I will definitely win again.
15. Relating my losses to probability makes me continue gambling.
16. Having a gamble helps reduce tension and stress.

Raylu and Oei, Addiction, 2004
Neural correlates of subjective scores

(A) $p < 0.05$ FWE corrected (masked with win > loss). Map: $p < 0.005$ unc.

(B) $p < 0.05$ FWE corrected (masked with win > loss). Map: $p < 0.005$ unc.

Clark et al., Neuron, 2009
Near-misses in healthy controls - summary

- Wins activate the common reward network.

Within this network:

- Near-misses activate ventral striatum more than full-misses.
- An interaction of control and near- vs. full-miss is found in the rACC.
- Near-miss vs. Full-miss activation in anterior insula correlates with GRCS and desire to continue gambling.

Clark et al., Neuron, 2009
The discussion of the authors.

«Near-misses were associated with significantly greater BOLD signal in the ventral striatum and anterior insula; areas that were also activated by unpredictable monetary wins on the task.”

Clark et al., Neuron, 2009
Open question

Are these findings relevant for pathological gambling or do they simply reflect normal behavior?

Clark et al., Neuron, 2009
Near-misses vs. Full-misses in regular gamblers

• Same paradigm as used in Clark et al (2009).

• 24 regular gamblers, 20 in Analysis (scored with DSM IV and SOGS).

• Analysis restricted to ROI defined in Clark et al. (2009).

• 4 contrasts (as in Clark et al) correlated with SOGS.

Chase and Clark, Journal of Neuroscience, 2010)
The game - reminder

Chase and Clark, Journal of Neuroscience, 2010)
Near-misses vs. Full-misses in regular gamblers

Chase and Clark, Journal of Neuroscience, 2010)
Gambling severity vs. midbrain activity (near - full miss)

Chase and Clark, Journal of Neuroscience, 2010

Cognitive and Neuroimaging findings in PG
Less smoothing (4 mm) to better detect midbrain nuclei

$p < 0.005$, blue circles $p < 0.001$ (unc.)

Chase and Clark, Journal of Neuroscience, 2010)
Comparison to non-gamblers from (Clark et al, 2009)

$p < 0.001$ (unc.)

Chase and Clark, Journal of Neuroscience, 2010)
Near-misses vs. Full-misses in regular gamblers - Summary

- Gambling severity is related to activity in the midbrain (SOGS) scores. However, no difference to healthy controls!
- Reward coding difference (confirm Reuter et al., 2005), but no difference in near-miss activity compared to controls.
- No single comorbidity scale had an influence on significance levels.

Chase and Clark, Journal of Neuroscience, 2010)
Summary

- Cognitive functions are distorted in pathological gamblers

- fMRI findings suggest a distorted reward coding (Reuter et al. 2005, Chase and Clark, 2010), but no evidence for distorted coding of near-misses.

- Cognitive functions have not been tested sufficiently using fMRI.