What are the odds?
Sensory game features, decision making and arousal

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Sensory Game Features
Harmless Fun or Addiction by Design?

Korn & Shaffer 1999
“It’s like being in the eye of a storm, is how I’d describe it. Your vision is clear on the machine in front of you but the whole world is spinning around you, and you can’t really hear anything. You aren’t really there— you’re with the machine and that’s all you’re with.”
Sensory reward features

Structural features → Psychological processes → Impaired control

Excessive gambling

PG prevalence
Persistence
Bet size

Dickerson & Baron 2000
**Structural game characteristics**

**Multiple Lines**

Dixon et al 2014

**Losses Disguised as Wins**

Novice players

Dixon et al 2010

Jensen et al 2013
Structural game characteristics

Near misses

• Experienced as frustrating
• Increase urge to play and gambling persistence
• Lead to overestimate frequency of winning
• Activate the reward circuitry
• Increase arousal

Reviewed in Barton et al, J Gambl Stud, 2017

Stop buttons

• Foster illusion of control in novice players (Ladouceur & Sevigny, 2005)
• 13.6 % of gamblers held erroneous believes despite casino signage (Dixon et al 2018)
• Associated with gambling persistence (Ladouceur & Sevigny, 2005)
Sensory reward features

- Sensory features are attractive to gamblers \((Griffiths\ 1990; \ Dixon\ et\ al\ 2010,\ Livingstone\ &\ Woolley\ 2008;\ Loba\ et\ al\ 2001)\)
  - particularly to pathological gamblers
  - some gamblers dislike the sounds \((Livingstone\ &\ Woolley\ 2008)\)

**Slots sounds are arousing**
\((Dixon\ et\ al\ 2014)\)

**Slots sounds help disguise losses as wins**
\((Dixon\ et\ al\ 2010,\ 2014,\ 2015)\)
Sensory reward features

Psychological processes

Emotional: enjoyment
Physiological: arousal
Cognitive: win estimates

Impaired control
Excessive gambling

DECISION MAKING UNDER RISK
Decision making deficits in addictions, including gambling (e.g. Kovacs et al 2017, Bechara et al 2001)

Decision making “recovers” along similar time frame as craving diminishes (e.g. Wang et al. 2013)

Risky decision making is particularly good predictor of treatment failure (e.g. Stevens et al. 2013)
Sensory features & decision making in rodents

Dr. Catharine A Winstanley
The rodent gambling task

- P1: 1 pellet or 5s time out
  - 295

- P2: 2 pellets or 10s time out
  - 411

- P3: 3 pellets or 30s time out
  - 135

- P4: 4 pellets or 40s time out
  - 99
Sensory cues promote risky choice on the rGT

D3 Agonist

D3 Antagonist

Barrus & Winstanley, JN 2016
Studies in healthy human volunteers

A: Iowa Gambling Task

Decision (unlimited)

Feedback (3500 ms)

Uncued

Cued

B: Vancouver Gambling Task

Decision (unlimited)

Anticipation (1000 ms)

Feedback

win: 3500 ms
no-win: 2500 ms

Total: $10.50
You win!
5

ITI (500 ms)

Total: $10.50
You win!

Behavioural economic two-choice lottery task; Sharp et al, 2012, 2013
Vancouver Gambling Task (VGT)
Vancouver Gambling Task (VGT)

Total: 5

You won!
You won!

Total: $5
Expected value (EV)
Vancouver Gambling Task (VGT)

Rate of choosing the high-probability (safer) prospect

More risk-seeking

More risk-averse

EVR

Favors riskier choice

Favors safer choice
Between-subjects design, n=131

Cherkasova et al, in revision
Sensory features & decision making: VGT

Study 1: between-subject
n=131

EVR
Rate of choosing the high-probability (safer option) +/- SE

More risk-averse
More risk-seeking
Favors riskier choice
Favors safer choice

Sensory Features: $b = 0.58$, SE = 0.22, $z= 2.64$, $p = 0.008$

Study 2: within-subject
n=58

EVR
Rate of choosing the high-probability (safer option) +/- SE

More risk-averse
More risk-seeking
Favors riskier choice
Favors safer choice

Sensory Features: $\beta = 0.27$, SE = 0.11, $z= 2.51$, $p = 0.02$
Magnitude x SF: $\beta = 0.63$, SE = 0.17, $z=3.66$, $p = .0002$

Cherkasova et al, in revision
Sensory features & attention

Study 1
Decision
- Sensory features
+ Sensory features
p = .03

Study 2
Decision
- Sensory features
+ Sensory features
p < .0005

Feedback
Total: $ x.xx
You won!
Text
1. Does attending less to odd and/or more to the amount promote riskier choice?

2. Is this a mechanism whereby sensory features promote risky choice?

<table>
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<th>β</th>
<th>SE</th>
<th>z</th>
<th>p</th>
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Fixations predicting risky choice
1. Does attending less to odd and/or more to the amount promote riskier choice?

2. Is this effect modulated by the sensory features?

```
cues | .0588** | risky choice

-.1055**

-.0413** CI [-.0594, -.0256]
```
Sensory features & arousal

- Gambling associated with increases in arousal (Sharpe 2002)
  - Greater in PG (e.g. Goudriaan et al 2004)
- Gambling cues elicit arousal in gamblers (Baudinet & Blaszczynski 2013)
- Impaired decision making related to aberrant arousal patterns in problem gamblers (Goudriaan et al, 2006)

Adaptive Gain Theory

Aston Jones & Cohen, 2005
Sensory features & arousal

Pupil size modulation with respect to baseline

Risk & Cue dependent pupil modulation

Baseline

Total: $10.5
You won!
• ~73% of people in BC report having gambled in the past year
• Prevalence of problem gambling 4.9%
• Prevalence of gambling disorder .9%
• Can we identify individuals who are especially susceptible to risk-promoting effects of sensory features?
Individual variation in attribution of motivational value to reward-predictive cues (Robinson & Flagel 2009; Meyer et al, 2012)

Linked to addiction vulnerability in animal models

- Sign-trackers seek drugs and relapse in the presence of discrete drug cues (e.g. Saunders & Robinson 2010, 2011)
- Goal-trackers more responsive to contextual cues (Saunders & Robinson 2012)

Sign & Goal Tracking
Individual differences in cue sensitivity: humans

Garofalo & di Pellegrino, 2015
Study 2: n=58

Cue reactivity of choice

**Sign-Trackers**

Effect of sensory cues:
\[ \beta = 0.47, SE = 0.11, z = 4.16, p < 0.005 \]

- No enhancement
- Sensory cues

**Goal-Trackers**

Effect of sensory cues:
\[ \beta = 0.05, SE = 0.17, z = 0.26, p = 0.79 \]

- No enhancement
- Sensory cues

EVR

Favors riskier choice

Favors safer choice

More risk-seeking

More risk-averse
Interim summary

- Sensory features promote risky choice in both rodents and healthy human volunteers
- Attentional mechanisms may be involved
- Risk-promoting effects are more apparent in cue-sensitive individuals
- Sensory features promote arousal
  - Independent of the risk-promoting effects

RELEVANCE TO PROBLEM GAMBLING ?
Inclusion / exclusion criteria

- Problem gambling severity index (PGSI, *Ferris & Wynne, 2001*) ≥ 3
- No neurological conditions
- No mental health problems requiring hospitalization
- No change in medication within 6 weeks

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<th>Controls</th>
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<tr>
<td>n</td>
<td>27</td>
<td>24</td>
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<tr>
<td>Males</td>
<td>11</td>
<td>9</td>
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<tr>
<td>Females</td>
<td>16</td>
<td>15</td>
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<tr>
<td>Age</td>
<td>46.85 ± 11.89</td>
<td>46.21 ± 12.66</td>
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<tr>
<td>PGSI</td>
<td>11.96 ± 4.4</td>
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<tr>
<td>GD</td>
<td>15</td>
<td>0</td>
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<tr>
<td>Ψ Meds</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>Gambling tx</td>
<td>11</td>
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</table>
Clinical characteristics

Severity

Games

Current Comorbidity
Can we predict clinical course from decision making and reactivity to sensory features?

- PGSI
- Gambling frequency
- Tx status

n = 12
Heterogeneity of risk attitudes

Frequency of choosing the high-probability (safer option) + SE

Controls
GD
PG
Favors riskier choice
Favors safer choice

EVR

0.0
0.5
1.0
1.5
• Are problem gamblers more susceptible to the effects of sensory features

• Do these features differentially modulate arousal in problem gamblers?

• How is response to sensory features related to individual differences and clinical heterogeneity in problem gambling?

• How is it related to clinical course?

• What are the neural substrates?
Acknowledgments

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PARTICIPANTS!

Game Sense

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