Can a new form of inhibitory training reduce heavy drinking?

Janette L Smith

Inhibitory deficits in addiction

- Inhibition: the ability to interrupt, delay, or withhold performance of an inappropriate response
- Increasing importance in models of development and maintenance of addiction
  - Old models: limbic system → generates pathological desire for drug
  - New models: frontal control system → problems exercising control over those desires
    (e.g., Jentsch & Pennington, 2014, Neuropharmacology; Goldstein & Volkow, 2002, Am J Psychiatry)
- Inhibitory deficit differs by addiction
  (Smith et al., 2014, Drug Alc Depend)
- Apparent for alcohol dependence as well as heavy drinking
- Which came first?
  - Consumption → dysfunction
  - Dysfunction → consumption
- Remediate dysfunction → reduction in consumption?
Can inhibitory training reduce heavy drinking?

- If inhibition improves, undesirable behaviours decrease
  - Substantial literature on binge eating, overweight and obesity, healthy food choices
  - Growing literature concerning risky alcohol consumption
  - 10 minute computer task $\rightarrow$ ~20% reduction in uni students over 1 week
  - Also effective with motivated individuals seeking treatment (e.g., Wiers' work)
  - Theoretically could be delivered online

- Two main methodologies: Beer-NoGo and Restrained-Stop

Beer-NoGo

“Press the button when you see the letter F; do not press when you see the letter P”

Images are task-irrelevant, but alcohol always presented with P – ‘NoGo’ – requiring inhibition
Can inhibitory training reduce heavy drinking?

- If inhibition improves, undesirable behaviours decrease
  - Substantial literature on binge eating, overweight and obesity, healthy food choices
  - Growing literature concerning risky alcohol consumption
  - 10 minute computer task → ~20% reduction in uni students
  - Also effective with motivated individuals seeking treatment
  - Theoretically could be delivered online

- Beer-NoGo:
  - Pairing response inhibition with task-irrelevant images of beer
  - Alters alcohol associations
  - Effect size ~0.48 (Jones et al., 2016, Appetite; Allom et al., 2016, Health Psychol Rev)

Restrained-Stop

“Press left for F, right for P, and do not press if the letter turns red. Correct responses are more important than fast responses”
Can inhibitory training reduce heavy drinking?

- If inhibition improves, undesirable behaviours decrease
  - Substantial literature on binge eating, overweight and obesity, healthy food choices
  - Growing literature concerning risky alcohol consumption
  - 10 minute computer task → ~20% reduction in uni students
  - Also effective with motivated individuals seeking treatment
  - Theoretically could be delivered online

- Beer-NoGo:
  - Pairing response inhibition with task-irrelevant images of beer
  - Alters alcohol associations
  - Effect size ~0.48 (Jones et al., 2016, Appetite; Allom et al., 2016, Health Psychol Rev)

- Restrained-Stop
  - Complete an inhibitory task with instructions to be particularly restrained (no images of alcohol)
  - Primes a restrained response set generally
  - Effect size ~0.24 (Jones et al., 2016, Appetite; Allom et al., 2016, Health Psychol Rev)

Past research

- Inhibitory training often compared to ‘control’ conditions which actually increase alcohol consumption
  - Possibly overestimating the effect of training (as measured by time x group interaction)

- Few studies compare to other proven methods of reducing consumption such as Brief Alcohol Intervention (BAI)

- No link between alcohol and inhibition (Restrained-Stop), or no necessary link (Beer-NoGo)

Our study

- A better control condition which should not increase consumption
  - A 10 minute computer task not requiring inhibition
  - In fact, expected this group to also decrease consumption due to effect of assessment alone (a Hawthorne effect; e.g., Kypri et al., 2007, Addiction; McCambridge & Gray, 2009, Addiction)
  - Training conditions must produce greater reductions than Control in order to be considered effective
  - Included a BAI condition
  - Added a new ‘Combined’ training task which more strongly links alcohol and inhibition

- Possibly overestimating the effect of training (as measured by time x group interaction)

- Few studies compare to other proven methods of reducing consumption such as Brief Alcohol Intervention (BAI)

- No link between alcohol and inhibition (Restrained-Stop), or no necessary link (Beer-NoGo)
A new ‘Combined’ training task

“Press left for F, right for P, and do not press if the image changes”

Alcohol is the cue for inhibition

Participants

• 114 university students:
  • Aged 18-30
  • Liked beer
  • Consumed at least 4 standard drinks in the week before baseline testing
  • Not pregnant or have any other contraindications to drinking alcohol

• Not informed of the study’s true aims until debriefing (similar to other studies)

• Randomly assigned to conditions
  • Control (n = 22)
  • Beer-NoGo (n = 24)
  • Restrained-Stop (n = 22)
  • Combined (n = 22)
  • BAI (n = 24)

• Groups not significantly different for age (~22), sex ratio (37%F), AUDIT score (~11), BIS-11 impulsivity (~63) or drinks/week (~16)
Methods

Baseline (60 minutes)
- Consent
- Demographics
- AUDIT
- Barratt Impulsiveness Scale (BIS-11)
- TLFB for week preceding
- Implicit Association Task
- Flanker task
- Training task or BAI
- Implicit Association Task
- Flanker task
- Bogus taste test

TLFB primary measure: total drinks/week
14 drinks/week = 14 on 1 day, or 2-3 on 5 days?
Secondary measures: beer drinks/week, drinking days/week, binge days/week, maximum drinks/day, average drinks/drinking day

**Total drinks/week:** Significant reduction over time across conditions
No difference between conditions: while training and BAI conditions were associated with small-medium reductions in drinking, so was the Control condition

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Beer-NoGo</th>
<th>Restrained-Stop</th>
<th>Combined</th>
<th>BAI</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total drinks/week</strong></td>
<td>d_{RM}</td>
<td>0.336</td>
<td>(0.052, 0.723)</td>
<td>0.301</td>
<td>0.212</td>
<td>0.291</td>
</tr>
<tr>
<td></td>
<td>d_{GPP}</td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.212</td>
<td>0.291</td>
<td>(0.036, 0.723)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.291</td>
<td>(0.036, 0.723)</td>
<td>0.291</td>
</tr>
<tr>
<td><strong>Binge days/week</strong></td>
<td>d_{RM}</td>
<td>0.048</td>
<td>(0.008, 0.494)</td>
<td>0.367</td>
<td>0.212</td>
<td>0.455</td>
</tr>
<tr>
<td></td>
<td>d_{GPP}</td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.212</td>
<td>(0.036, 0.723)</td>
<td>0.455</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.455</td>
<td>(0.036, 0.723)</td>
<td>0.455</td>
</tr>
<tr>
<td><strong>Max drinks/day</strong></td>
<td>d_{RM}</td>
<td>0.414</td>
<td>(0.119, 0.948)</td>
<td>0.367</td>
<td>0.212</td>
<td>0.455</td>
</tr>
<tr>
<td></td>
<td>d_{GPP}</td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.212</td>
<td>(0.036, 0.723)</td>
<td>0.455</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.455</td>
<td>(0.036, 0.723)</td>
<td>0.455</td>
</tr>
<tr>
<td><strong>Average drinks/day</strong></td>
<td>d_{RM}</td>
<td>0.459</td>
<td>(0.042, 0.960)</td>
<td>0.138</td>
<td>0.100</td>
<td>0.460</td>
</tr>
<tr>
<td></td>
<td>d_{GPP}</td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.100</td>
<td>(0.036, 0.723)</td>
<td>0.460</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.036, 0.723)</td>
<td>(0.036, 0.723)</td>
<td>0.460</td>
<td>(0.036, 0.723)</td>
<td>0.460</td>
</tr>
</tbody>
</table>

**d_{RM}:** Repeated measures effect size
Indexes change over time Positive effect size reflects reduction from baseline to follow-up

**d_{GPP}:** Difference in effect of time between conditions
Positive effect size reflects greater reduction in the test condition relative to Controls

0.2 = small
0.5 = medium
0.8 = large
In line with many other studies reporting an effect of assessment on alcohol consumption, McCambridge & Day, 2008, Addiction). Regardless of the control/training/BAI condition to which the participant was randomly assigned, Only BAI showed greater reduction relative to time across conditions.

Summary

- Participation in our study associated with reduction in weekly alcohol consumption
  - Total drinks, 4/5 secondary measures
  - Within-subject effect sizes 0.21-0.34 across conditions
  - Regardless of the control/training/BAI condition to which the participant was randomly assigned

- In line with many other studies reporting an effect of assessment on alcohol consumption
  - Mechanism of this effect is debated
  - But from a public health perspective, the mechanism of action is unimportant so long as it is reliable (McCambridge & Day, 2008, Addiction)
  - Suggests utility of widespread application of assessment protocols via the internet or in primary care settings

**Maximum drinks/day:** Significant reduction over time across conditions

**Average drinks/day:** No difference between conditions

**Total drinks/week:** Significant reduction over time across conditions

**Beer drinks/week:** No difference between conditions

**Drinking days/week:** No difference between conditions

**Binge days/week:** No difference between conditions

**Max drinks/day:** No difference between conditions

**Average drinks/drink/day:** No difference between conditions

---

**Table 1:**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Control (95% CI)</th>
<th>Beer-NoGo (95% CI)</th>
<th>Restrained-Stop (95% CI)</th>
<th>Combined (95% CI)</th>
<th>BAI (95% CI)</th>
<th>All (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total drinks/week</td>
<td>0.336 (0.052, 0.723)</td>
<td>0.301 (-0.112, 0.714)</td>
<td>0.212 (-0.138, 0.562)</td>
<td>0.291 (-0.051, 0.632)</td>
<td>0.472 (0.107, 1.052)</td>
<td><strong>0.324</strong> (0.130, 0.519)</td>
</tr>
<tr>
<td>Beer drinks/week</td>
<td>0.232 (-0.030, 0.493)</td>
<td><strong>0.414</strong> (0.075, 0.763)</td>
<td>0.068 (-0.305, 0.442)</td>
<td>-0.031 (0.376, 0.314)</td>
<td><strong>1.095</strong> (0.517, 1.672)</td>
<td>0.336 (0.162, 0.509)</td>
</tr>
<tr>
<td>Drinking days/week</td>
<td>-0.173 (-0.423, 0.077)</td>
<td>0.246 (-0.117, 0.610)</td>
<td>0.187 (-0.156, 0.530)</td>
<td>-0.1 (-4.153, 0.415)</td>
<td>-0.263 (-0.696, 0.170)</td>
<td>0.863 (0.293, 1.496)</td>
</tr>
<tr>
<td>Binge days/week</td>
<td>0.048 (-0.308, 0.404)</td>
<td>0.340 (-0.069, 0.748)</td>
<td><strong>0.443</strong> (0.053, 0.833)</td>
<td>0.218 (0.218, 0.218)</td>
<td>0.218 (0.218, 0.218)</td>
<td>0.218 (0.218, 0.218)</td>
</tr>
<tr>
<td>Max drinks/day</td>
<td>0.414 (-0.119, 0.948)</td>
<td>0.367 (-0.044, 0.777)</td>
<td>0.212 (-0.208, 0.631)</td>
<td>0.212 (-0.208, 0.631)</td>
<td>0.212 (-0.208, 0.631)</td>
<td>0.212 (-0.208, 0.631)</td>
</tr>
<tr>
<td>Average drinks/drink/day</td>
<td>0.459 (-0.042, 0.960)</td>
<td>0.138 (-0.224, 0.501)</td>
<td>0.100 (-0.267, 0.467)</td>
<td>0.100 (-0.267, 0.467)</td>
<td>0.100 (-0.267, 0.467)</td>
<td>0.100 (-0.267, 0.467)</td>
</tr>
<tr>
<td>Average drinks/week</td>
<td>-0.321 (-0.933, 0.291)</td>
<td>-0.359 (-0.982, 0.232)</td>
<td>0.001 (-0.648, 0.648)</td>
<td>0.001 (-0.648, 0.648)</td>
<td>0.001 (-0.648, 0.648)</td>
<td><strong>-0.495</strong> (-1.167, 0.177)</td>
</tr>
</tbody>
</table>
Summary

• Brief alcohol intervention was most successful at reducing alcohol consumption
  • Beer drinks/week, drinking days/week
  • Largest effect size for total drinks/week, although not significantly different to Controls
  • In line with numerous studies showing that BAIs are effective at reducing consumption among heavy drinkers

• Can inhibitory training reduce heavy drinking?
  • When compared to a carefully selected Control condition, no
  • Considering training as a treatment adjunct may be premature, although better results have been observed among motivated individuals (vs. uni students not seeking treatment)
  • Despite the discouraging lack of a large effect for our three training protocols, investigation of inhibitory training is not a fruitless endeavour
  • Rather, investigators will need to carefully consider the possible sources of observed alterations in drinking behaviour
  • Ensure chosen task design produces an effect beyond that of simple assessment, and indeed beyond other proven methods of reducing consumption

Acknowledgements

• Ms Nicole Dash, University of Wollongong, Australia
• Assoc Prof Stuart Johnstone, University of Wollongong, Australia
• Dr Katrijn Houben, Maastricht University, The Netherlands
• Prof Matt Field, University of Liverpool, United Kingdom
• Australian Rotary Health Postdoctoral Research Fellowship
• Mr Tony Kemp, programmed training tasks
• janette.smith@unsw.edu.au
• Smith, Dash, Johnstone, Houben, Field (submitted Oct 18 2016) Current forms of inhibitory training produce no greater reduction in drinking than simple assessment. Drug and Alcohol Dependence
What’s next?

- Beer-NoGo: largest effect size among inhibitory tasks for reducing beer drinks/week
  - More effective with participants who prefer (not just like) beer?
  - Use participant’s preferred drink (beer, red wine, white wine, spirits etc)?
  - Use participant’s preferred brand/label?

- Presentation of beer images in Beer-NoGo and Combined conditions may have increased alcohol consumption (e.g., by increasing craving), counteracting the inhibitory training
  - What is the effect of presenting beer images with no associated task?

- For how long does the effect last? Longer follow-ups than 1 week

- Combined task: alcohol images perhaps still not necessarily the signal for inhibition
  - Possible that an image change was the attended feature
  - Images change from landscapes to water (ignore, respond) or alcohol (inhibit) – must process content of image

Floor effects?

- Consumption and AUDIT scores among our sample of heavy drinkers are lower than previous studies

- Light drinkers have less room to reduce drinking, or perhaps the protocols are more effective with heavy drinkers?

- Split into groups with AUDIT 11 or less (n = 66) vs. 12 or more (n = 48)

- Group x training condition x time ANOVA

- Greater reduction for BAI than Controls, larger in the heavier drinkers, for
  - Total drinks
  - Beer drinks
  - Binge episodes
  - → BAI intervention most successful with heavier drinkers
  - But still no effects for other training conditions
Results

<table>
<thead>
<tr>
<th></th>
<th>Control (n = 22)</th>
<th>Beer-NoGo (n = 24)</th>
<th>Restrained-Stop (n = 22)</th>
<th>Combined (n = 22)</th>
<th>BAI (n = 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>22.2 ± 0.8</td>
<td>21.6 ± 0.6</td>
<td>21.7 ± 0.7</td>
<td>21.4 ± 0.6</td>
<td>21.6 ± 0.6</td>
</tr>
<tr>
<td>Sex ratio (F:M)</td>
<td>9:13</td>
<td>9:15</td>
<td>6:16</td>
<td>9:13</td>
<td>9:15</td>
</tr>
<tr>
<td>AUDIT</td>
<td>11.4 ± 0.9</td>
<td>12.0 ± 1.0</td>
<td>12.0 ± 1.0</td>
<td>9.6 ± 0.7</td>
<td>11.4 ± 0.9</td>
</tr>
<tr>
<td>Impulsivity (BIS)</td>
<td>60.2 ± 2.0</td>
<td>63.2 ± 1.9</td>
<td>64.1 ± 2.1</td>
<td>63.4 ± 2.0</td>
<td>61.5 ± 2.1</td>
</tr>
<tr>
<td>Drinks/week at entry</td>
<td>14.4 ± 2.4</td>
<td>16.5 ± 2.0</td>
<td>20.1 ± 3.1</td>
<td>13.7 ± 1.6</td>
<td>16.5 ± 2.7</td>
</tr>
</tbody>
</table>

- Values are mean ± SE
- Recruited a sample of heavy drinkers (AUDIT ≥ 8), not significantly different between groups for AUDIT, impulsivity, or drinks/week

Cause and effect?

- Deficits in inhibitory performance and/or brain activation at baseline, predicts substance use anywhere from 3 months to 6 years later
  - Dalton (poster 60); Malmood et al. (2013, Addict Behav); Norman et al. (2011, Drug Alc Depend); Tarler et al. (2003, Am J Psych); Rubio et al. (2008, Alc Clin Exp Res)

- Alcohol consumption
  - Reductions in alcohol consumption produce recovery of cognitive function?
  - Improvement in cognitive function produces reductions in alcohol consumption?

- Causal role explicitly or implicitly assumed by most researchers
- Few directly test this
  - Maurage et al. (2009, J Psychiatric Neurosci);
  - Non-binge drinkers tested at baseline and 9 months later
  - Half had commenced binge drinking
  - Binge drinkers showed delayed processing of emotional stimuli at Time 2, despite no difference at Time 1

The difference is research
- Reduction over time across groups (p = 0.005)

- No effect of condition: inhibitory tasks produced small reductions, but so did the Control

<table>
<thead>
<tr>
<th>Condition</th>
<th>Control</th>
<th>Beer-NoGo</th>
<th>Restrained-Stop</th>
<th>Combined</th>
<th>BAI</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d_{RM}) (95% CI)</td>
<td>0.232</td>
<td>0.414</td>
<td>0.068</td>
<td>-0.031</td>
<td>1.095</td>
<td>0.336</td>
</tr>
<tr>
<td>(d_{IGPP}) (95% CI)</td>
<td>0.183</td>
<td>-0.163</td>
<td>-0.263</td>
<td>0.863</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- BAI reduced more than Controls (p = 0.064)
• No reduction over time across groups (p = 0.125)
• BAI reduced number of drinking days more than Controls (p = 0.024)

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Beer-NoGo</th>
<th>Restrained-Stop</th>
<th>Combined</th>
<th>BAI</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>dRM (95% CI)</td>
<td>-0.173 (-0.423, 0.177)</td>
<td>0.246 (-0.117, 0.610)</td>
<td>0.187 (-0.106, 0.483)</td>
<td>-0.115 (-0.418, 0.189)</td>
<td>0.571 (0.068, 1.053)</td>
<td>0.143 (-0.025, 0.306)</td>
</tr>
<tr>
<td>dIGPP (95% CI)</td>
<td>0.420 (-0.022, 0.861)</td>
<td>0.360 (-0.064, 0.785)</td>
<td>0.058 (-0.335, 0.452)</td>
<td>0.744 (0.201, 1.288)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

• Reduction over time across groups (p = 0.006)
• No effect of condition

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Beer-NoGo</th>
<th>Restrained-Stop</th>
<th>Combined</th>
<th>BAI</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>dRM (95% CI)</td>
<td>0.048 (-0.308, 0.404)</td>
<td>0.340 (-0.069, 0.748)</td>
<td>0.443 (-0.033, 0.833)</td>
<td>0.272 (-0.095, 0.638)</td>
<td>0.199 (-0.237, 0.635)</td>
<td>0.268 (0.061, 0.445)</td>
</tr>
<tr>
<td>dIGPP (95% CI)</td>
<td>0.292 (-0.256, 0.834)</td>
<td>0.395 (-0.132, 0.924)</td>
<td>0.224 (-0.287, 0.735)</td>
<td>0.151 (-0.412, 0.715)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• Reduction over time across groups (p = 0.006)
• No effect of condition

**Maximum drinks/day**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Control</th>
<th>Beer-NoGo</th>
<th>Restrained-Stop</th>
<th>Combined</th>
<th>BAI</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d_{RM}$ (95% CI)</td>
<td>0.414</td>
<td>0.367</td>
<td>0.212</td>
<td>0.455</td>
<td>0.292</td>
<td>0.341</td>
</tr>
<tr>
<td>$d_{IGPP}$ (95% CI)</td>
<td>-0.047</td>
<td>-0.202</td>
<td>0.041</td>
<td>-0.122</td>
<td>-0.036</td>
<td>-0.036</td>
</tr>
</tbody>
</table>

**Average drinks/drinking day**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Control</th>
<th>Beer-NoGo</th>
<th>Restrained-Stop</th>
<th>Combined</th>
<th>BAI</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td>$d_{RM}$ (95% CI)</td>
<td>0.459</td>
<td>0.138</td>
<td>0.100</td>
<td>0.460</td>
<td>-0.036</td>
<td>0.209</td>
</tr>
<tr>
<td>$d_{IGPP}$ (95% CI)</td>
<td>-0.321</td>
<td>-0.359</td>
<td>0.001</td>
<td>-0.495</td>
<td>-1.877</td>
<td>-1.877</td>
</tr>
</tbody>
</table>