Differential Rearing Effects on Impulsivity

Kimberly Kirkpatrick
Andrew Marshall

Kansas State University

Introduction

- Environmental enrichment during rearing produces a variety of neurobiological and behavioral changes
- Environmental enrichment appears to provide a "protective effect" against addictive behaviors
  - This may be due to impulsivity, which has been linked with drug abuse
  - Impulsivity is a vulnerability factor in drug use initiation, and also predicts relapse following participation in treatment programs

Introduction

- Impulsive choice
  - A smaller magnitude available after a shorter delay (the SS) versus a larger magnitude available after a longer delay (the LL)
- Impulsive action
  - Individuals must withhold/inhibit responding at particular times

Introduction

- Enrichment and impulsive choice
  - Perry et al. (2008) – Enriched condition (EC) rats displayed decreased impulsive choice
  - Hellmans et al. (2005) – Isolated condition (IC) rats displayed decreased impulsive choice
- Enrichment and impulsive action
  - Hill et al. (2012) – IC displayed fewer impulsive responses
  - Ough et al. (1972) – EC displayed better inhibition of responses
  - Zeeb et al. (2013) and Dalley et al. (2002) – IC displayed decreased premature responding

Experiment 1

Impulsive choice, impulsive action, and reward discrimination

Kirkpatrick et al. (in press). Behavioral Neuroscience

Experiment 1: Rearing Method

- Rats reared for 30 days
  - Enriched Condition (EC, n=9)
  - Isolated Condition (IC, n=9)
- Rearing environment maintained during behavioral testing

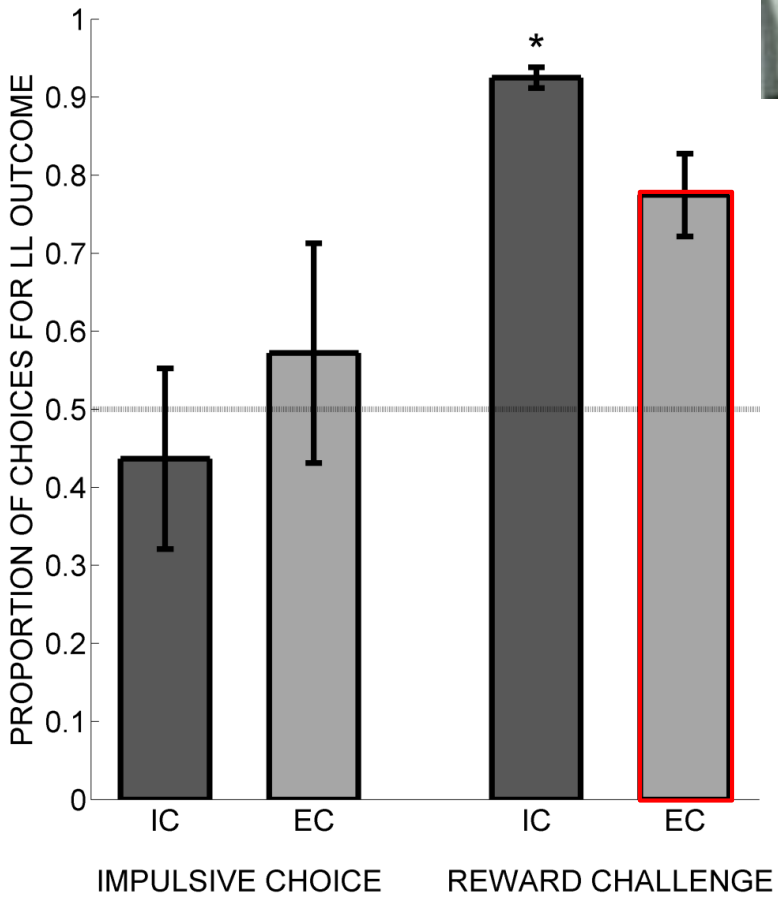
Experiment 1: Behavioral Testing

Group	Phase 1	Phase 2
1 (2)	Impulsive Choice SS: 1 pellet, 10 s LL: 2 pellets, 30 s	Reward Challenge SS: 1 pellet, 30 s LL: 2 pellets, 30 s
2 (1)	DRL 30 s	DRL 60 s

Experiment 1: Impulsive Choice and Reward Challenge Results

IC

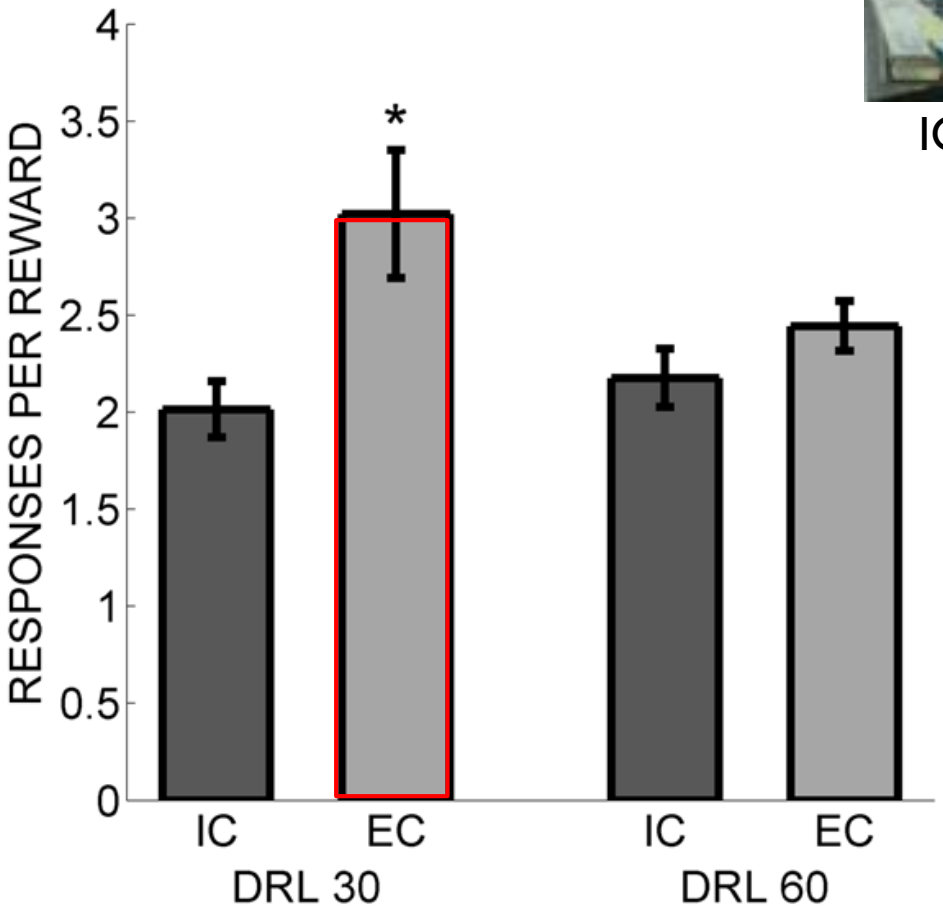
EC



Experiment 1: Impulsive Action Results

IC

EC



Experiment 1: Summary

- EC rats showed a trend towards increased LL choices, but not significant
  - Follow-up in Experiment 2 by testing impulsive choice over a wider range of parameters
- EC rats displayed deficits in reward discrimination in the reward challenge task
- EC rats also displayed deficits in impulsive action (DRL 30)
- Both of these results suggest deficits in reward sensitivity and/or reward-seeking behaviors in the EC rats
  - Follow-up in Experiment 3 by testing their reward magnitude sensitivity

Experiment 2

Impulsive choice behavior

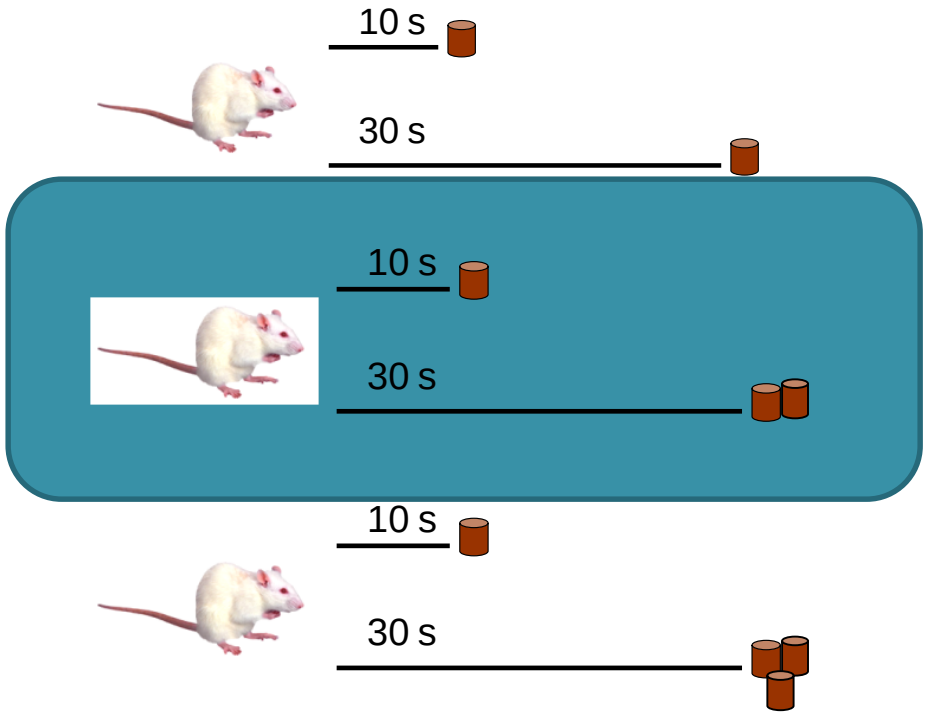
Kirkpatrick et al. (in preparation). Behavioural Brain Research

Experiment 2: Rearing Method

- Rats reared for 30 days
  - Enriched Condition (EC, n=11)
  - Isolated condition (IC, n=12)
- Rearing environment maintained during behavioral testing

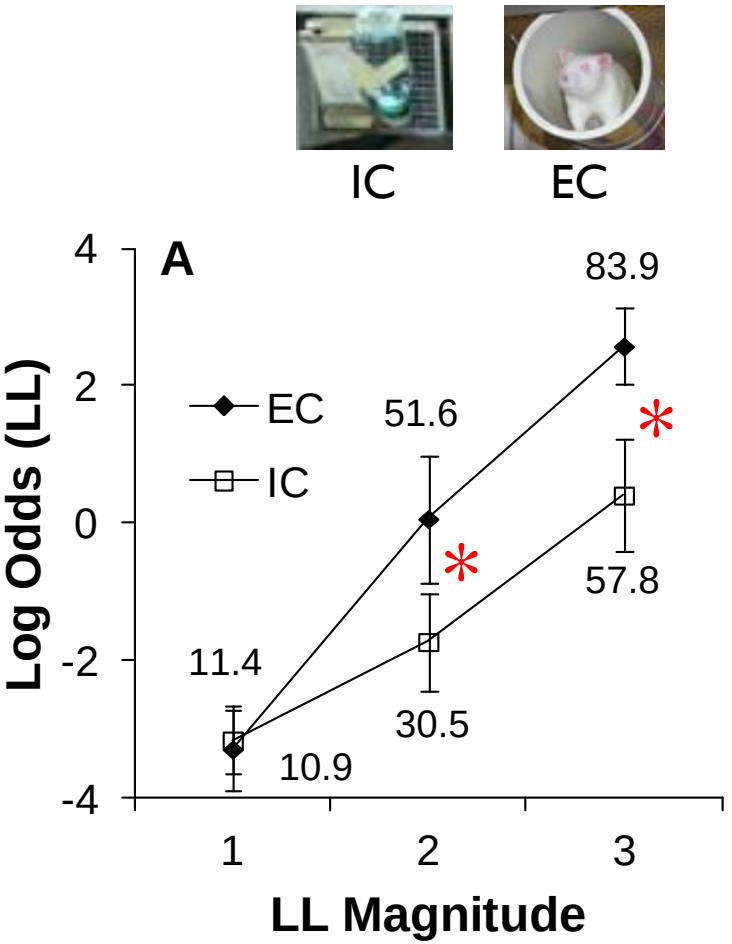
Experiment 2 Method: Behavioral Testing

Impulsive Choice



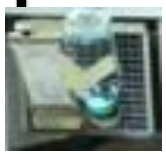
Experiment 2 Results: Impulsive Choice

- EC rats were more likely to choose the LL (self-controlled) option as the LL magnitude increased



Experiment 2 Results: Impulsive slope versus mean

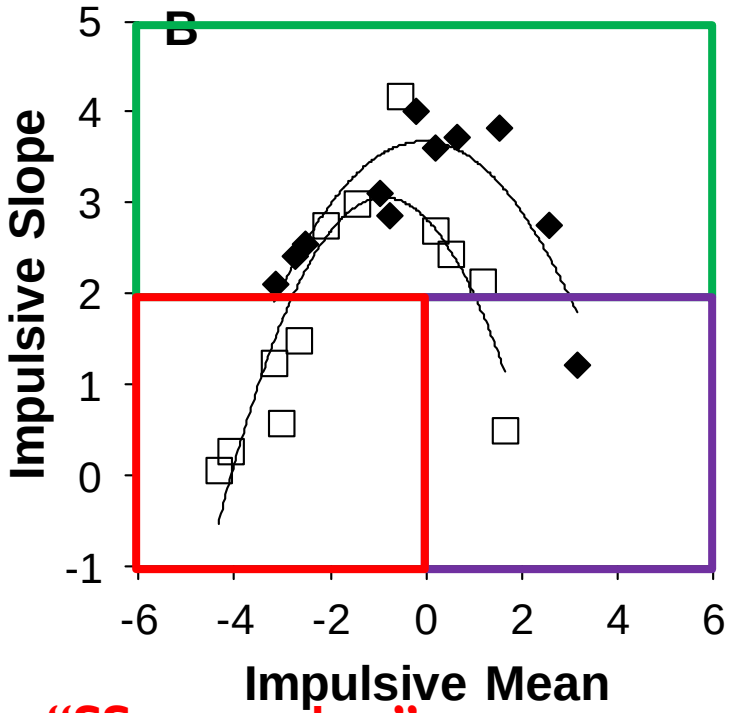
- IC rats were more likely to be "SS responders"
- EC rats were more likely to be "Adaptive decision makers"
- Distributional shift with environmental rearing



IC

EC

"Adaptive decision makers"



"SS responders"

"LL responders"

Experiment 3

Reward magnitude sensitivity

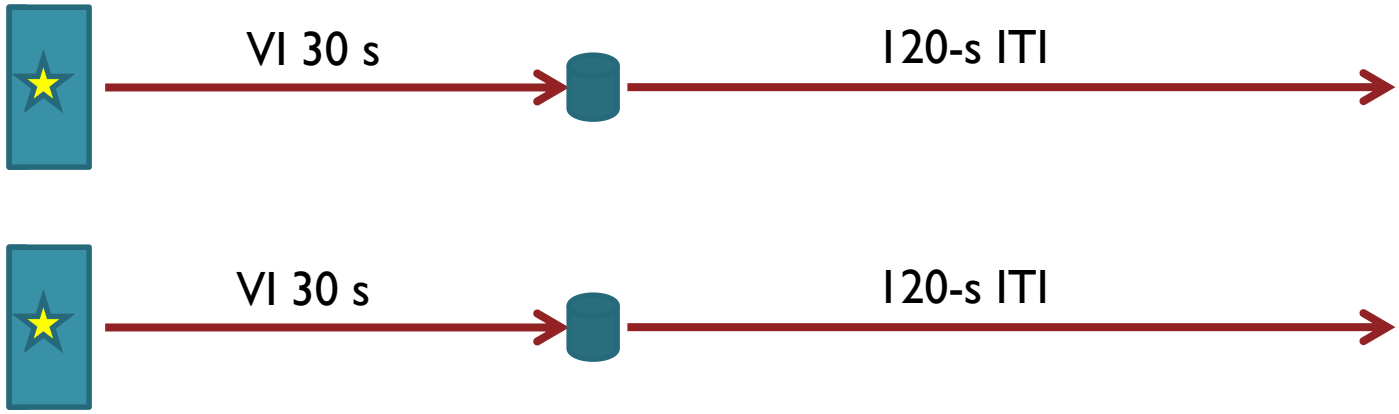
Kirkpatrick et al. (in press). Behavioral Neuroscience

Experiment 3: Rearing Method

- Rats reared for 30 days
  - Enriched condition (EC, n=8)
  - Standard condition (SC, n=8)
  - Isolated condition (IC, n=8)
- Rearing conditions maintained during behavioral testing

Experiment 3 Method: Reward Sensitivity

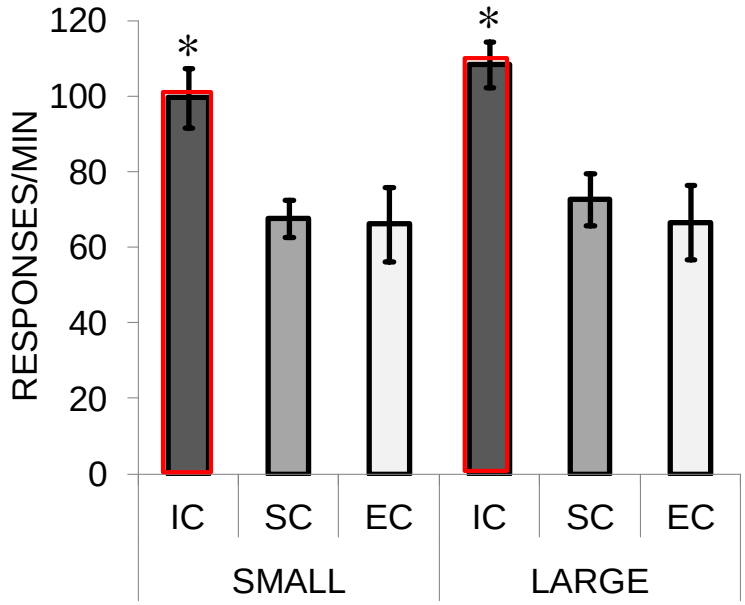
- Discrete-trial, two-lever, VI 30-s schedule
  - Only one lever inserted at a time



  - Delivered a series of magnitudes
    - 1:1, 1:2, 1:3, 2:3, 1:4, 2:4

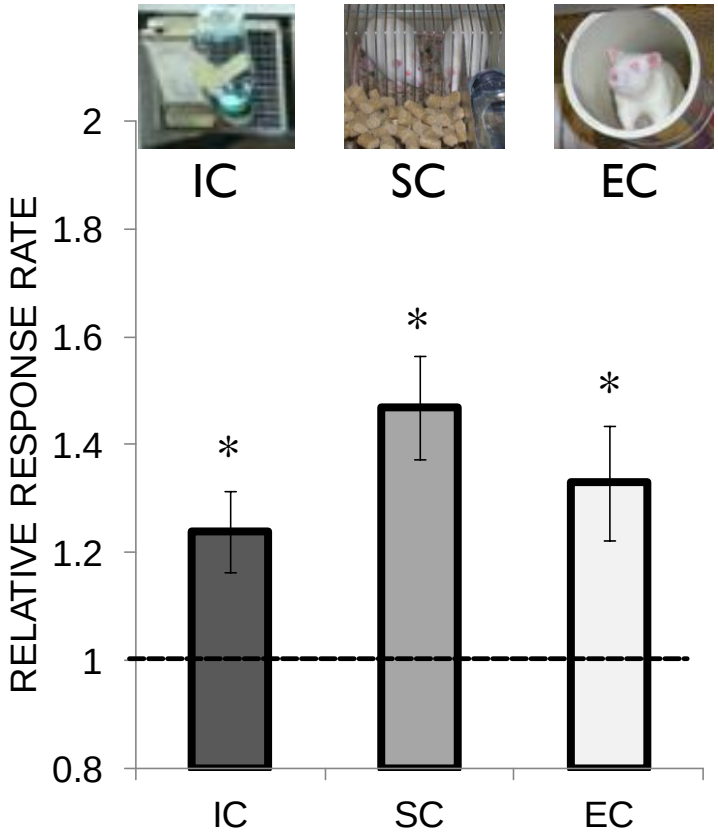
Experiment 3: Baseline Results

- IC rats respond more for 1-pellet food rewards during baseline VI 30 s schedule
- No difference between "Small" and "Large" levers (no pre-existing lever biases)



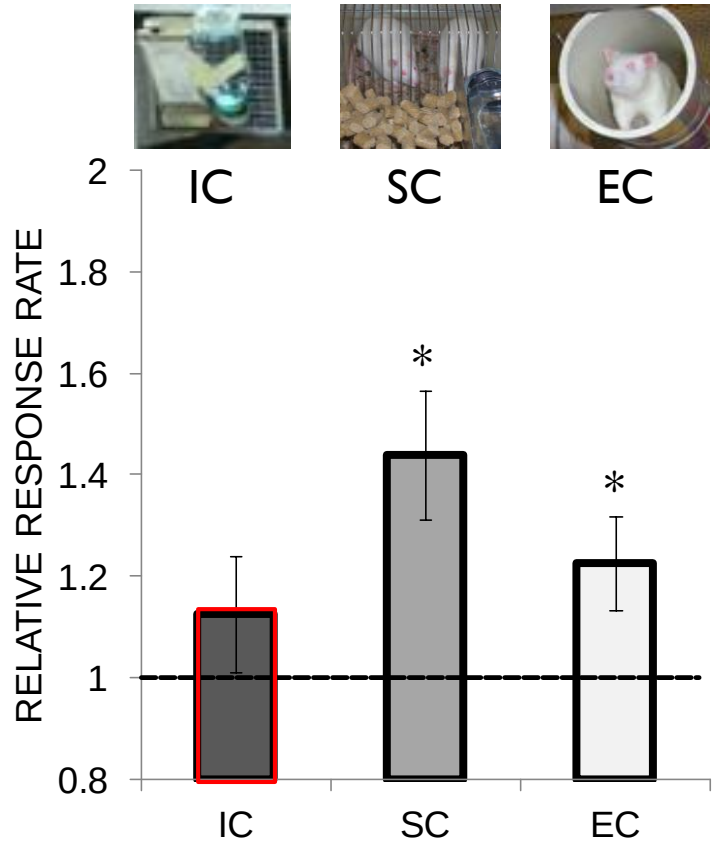
Experiment 3: Reward Sensitivity, Large Lever

- All rearing conditions significantly increased their relative response rate on the large lever as a function of reward magnitude
- No effect of rearing condition on response to LG reward



Experiment 3: Reward Sensitivity, Small Lever

- EC and SC rats increased responding on the small lever
- IC rats did not change their responding on the small lever



Overall Summary

- EC (and SC) rats compared to IC rats:
  - Poorer reward magnitude discrimination in both choice (Exp 1) and reward sensitivity (Exp 3) paradigms
    - May be due to increased generalization between magnitudes
  - Poorer performance on the DRL 30 task (Exp 1), a measure of impulsive action
    - Replicates Hill, Zeeb and Dalley studies
  - Increased self-controlled choices in the impulsive choice task (Exp 2)
    - Replicates Perry
- The results suggest that enrichment may be reducing reward sensitivity/discrimination and reward seeking behaviors
  - Lower reward sensitivity and/or motivation to seek rewards could play a role in the protective effect of enrichment against drug-seeking behaviors.
  - IC rats are better at reward-earning, except in the impulsive choice task
- Another possibility…
  - Differences in exploration/exploitation
  - EC rats appear to sample their environment more frequently
- Perhaps a combination of exploration and reward-seeking differences could explain the results of the combined experiments?

Acknowledgements

- Aaron Smith
- Jon Smith
- Dr. Tiffany Galtress
- Dr. Mary Cain
- Kansas State USRG funding