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Individual differences in impulsive and risky choice

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Individual differences in impulsive and risky choice

- Individual differences in impulsive and/or risky choice are related to:
  - Substance abuse (e.g., Bickel & Marsch, 2001; Carroll et al., 2009; deWit, 2008)
  - Pathological gambling (e.g., Alessi & Petry, 2003; MacKillop et al., 2011; Reynolds et al., 2006)
  - Obesity (e.g., Davis et al., 2010)
  - ADHD (e. g., Barkley, Edwards, Laneri, Fletcher, & Metevia, 2001; Solanto et al., 2001; Sonuga-Barke, 2002; Sonuga-Barke, Taylor, Sembi, & Smith, 1992)
- Impulsive and risky choice are trans-disease processes

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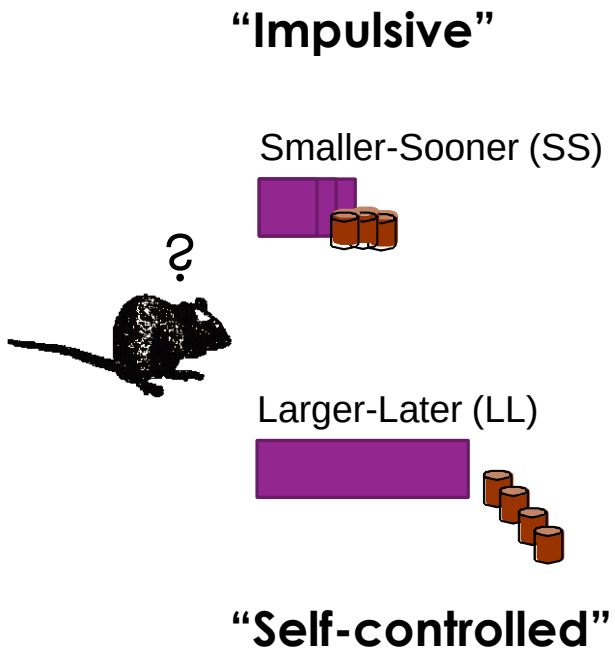
Impulsive choice: Method

- Offer rats choices between smaller-sooner (SS) and larger-later (LL) rewards (based on Green & Estle, 2003)
  - SS = 1 pellet in 10 s
  - LL = 2 pellets in 30 s
- Can manipulate delay to and/or magnitude of reward
- Choices of SS in most cases indicate impulsive choice



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Impulsive choice: Individual differences in rats

- In humans, impulsive choice appears to be a stable trait variable
- Are the most impulsive individuals at Time 1 also the relatively most impulsive individuals at Time 2?
- Studies have typically observed test-retest correlations in the .6-.7 range over periods ranging from 1 week to 1 year, comparable to other trait variables (Baker, Johnson, & Bickel, 2003; Jimura et al., 2011; Johnson, Bickel, & Baker, 2007; Kirby, 2009; Matusiewicz, Carter, Landes, & Yi, 2013; Ohmura, Takahashi, Kitamura, & Wehr, 2006; Peters & Büchel, 2009).

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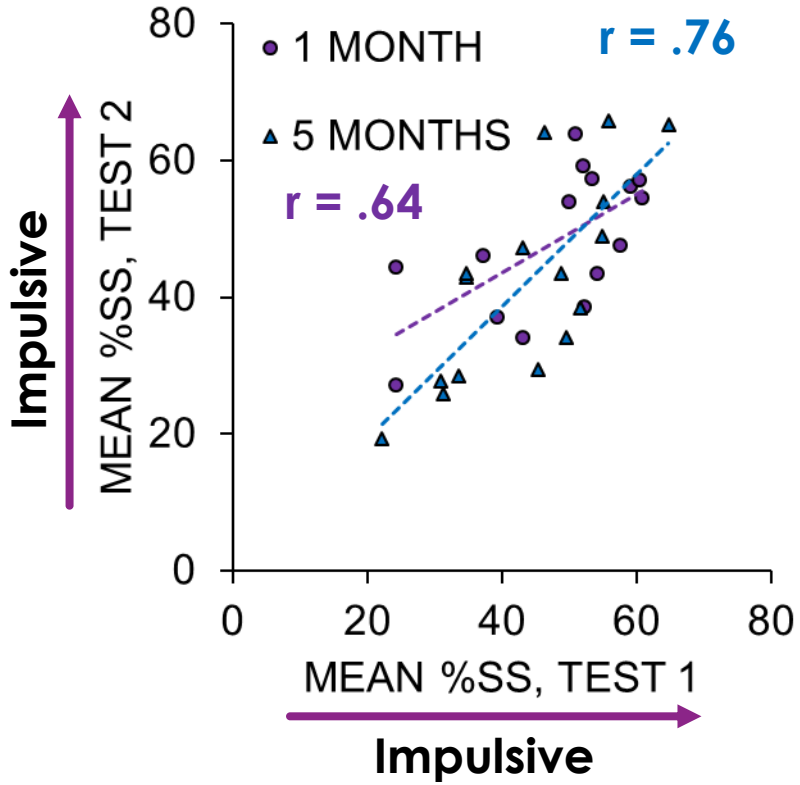
Impulsive choice: Individual differences in rats

- Galtress, Garcia and Kirkpatrick (2013); Garcia and Kirkpatrick (2013)
  - Individual differences in impulsive choice accounted for 22-55% of the variance in choice behavior
- Peterson, Hill and Kirkpatrick (2015)
  - Tested rats on impulsive choice with changes in LL delay (5→15→30→60 s)
  - Significant test-retest reliability at 1-month and 5-month delays



Peterson et al. (2015)

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Moderation of individual differences

- Given that impulsive choice appears to be a stable trait in rats, can we moderate impulsive choice?
- Three moderators of impulsive choice:
  - Time-based behavioral intervention
  - Genetic differences
  - Rearing environment

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Moderation of individual differences: Time-based interventions

- One factor that has emerged in the literature is timing processes
- More impulsive humans tended to overestimate interval durations (Baumann & Odum, 2012), and have *poorer temporal discrimination abilities* (Van den Broek, Bradshaw, & Szabadi, 1987)
- Adolescents with ADHD exhibit *poorer temporal discrimination abilities* (Barkley et al. 2001; Smith et al. 2002) and display steeper impulsive choice functions than controls (e.g., Barkley et al. 2001; Scheres et al. 2010; Wilson et al. 2011)
- More impulsive rats have *poorer temporal discrimination abilities* (McClure, Podos, & Richardson, 2014; Marshall, Smith & Kirkpatrick, 2014)
- Some previous studies have indicated that self-control can be promoted with delay-based interventions
  - **Humans**: Binder et al. 2000; Dixon et al. 1998; Dixon & Holcomb, 2000; Dixon, et al., 2003; Eisenberger &Adornetto, 1986; Neef et al., 2001; Schweitzer & Sulzer-Azaroff, 1995
  - **Pigeons**: Mazur & Logue, 1978
  - **Rats**: Stein et al., 2013

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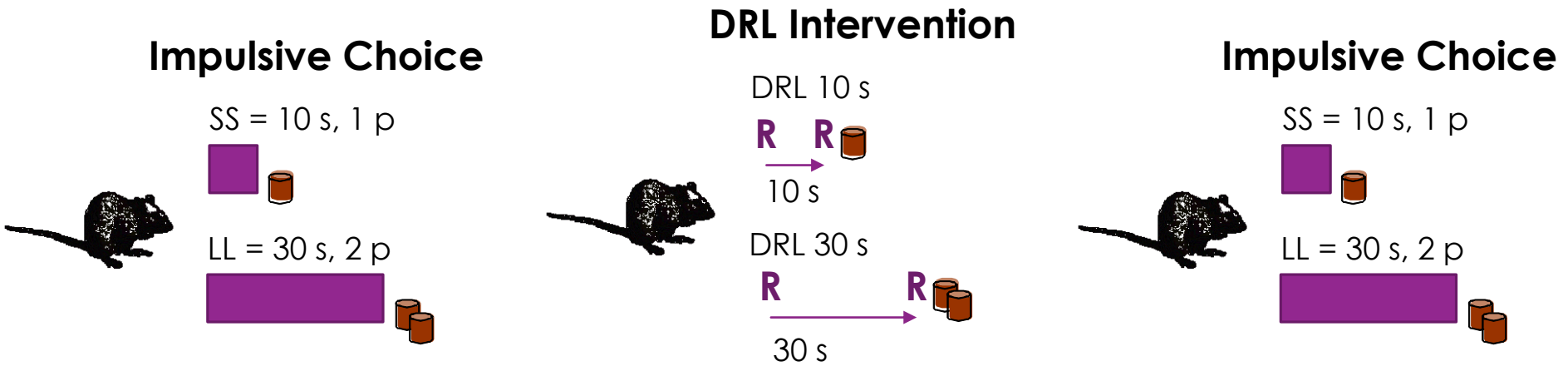
Moderation of individual differences: Time-based interventions



Smith, Marshall, & Kirkpatrick (2015)

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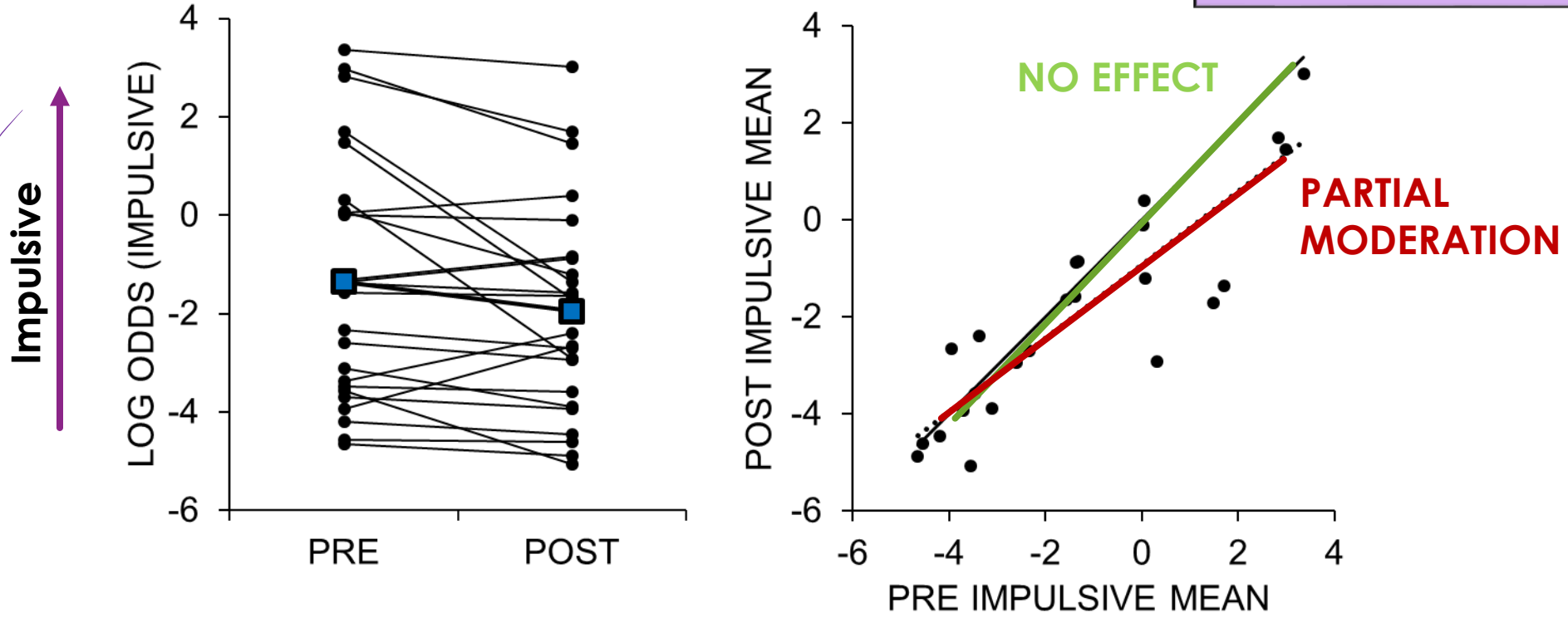
Moderation of individual diffe
Time-based interventions

Log Odds = $\log(N_{SS}/N_{LL})$
Log Odds = 0 Neutral
Log Odds > 0 Impulsive
Log Odds < 0 Self-controlled

The DRL intervention decreased impulsive choice
Partial moderation of individual differences



Smith, Marshall, & Kirkpatrick (2015)

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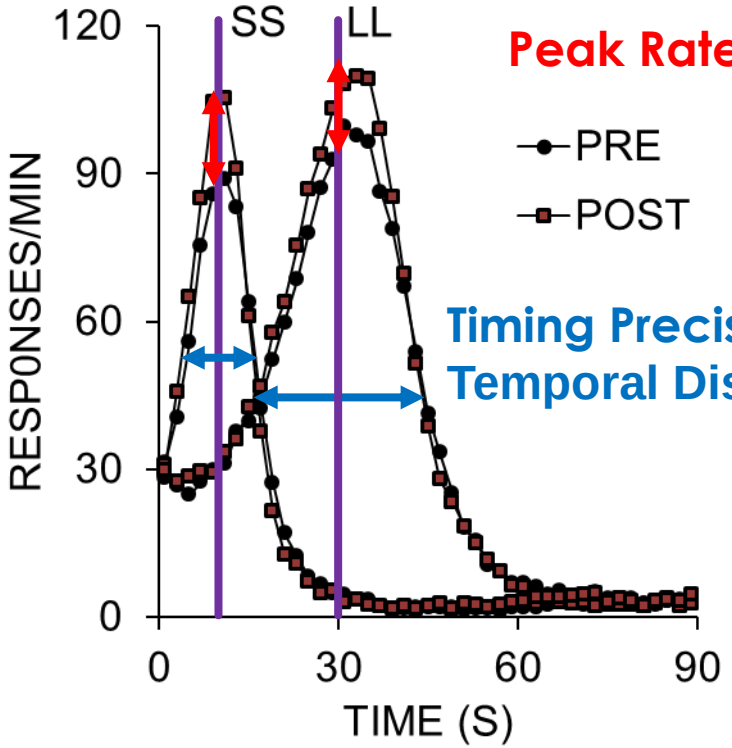
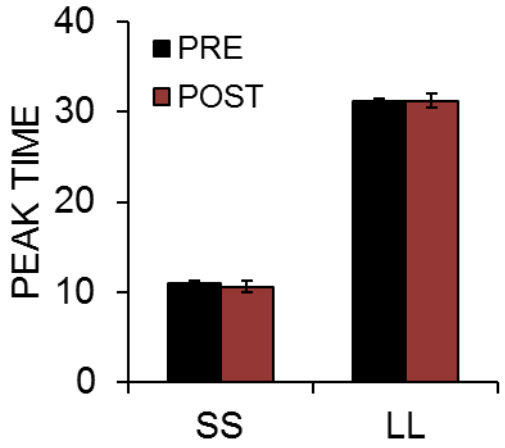
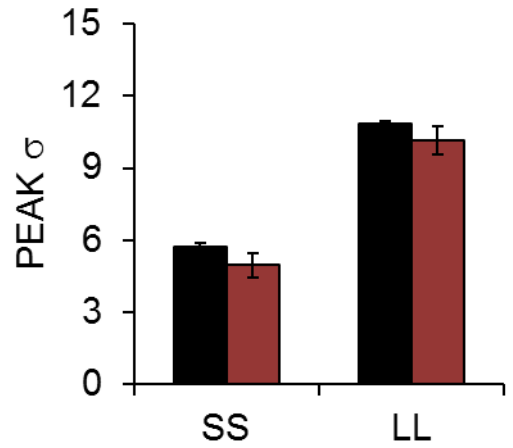
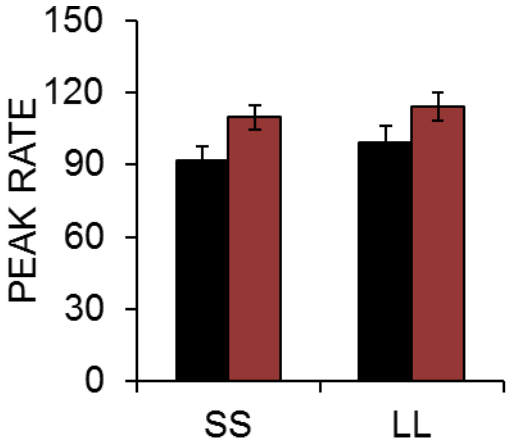
Moderation of individual differences: Time-based interventions

Timing Accuracy (Peak Time)









Smith, Marshall, & Kirkpatrick (2015)

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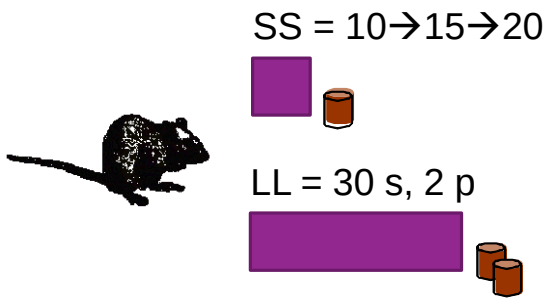
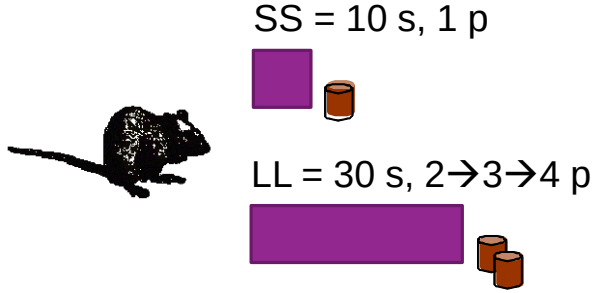
Moderation of individual differences: Strain differences

Impulsive Choice: Delay



Impulsive Choice: Magnitude



- Spontaneously Hypertensive Rats (SHR) versus Wistar Kyoto (WKY)
- Lewis (LEW) versus Wistar (WIS)
- Both SHR and LEW have been shown to display increased impulsive behaviors
  - Anderson & Diller, 2010; Bizot et al., 2007; Fox, Hand, & Reilly, 2008; García-Lecumberri et al., 2010; Hand, Fox, & Reilly, 2009; Huskinson, Krebs, & Anderson, 2012; Stein, Pinkston, Brewer, Francisco, & Madden, 2012
- Determined whether delay or magnitude sensitivity was responsible for any deficits

Garcia & Kirkpatrick (2013)

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Moderation of individual differences: Strain differences

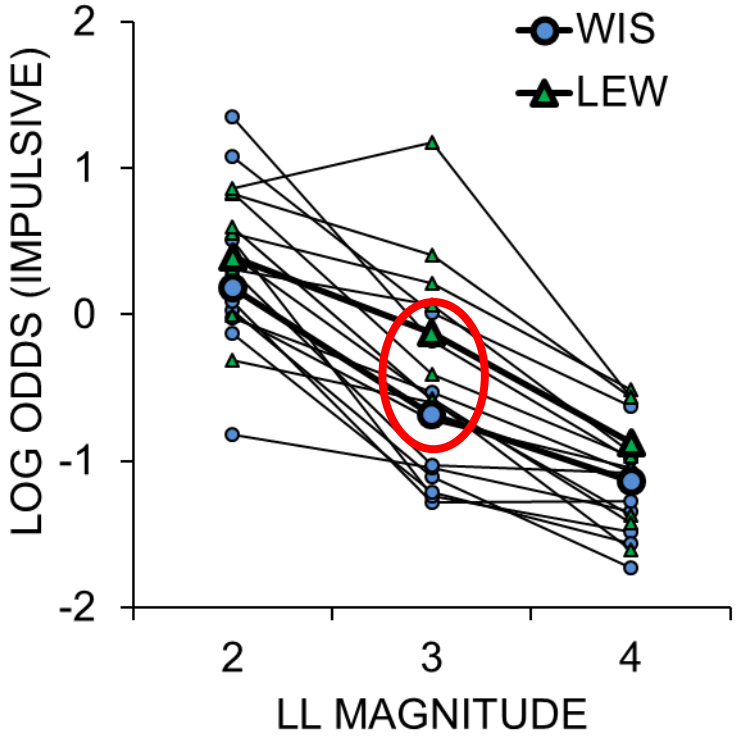
Impulsive Bias (μ)

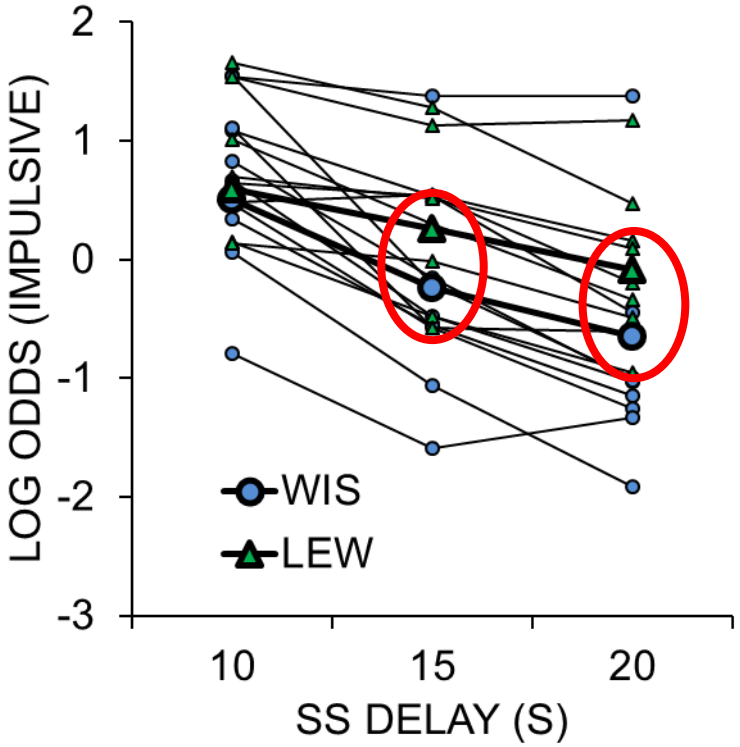
Sensitivity (slope)

SHR rats did not differ from WKY

The LEW strain showed increased impulsive choice relative to WIS

Impulsive





Garcia & Kirkpatrick (2013)

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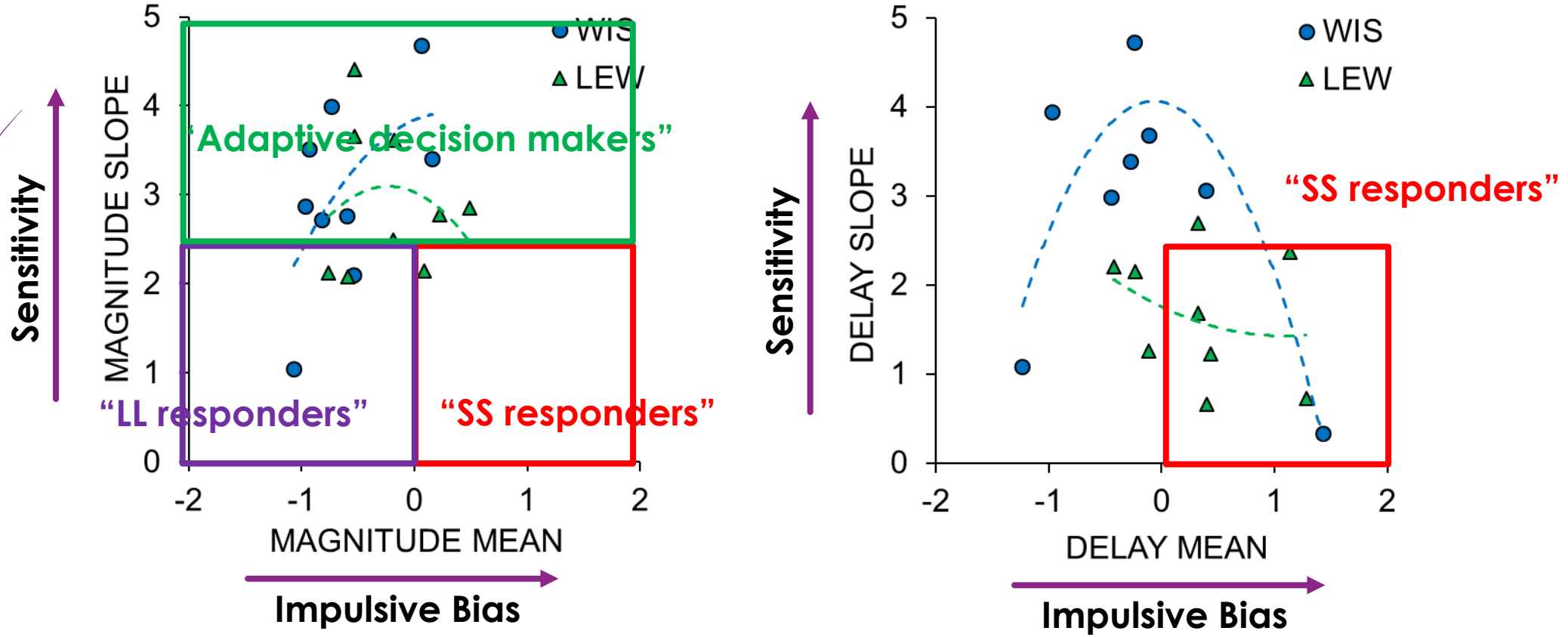
Moderation of individual differences: Strain differences

Weak moderation of individual differences in magnitude task
Strong moderation of individual differences in delay task



Garcia & Kirkpatrick (2013)

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Moderation of individual differences: Environmental rearing

- Early rearing environment has profound effects on brain and behavioral processes
  - Rearing in an enriched environment relative to a isolated environment appears to reduce impulsive choice (Kirkpatrick et al., 2013; Marusich & Bardo, 2009; Perry, Stairs, & Bardo, 2008)
  - Enrichment also appears to produce a protective effect against drugs of abuse, with reduced self-administration of stimulants, opiates, and ethanol (Bardo & Dwoskin, 2004; Cain, Mersmann, Gill, & Pittenger, 2012; Coolon & Cain, 2009; Deehan, Cain, & Kiefer, 2007; Deehan, Palmatier, Cain, & Kiefer, 2011; T. A. Green, Gehrke, & Bardo, 2002; J. K. Smith, Neill, & Costall, 1997; M. A. Smith, Bryant, & McClean, 2003; M. A. Smith et al., 2005; Stairs & Bardo, 2009)
  - And, enrichment decreases reward sensitivity and novelty-seeking (Bowling, Rowlett, & Bardo, 1993; Brenes, Padilla, & Fornaguera, 2009; Cain, Green, & Bardo, 2006; Gill & Cain, 2010; Lore & Levowitz, 1966; Zimmermann, Stauffacher, Langhans, & Würbel, 2001)

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Moderation of individual differences: Environmental rearing

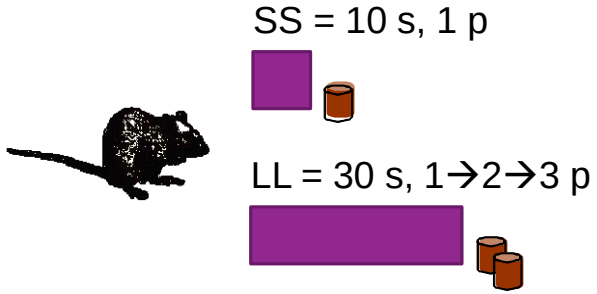
- Does enrichment moderate individual differences?

Rats reared from PND 21-51 in EC or IC

ENRICHED CONDITION (EC)

ISOLATED CONDITION (IC)

Impulsive Choice: Magnitude



Kirkpatrick et al. (2014)

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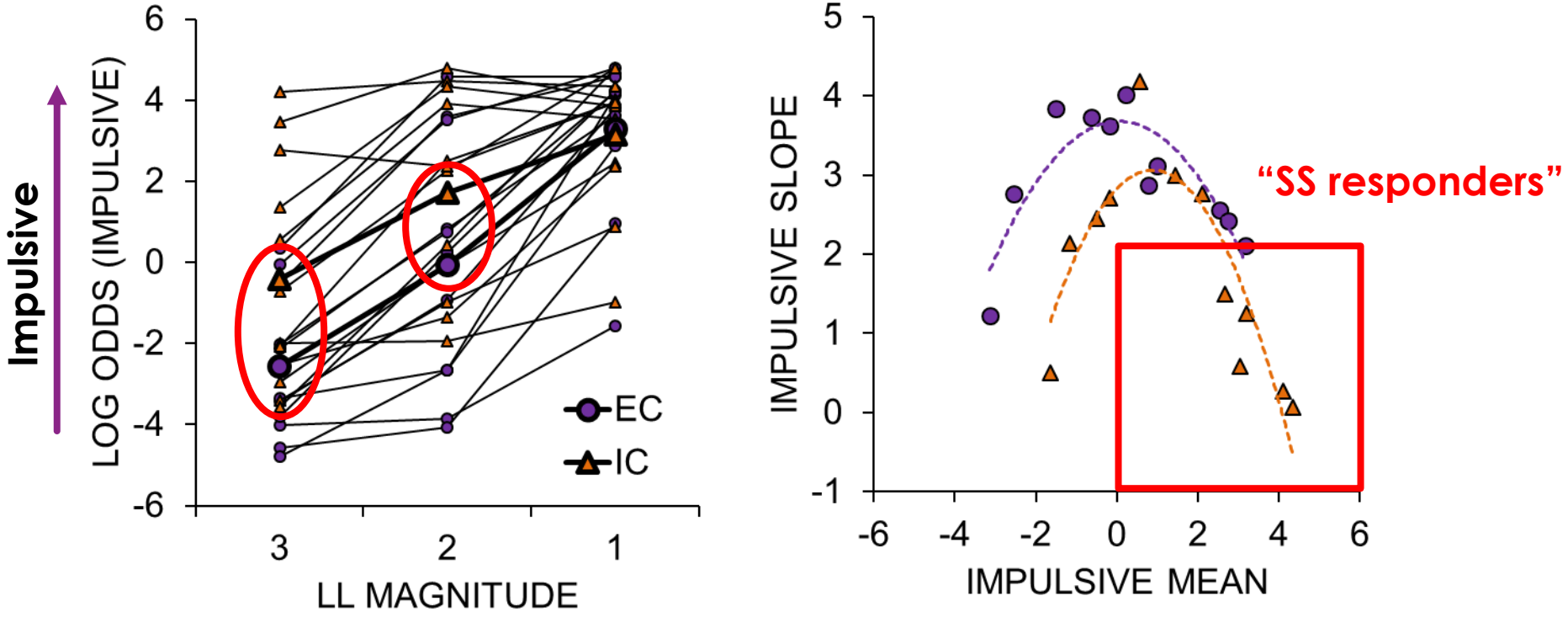
Moderation of individual differences: Environmental rearing

IC rearing increased impulsive choice relative to EC
Partial moderation of individual differences



Kirkpatrick et al. (2014)

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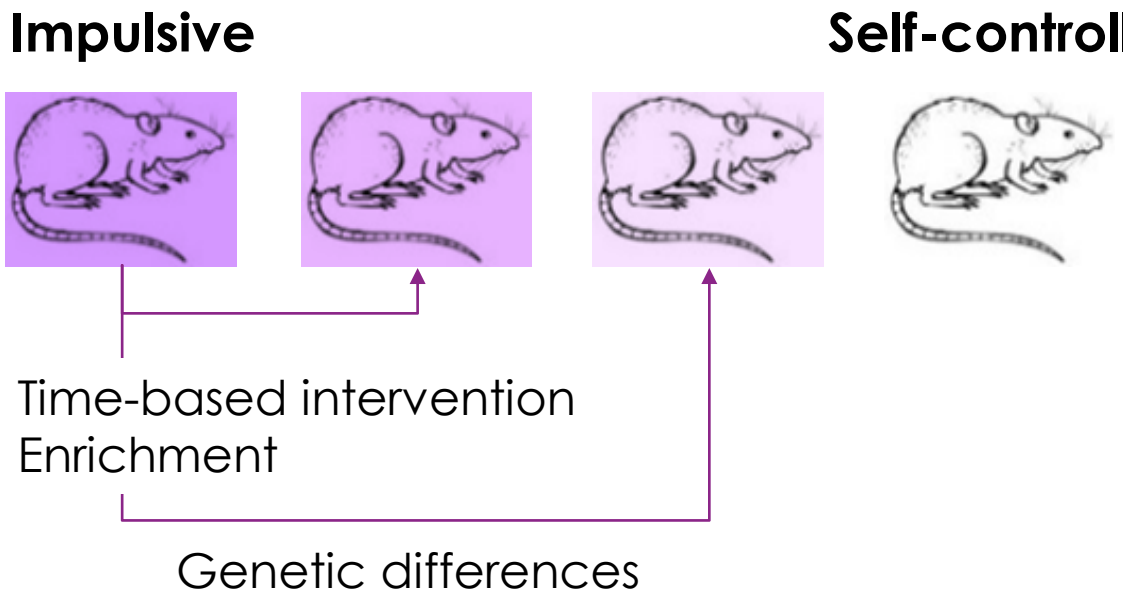
Impulsive Choice Summary

Impulsive choice appears to be a partially malleable trait



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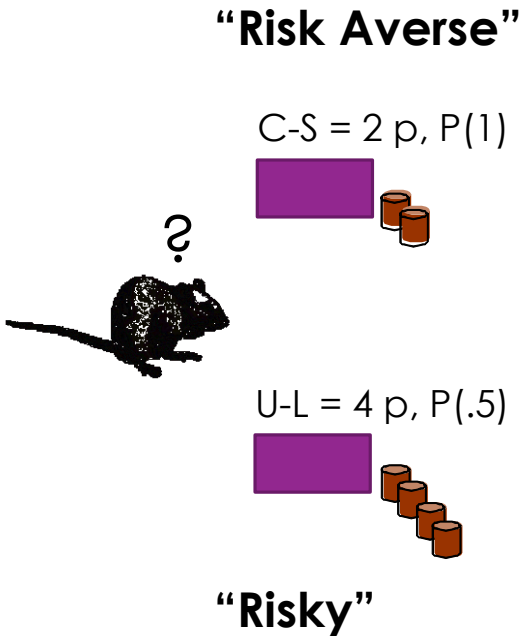
Risky choice: Method

- Offer rats choices between certain-smaller (C-S) and uncertain-larger (U-L) rewards
  - C-S = 2 pellets, P_{food} =1
  - U-L = 0 or 4 pellets, P_{food} = .5
- Can manipulate probability and/or magnitude of reward
- Choices of U-L in most cases indicate risky choice



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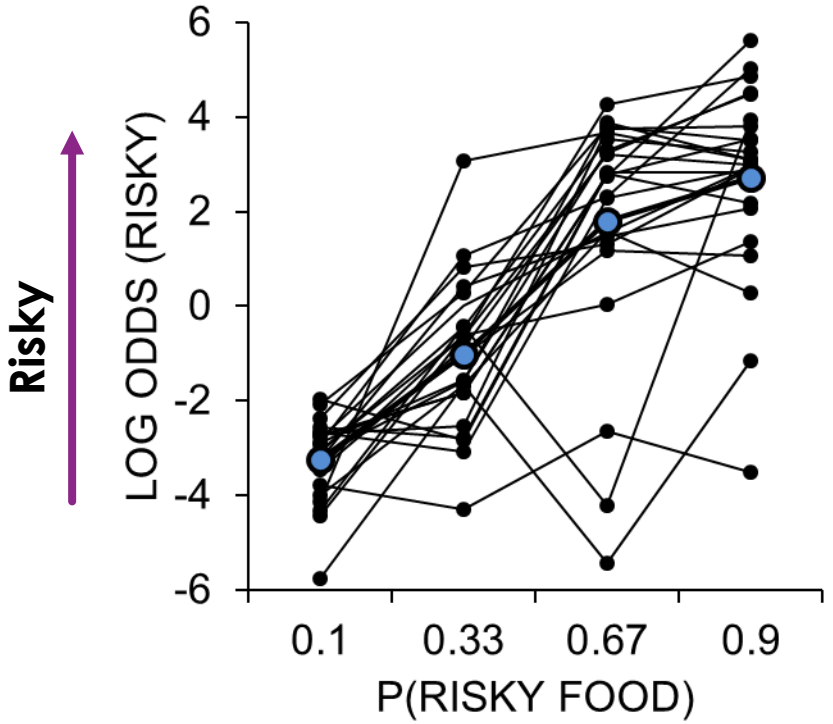
Risky choice: Individual differences in rats

Log Odds = log(N_{U-L}/N_{C-S})
Log Odds = 0 Neutral
Log Odds > 0 Risk Prone
Log Odds < 0 Risk Averse



Marshall & Kirkpatrick (2013)

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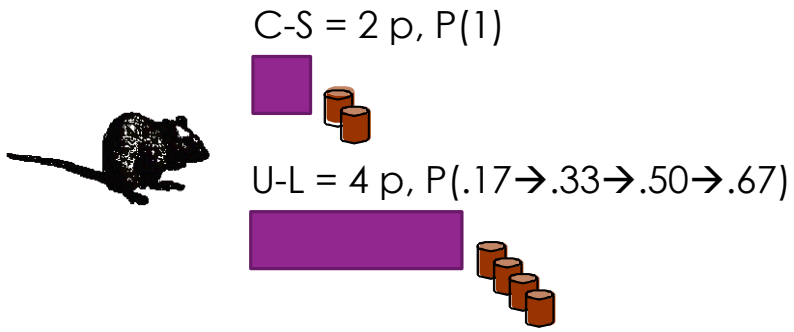
Moderation of individual differences: Environmental rearing

- Not much previous work on environmental rearing and risky choice
- Does enrichment moderate individual differences?

Risky Choice: Probability



Rats reared from PND 21-51 in EC or IC

ENRICHED CONDITION (EC)

ISOLATED CONDITION (IC)

Kirkpatrick et al. (2014)

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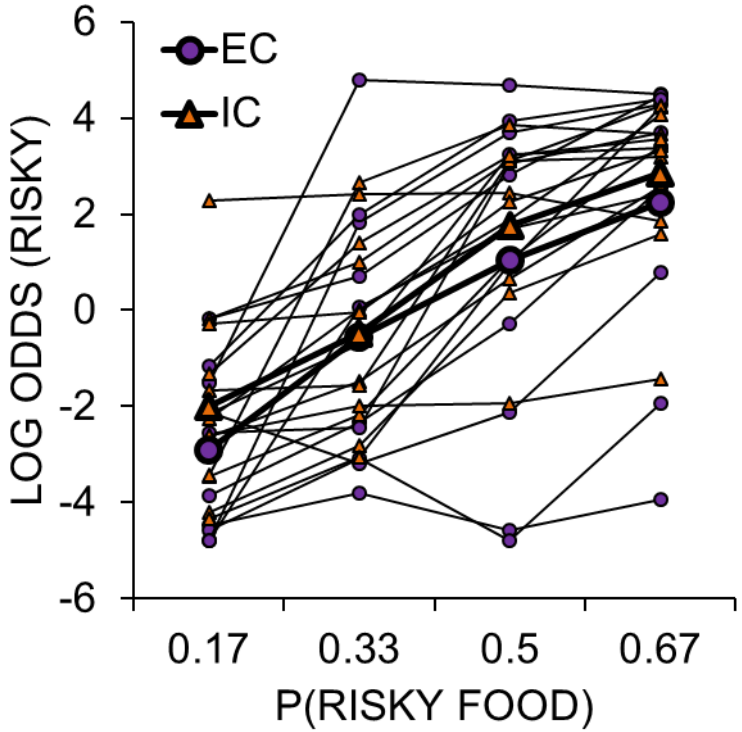
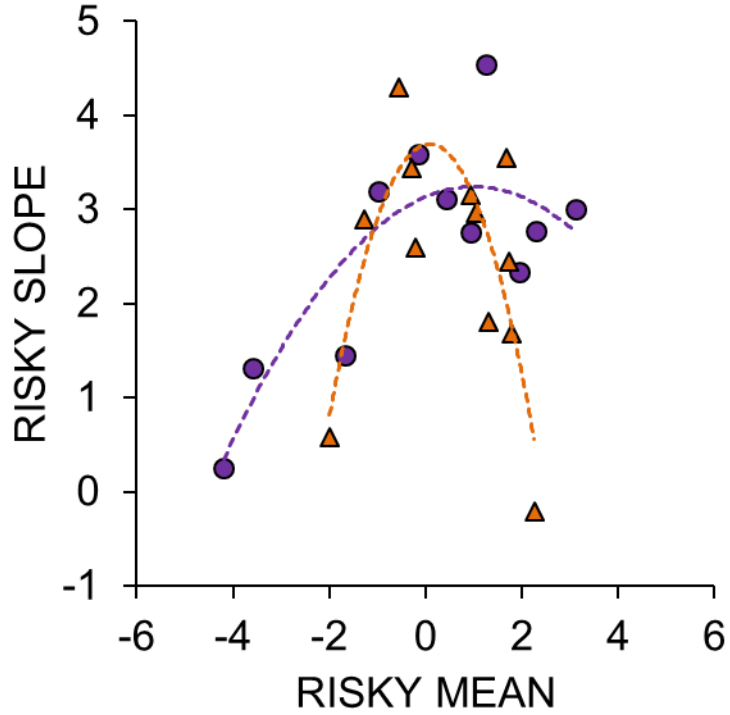
Moderation of individual differences: Environmental rearing

Rearing environment had no effect on risky choice
No moderation of individual differences





Kirkpatrick et al. (2014)

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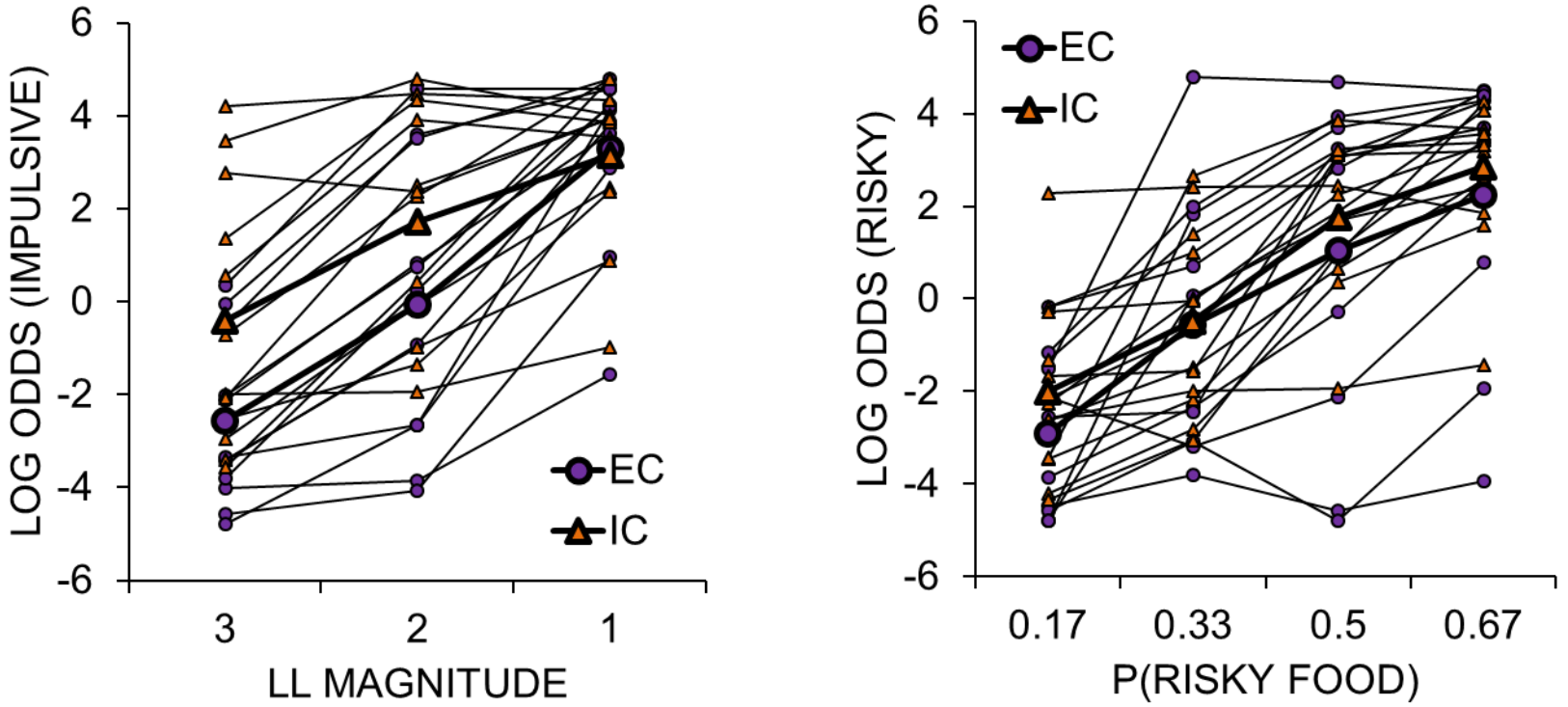
Environmental rearing effects on impulsive and risky choice comparison



Kirkpatrick et al. (2014)

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Risky Choice Summary

- There are prominent individual differences in risky choice in rats
  - More work is needed to assess test-retest reliability in risky choice
- Environmental rearing did not affect risky choice
- More research is needed on factors that moderate risky choice, and on the malleability of risky behavior

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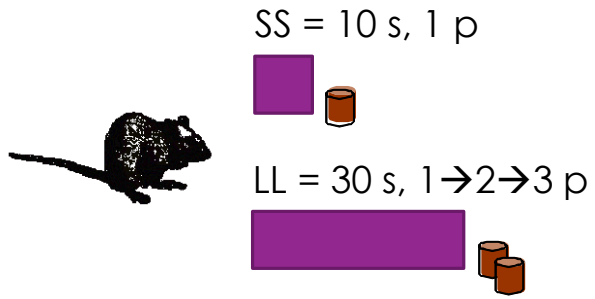
Correlation of impulsive and risky choice

- Rearing environment only partially moderated impulsive choice and did not moderate risky choice
- Therefore, we collapsed across rearing conditions to examine correlation issues in our individual rats

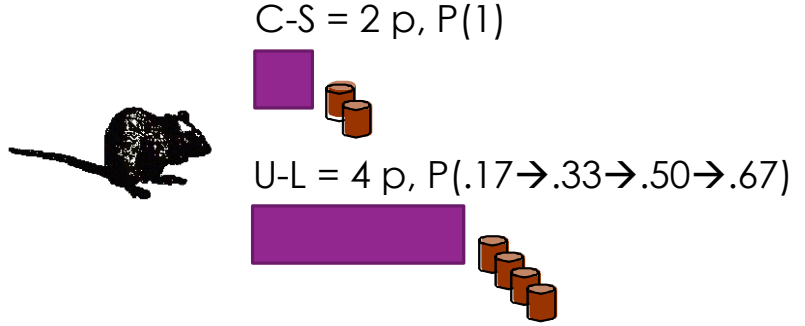
EC

IC

Impulsive Choice: Magnitude



Risky Choice: Probability



Kirkpatrick et al. (2014)

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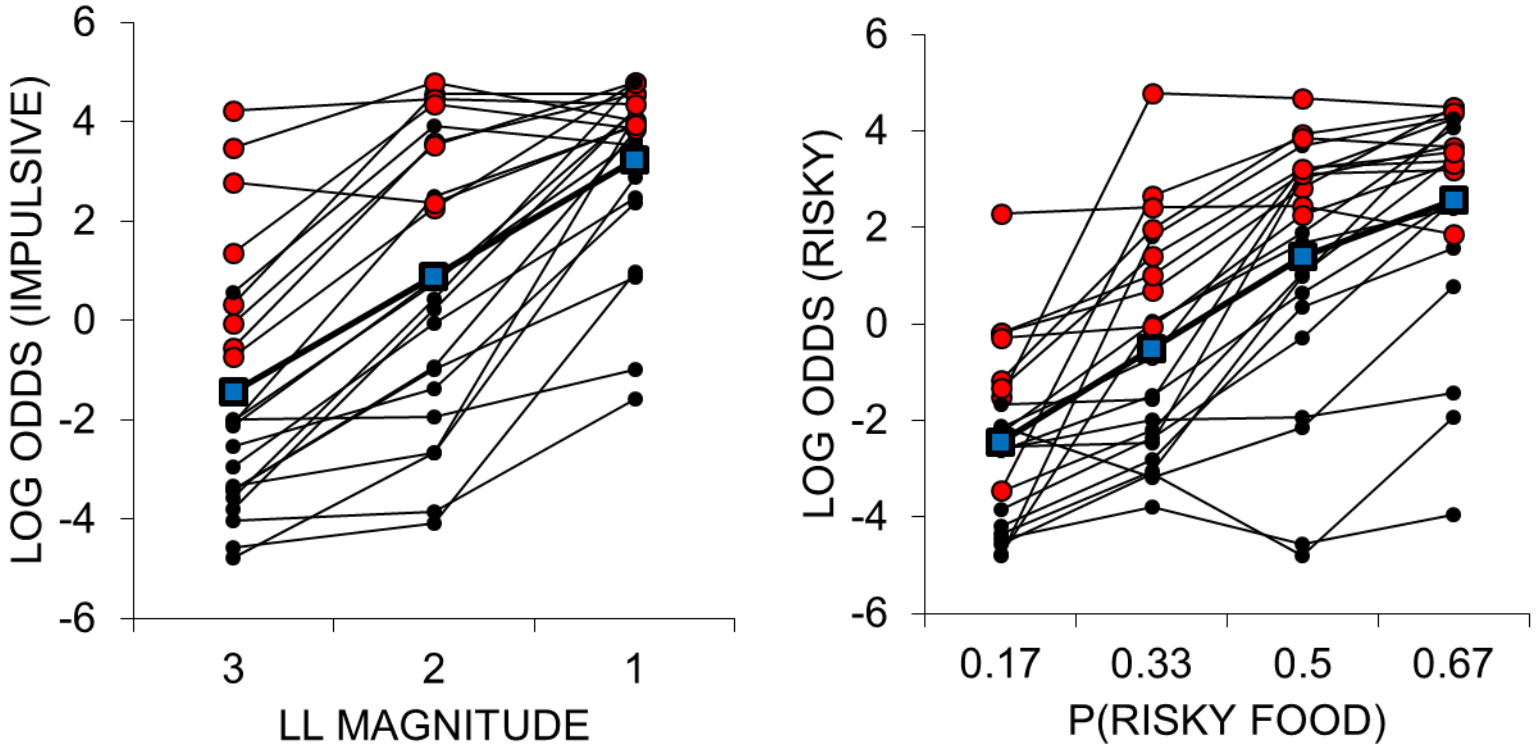
Correlation of impulsive and risky choice

"Impulsive and Risky" or I/R rats



Kirkpatrick et al. (2014)

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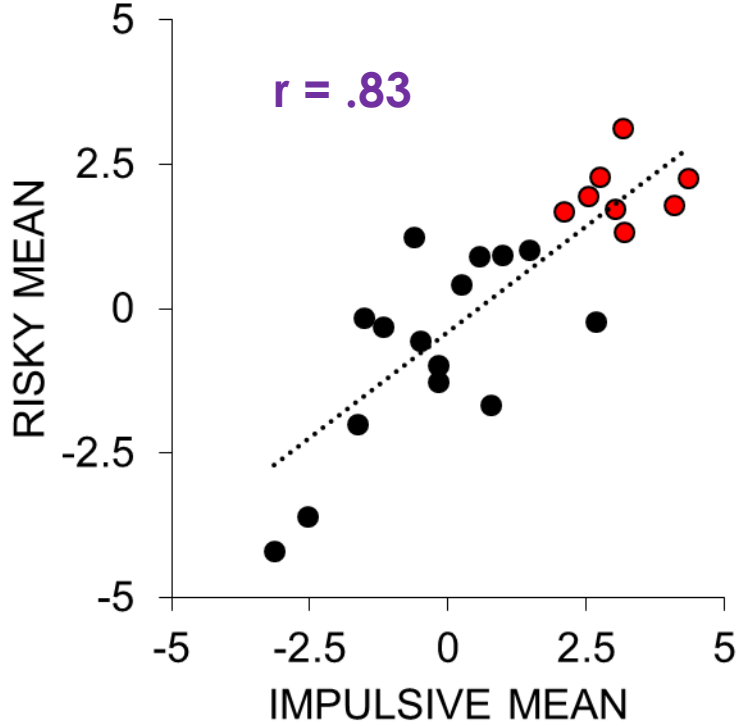
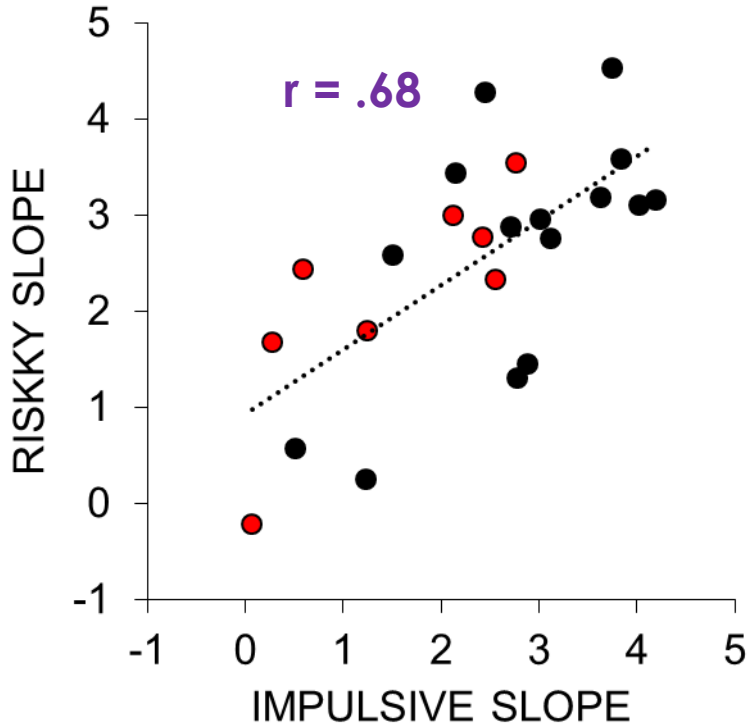
Correlation of impulsive and risky choice

Positive correlation between impulsive and risky mean
Positive correlation between impulsive and risky slope





Kirkpatrick et al. (2014)

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Impulsive-Risky Correlation Summary

- Correlations in impulsive and risky choice were evident
  - Positive correlation of impulsive and risky bias (see also Laude et al., 2014 for similar results in pigeons)
  - Positive correlation of impulsive and risky slopes
- Correlations were not moderated by environmental rearing

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Overall summary

- Impulsive and risky choice are traits (in rats and people)
  - Individual differences are stable and substantial
- Impulsive choice is malleable
  - Behavioral, environmental and genetic manipulations
- Impulsive and risky choice are correlated (relevance to trans-disease processes)
- Need to find ways of moderating risky choice
  - Dominance relationships
  - Behavioral interventions – probability sensitivity; reference points and loss chasing (Marshall & Kirkpatrick, 2015, PLOS ONE)

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