Junk food exposure disrupts selection of food-seeking actions in rats

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Introduction

- Alternative title: action selection after junk food
- Food-seeking actions are expected to be a function of expected food values
- Junk-food disrupts this

Hypothesis

1. Junk-food consumption makes food evaluation different, less sensitive to specific devaluation
2. Junk-food consuption impairs action-outcome and stimulus-outcome mappings, retrieval and formation

- Hypothesis 2 implies that junk-food impairs control on food-seeking behavior even when food values are not the primary basis for decision-making
- Hypothesis 2 is the one held by the authors, hypothesis 1 has already been 'confirmed' (Furlong et al. 2014)

Methods

- Sprague-dawley rats (n = 24)
- 85%~ by weight food restriction

Methods: pavlovian conditioning

- Training before diet exposure
- 8 daily sessions
- white noise & clicker; chocolate pellets || sweet condensed milk (SCM)
- outcome -> random time 30 sec

Methods: instrumental learning

- Training before diet exposure
- 11 days of training, 2 session per day
- 1 reward delivered (counterbalanced); chocolate pellets || SCM

Methods: instrumental learning

Days	Protocol
3-4	RR-5
5-6	RR-10
7-8	RR-15
9-11	RR-20

Junk-food diet

	Controls	Intermittent	Ad Libitum
Basal Diet	Chow + Water ad lib	Chow + Water ad lib	Chow + Water ad lib
Experimental Diet	-	+1 Hr junk-food access (CAF)	+24 Hr junk-food access (CAF)
Length	-	6 Weeks	6 Weeks
Pre-test	14 hours standard chow	14 hours standard chow	14 hours standard chow

Outcome devaluation testing

- 1 food devaluated at a time
- To devaluate: exposed to 1 hr of food ad lib (same two levers)
- 5 min choioce extintion test (no cues nor reward)
- Data: lever presses + food cup entries
- 48 later same test with the other food

Outcome devaluation test: why?

- The reinforcement learning theory posits that animals maximize rewards upon expected values
- Expected value is dependent on many variables, satiation is one of the most relevant
- Previous exposure to a specific food acts like a food-specific satiation
- Choices must reflect theoretical expect-value: pick the highest reward option more times
- If values changes, so must the election
- Extinction test picked, because it allows to separate effects from learning

Pavlovian-to-instrumental transfer testing

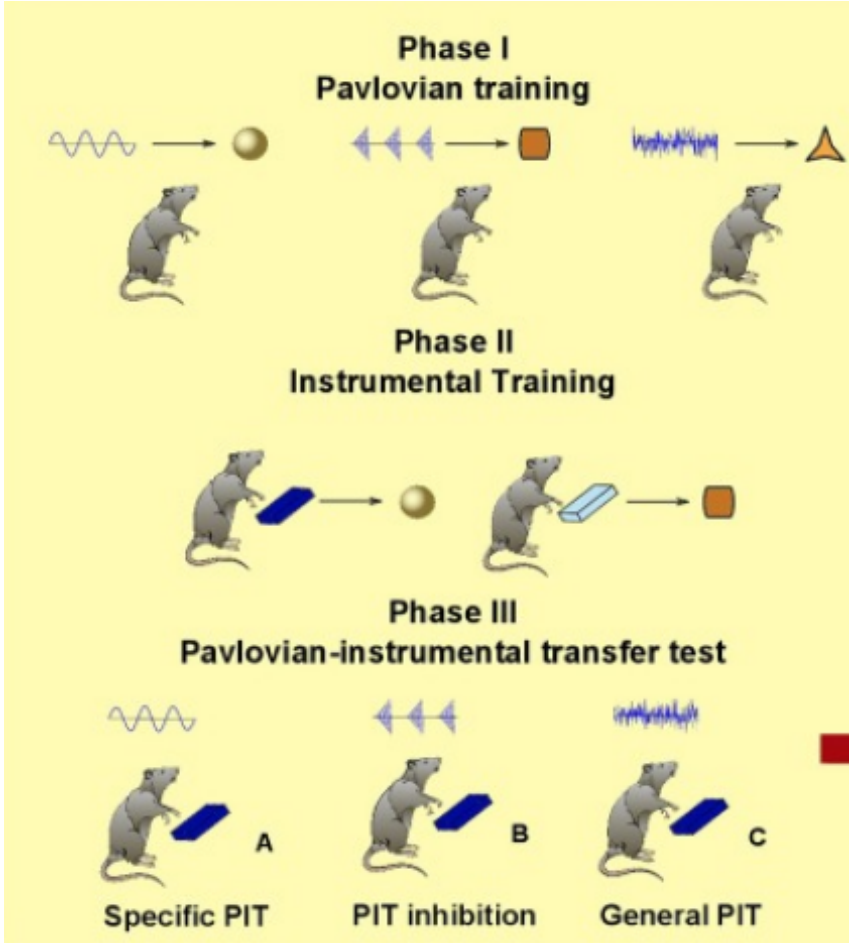

Figure 1: Pavlovian to instrumental transition

Pavlovian-to-instrumental transfer testing

- 48 hours after devaluation
- Data: lever-presses + food cup entries
- Non-contingent cue presentation (clicker || white noise)
- No outcome delivered
- 8 trials total with pseudorandom order
- cue presented for 2 minutes

Pavlovian-to-instrumental transfer testing: why?

- General (non-specific PIT): cue -> go eat food (regardless of cue type)
- Specific PIT: previously learned cue-food -> previously learned lever-food
- Authors want to measure impairements in cue-outcome / action-outcome mappings
- Possible because training was done previous to testing (learning not affected)

Experimental schedule

Experimental Timeline		
Phase	**Duration**	**Procedure**
Pavlovian Conditioning	8 d	Cue_1 → $Outcome_1$ Cue_2 → $Outcome_2$
Instrumental Training	11 d	$Response_1$ → $Outcome_1$ $Response_2$ → $Outcome_2$
Diet Exposure	6 weeks	Control, Intermittent or Ad libitum exposure
Mild Food Restriction	3 d	14 hrs chow per day
Outcome Devaluation Test 1	1 d	Sated on $Outcome_1$, Both levers extended, No outcomes.
Outcome Devaluation Test 2	1 d	Sated on $Outcome_2$, Both levers extended, No outcomes.
PIT Test	1 d	Cue_1 and Cue_2 present, Both levers extended, No outcomes.

Figure 2: Experimental phases

Results: behavioral training

Pavlovian

- Main measure: Cue responding vs pre-cue responding (food cup entries)
- There was no effect of diet in the main measure ($p = 0.82$); t-test $=/= 0$
- However, conditioned cup-entries during cue presentation ($p < 0.001$);
  food-cup entries matched cue

Results: behavioral training

Instrumental training

- Average of last 3 days of instrumental learning (mean response rate)
- Rats pressed more for chocolate pellet (mean 42.89 vs 22.10)
- Diet did not influence lever press rate ($p = 0.37$)
- Diet did not influence food preference ($p = 0.42$)

Results: junk-food exposure phase

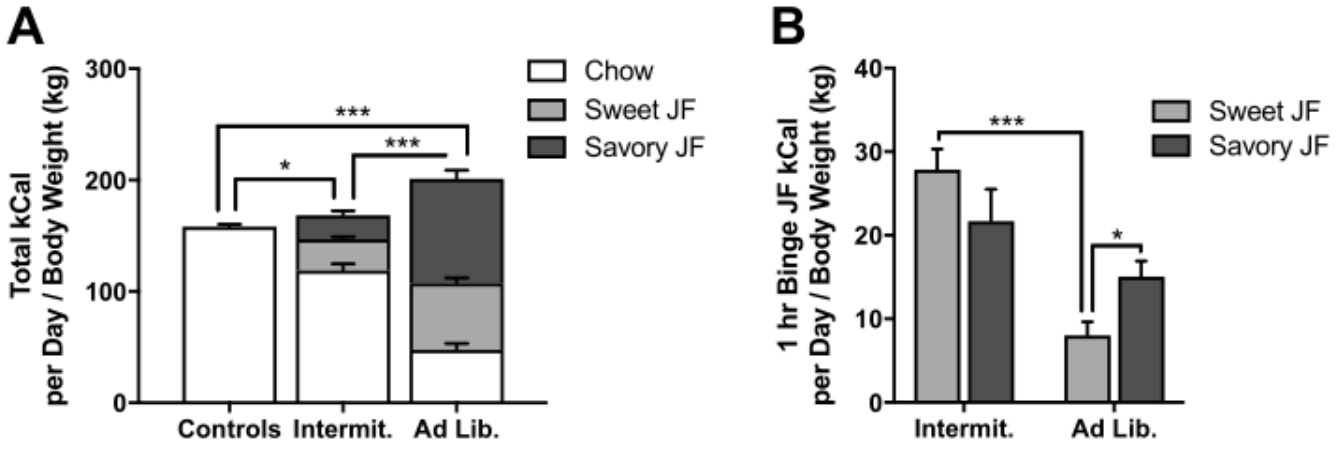

Figure 3: A. Average total calories, B. Average calories during binge feeding period

Results: Changes in body weight

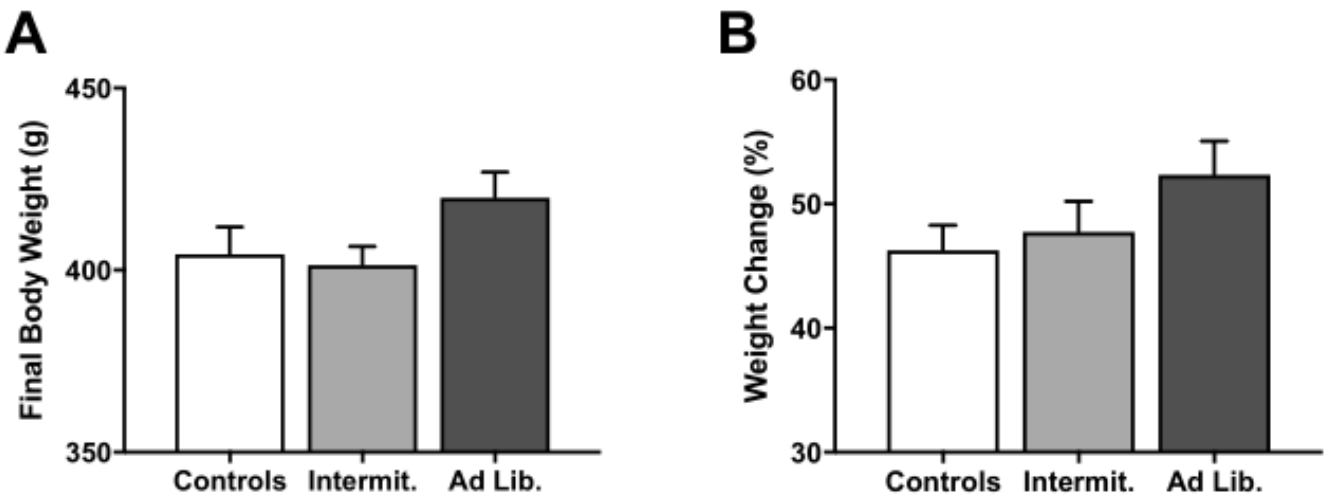

Figure 4: Only trend-level effects on bodyweight

Results: Outcome devaluation test

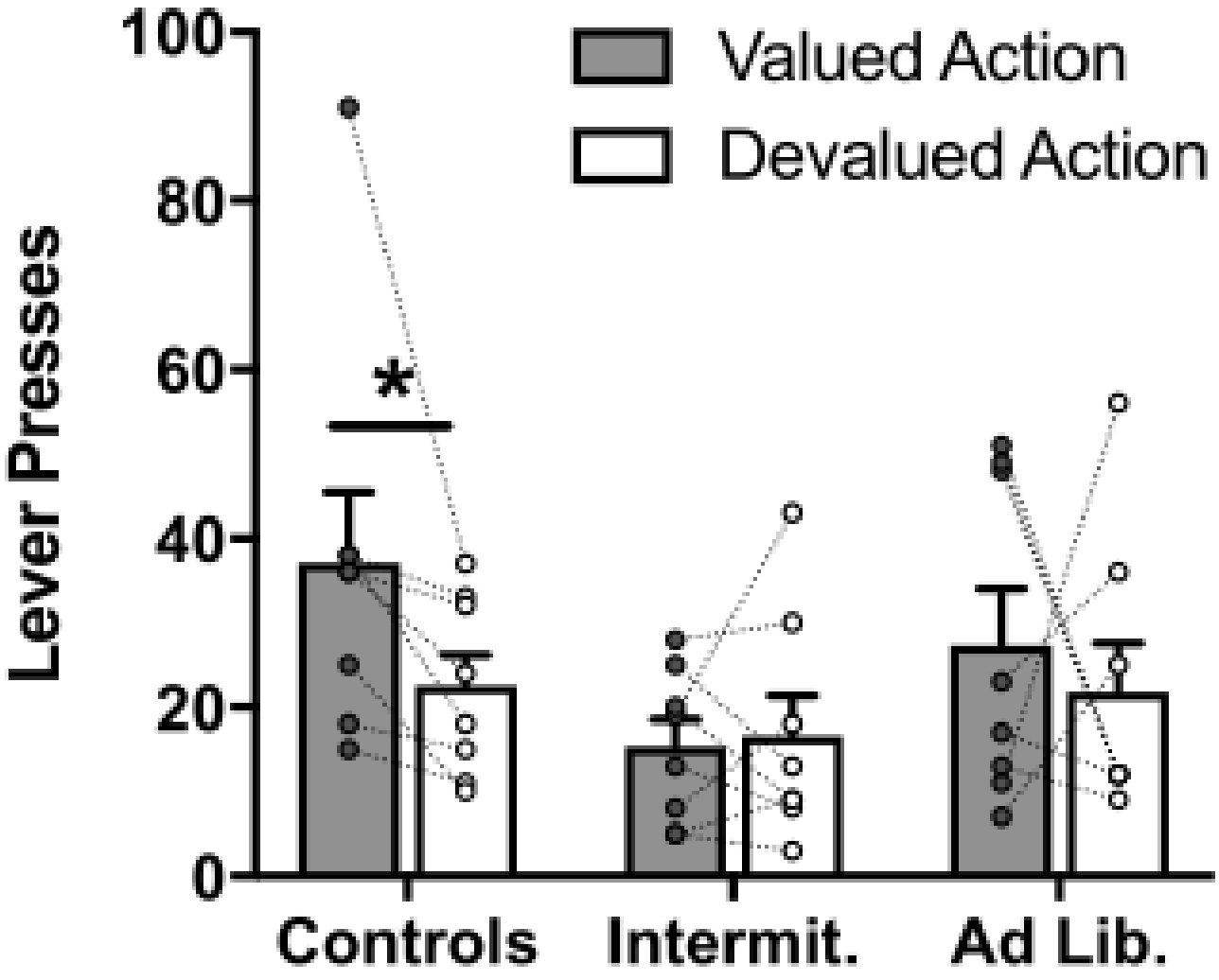

Figure 5: Adaptive control is lost in junk-food groups

Results: PIT test

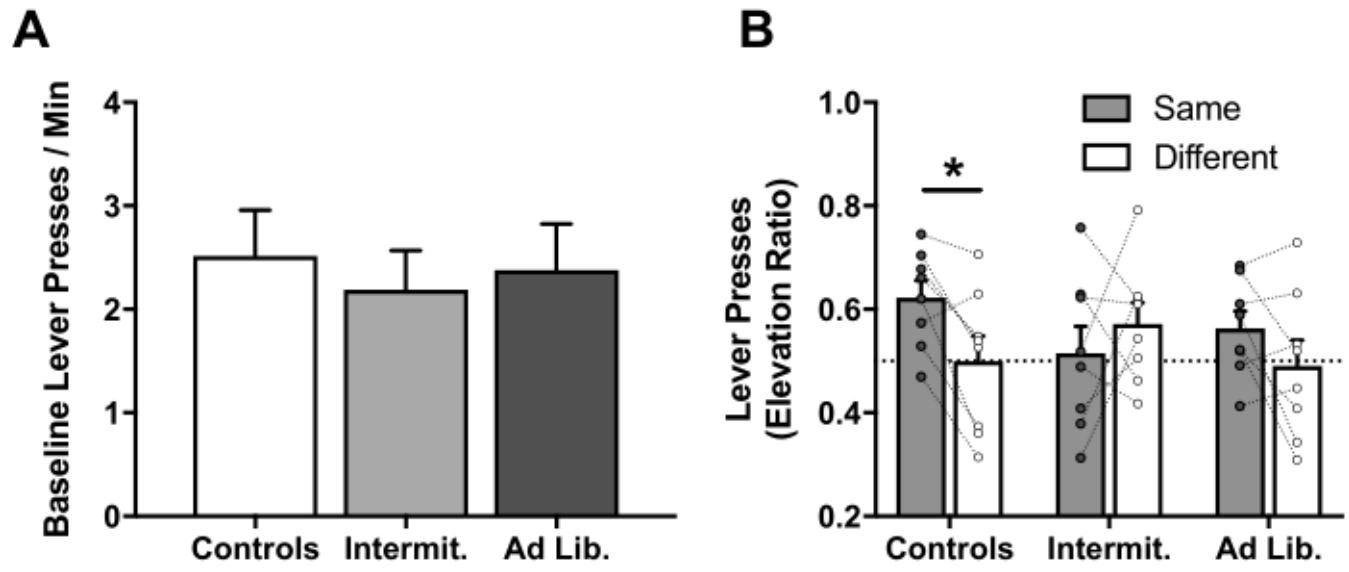

Figure 6: Food-seeking behavior is not augmented by junk-food diet. Same means correct behavior given a certain cue

Results: PIT test

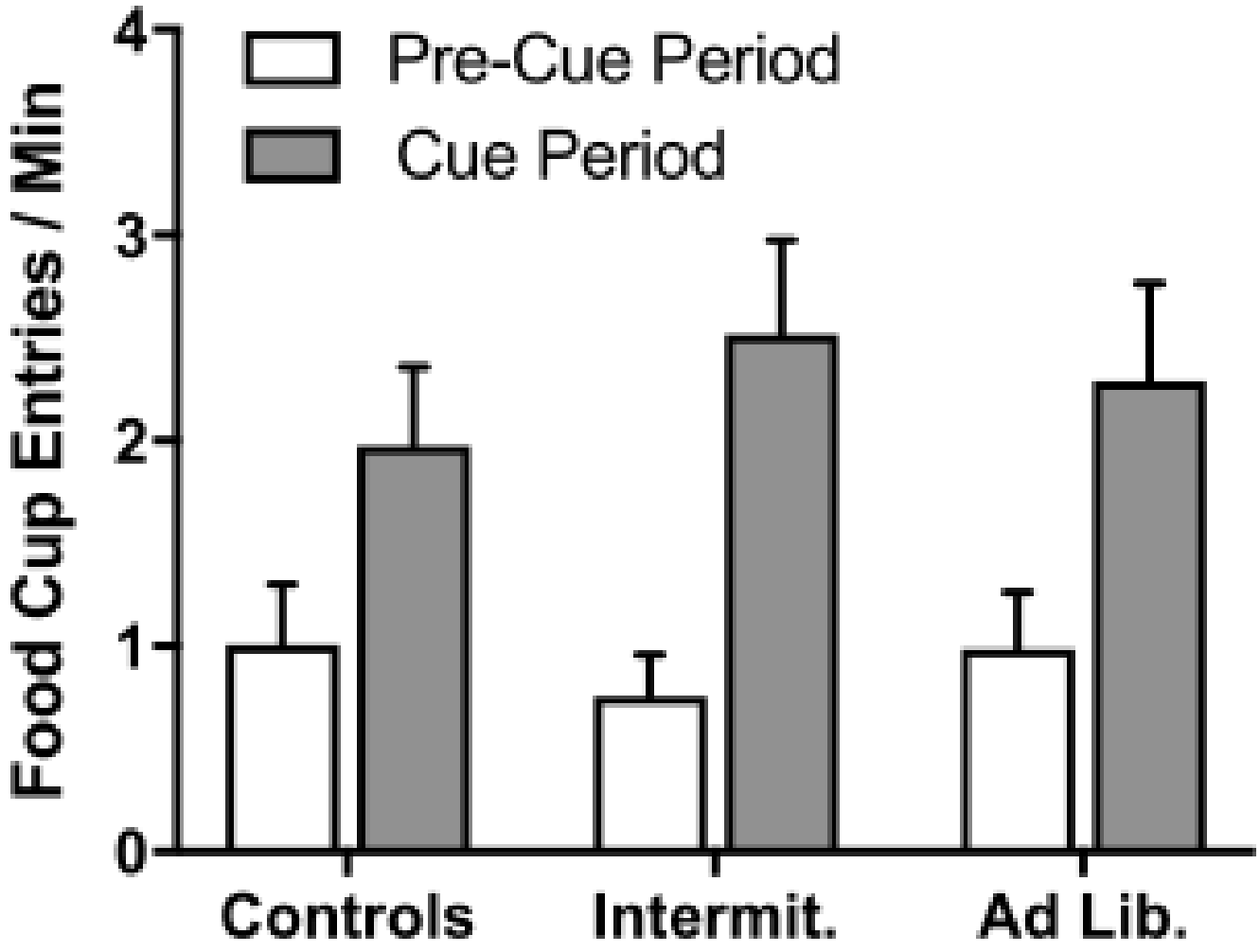

Figure 7: Conditioned response was similar between groups, notice how non-specific PIT is not affected

Discussion

- Decision-makings impairement is not due increase in food-seeking behavior
- This impairement is not caused by problems in the learning phase,
  a more plausible hypothesis is that value updating is impaired
- Moreover, even without the need to update values (PIT test), decision-making
  is impaired
- Retrieving or using cue-outcome / action-outcome is impaired

Discussion

- The problem might be an over-generalization of cues (a cue means food and just that)
- Sensitization of mesolimbic dopamine transmission (Avena and Hoebel 2003)
- Non-specific PIT was not affected. only specific PIT
- This difference might point that junk-food impair the use of environmental
  cues to guide food-seeking behavior

Discussion

- Intermittent group did not have an increase of food-seeking behavior?
- Authors posit that perhaps in the ad lib group junk-food created binge-eating micro-events
- I think, perhaps, the intermittent diet was too constant, so no perceived insecurity on food
  access was generated

Discussion: main point

- Junk-food exposure does not augmen food-seeking behavior magnitude
  it makes food-seeking behavior independent of top-down control, thus making it
  more ‘mindless’

References I

Avena, N.M., and B.G. Hoebel. 2003. "A Diet Promoting Sugar Dependency Causes Behavioral Cross-Sensitization to a Low Dose of Amphetamine." *Neuroscience* 122 (1): 17–20. https://doi.org/10.1016/S0306-4522(03)00502-5.

Furlong, Teri M., Hirosha K. Jayaweera, Bernard W. Balleine, and Laura H. Corbit. 2014. "Binge-like consumption of a palatable food accelerates habitual control of behavior and is dependent on activation of the dorsolateral striatum." *The Journal of Neuroscience: The Official Journal of the Society for Neuroscience* 34 (14): 5012–22. https://doi.org/10.1523/JNEUROSCI.3707-13.2014.