# Exploring Psychopathy through a Rodent Social Paradigm

**García-Pérez, M.A** [1,2,6]; Carrasco, B [1,2]; Cruz, K.G.[3], Cummings J.[3], Hatfield A.[3], Fellous J.M.[3,4,5], Contreras, M [1,3]; Valdés, JL [1,2].

1. Departamento de Neurociencia, Facultad de Medicina, Universidad de Chile.
2. Biomedical Neuroscience Institute (BNI), Facultad de Medicina, Universidad de Chile.
3. Department of Psychology, University of Arizona, Tucson, AZ, USA.
4. Department of Biomedical Engineering, University of Arizona, Tucson, AZ, USA.
5. Program in Applied Mathematics, University of Arizona, Tucson, AZ, USA.
6. Centro Nacional de Inteligencia Nacional (CENIA), Santiago, Chile.

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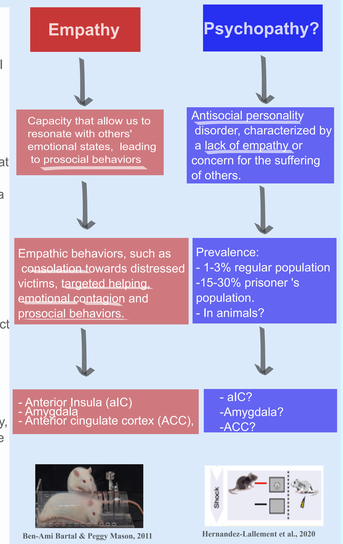
## Abstract

Psychopathy is a personality disorder primarily characterized by a lack of empathy and violent antisocial behavior, which often inflicts significant emotional and psychological harm on its victims. Currently, the absence of an animal model to effectively address this personality disorder poses a significant obstacle in investigating potential treatments. Here, we utilized unique operant conditioning rodent model of empathy to characterize a social paradigm that investigates the propensity to harm others while seeking personal gain. By considering factors such as familiarity, strain, and food availability, this paradigm offers valuable insights into this predisposition. During the initial phase of the task, the operant rat must establish a preference lever to acquire a reward (e.g., a drop of water with 20% sucrose). Subsequently, the operant rats face a choice between obtaining a reward by pressing the preferred lever, which comes at the expense of causing harm to the neighboring rat (either a Cagemate or Stranger) or opting to switch their preference and obtain the reward without causing harm to others.

Our findings revealed that, irrespective of whether the neighboring rat was a Cagemate or a Stranger, the operant rats consistently opted to switch their preference when it would result in causing harm to a conspecific. Interestingly, in the rat population sessions, we were able to identify and differentiate three distinct profiles: Switchers, Non-switchers, and Variable behavior. When examining the subjects' behavior, we observed that the animals who switched their preference, referred to as "Empaths" displayed a greater degree of empathy towards strangers, particularly when they were not food restricted. In contrast, the Non-switchers, whom we referred to as "Psychopaths," exhibited a consistent preference for causing harm to other rats, regardless of factors such as familiarity, strain, and food availability. This observation suggests that Non-switchers, unlike Switchers, lack of selectivity and inflict harm indiscriminately.

**Keywords: Psychopathy, empathy, operant conditioning, behavior, social paradigm, empathic decision**.




## Methods

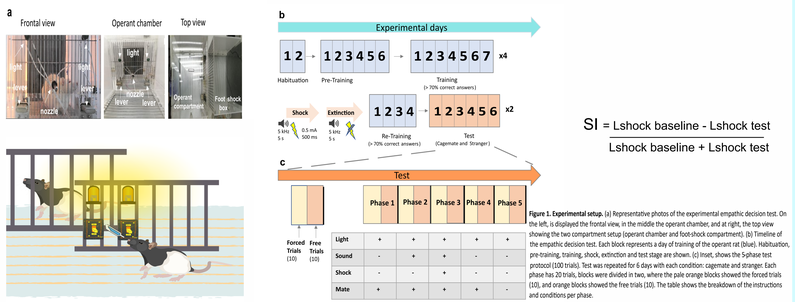



**Figure 1. Experimental setup.** (a) Representative photos of the experimental empathic decision test. On the left, is displayed the frontal view, in the middle the operant chamber, and at right, the top view showing the two compartment setup (operant chamber and foot-shock compartment). (b) Timeline of the empathic decision test. Each block represents a day of training of the operant rat (blue). Habituation, pre-training, training, shock, extinction and test stage are shown. (c) Inset, shows the 5-phase test protocol (100 trials). Test was repeated for 6 days with each condition: cagemate and stranger. Each phase has 20 trials, blocks were divided in two, where the pale orange blocks showed the forced trials (10), and orange blocks showed the free trials (10). The table shows the breakdown of the instructions and conditions per phase.

(Hernandez-Lallement et al., 2020)

## Results

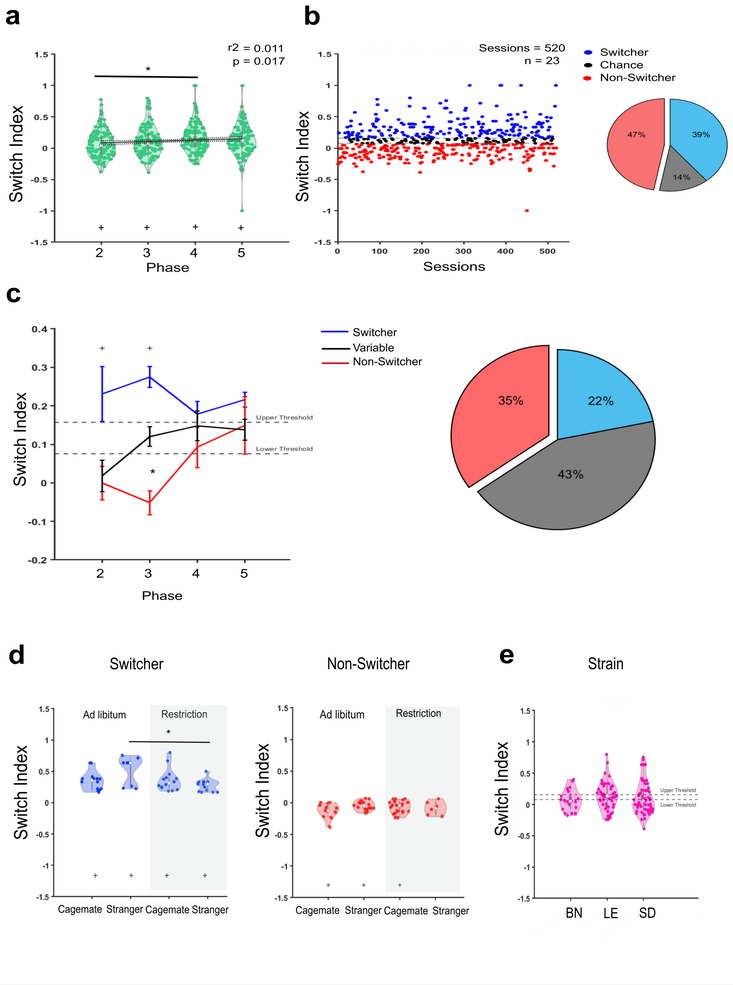



Figure 2: Subject Variability in the Empathy-decision test. (a) Population Behavior Analysis: A violin plot illustrates Switch Index (SI) across 520 sessions (n = 23 rats) per phase. Phase 2 differed significantly from phase 4 (p = 0.017). Positive correlation observed between SI and test phases (r2 = 0.011, p = 0.017). SI per phase significantly differed from chance (p < 0.05, Two-sided Wilcoxon signed-rank test). (b) Session Classification: Scatter plot displays SI values from phases 2-5. Sessions categorized as Switcher (blue dots), Non-Switcher (red dots), and Chance (black dots) based on a 95% confidence interval derived from phase 3 (CI = 0.076 - 0.157). Non-Switcher sessions constituted 47% (n = 245), Chance 14% (n = 74), and Switcher 39% (n = 201). (c) Subject-Specific SI Patterns: Distinct SI patterns were identified: Switcher (22%), Non-Switcher (35%), and Variable (43%) individuals. Significant differences observed between Switcher and Non-Switcher at phases 2 and 3 (p = 0.024, p < 0.001, respectively). Variable individuals differed from Non-Switcher at phase 3 (p = 0.028). No differences detected at phases 4 and 5. (d) Impact of Food restriction on empathetic decision (Phase 3): Food conditions (Ad libitum vs. Restriction) and familiarity conditions (Cagemate vs. Stranger) were analyzed. Switcher: Stranger ad libitum (n = 4) vs. Stranger restriction (n = 4) showed significant differences (*p = 0.021). Non-Switcher groups exhibited no differences. (e) Strain Influence (Phase 3): Strain differences (Brown Norway, Long Evans, Sprague Dawley) were not significant (p = 0.429).

## Conclusions

- This research presents a novel behavioral approach that can identify empathic and non-empathic behaviors consistently.
- We could observe that many animals consistently avoided harming a conspecific, irrespective of **familiarity and strain**.
- Only a modulation induced by **food restrictions** was observed towards stranger mates.
-Sessions where animals remained in ***ad libitum*** conditions, displayed more empathic responses with strangers than under a **food restriction** schedule.
- We found that 25% of the animals showed a **Switcher behavior** on phase 3 of the task, preventing causing distress to its mate, suggesting an **empathic-like behavior.**
- 35% of the animals consistently did not change their behavior or even increase the number of press levers, which caused distress over their mates, indicating a **Non-empathic behavior.**
- A variable population (43%) was also detected with behavior alternating between empathic-like or non-empathic-like depending on the day or sessions.
- During Phase 3, when the animal must decide whether to harm or not its mates, we observed the three well-defined behaviors

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## Contact information

alexandrag@uchile.cl
alexandra.garcia@cenial.cl

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