



Revista Mexicana de Análisis de la Conducta
ISSN: 0185-4534
ISSN: 2007-0802
editor@rmac-mx.org
Sociedad Mexicana de Análisis de la Conducta
México

Blystad, Magnus H.
A critical review of the rodent social release paradigm: empathy or social reinforcement
Revista Mexicana de Análisis de la Conducta, vol. 45, núm. 2, 2019, pp. 199-222
Sociedad Mexicana de Análisis de la Conducta
Distrito Federal, México

DOI: <https://doi.org/10.5514/rmac.v45.i2.75563>

Disponible en: <https://www.redalyc.org/articulo.oa?id=59367995004>

- Cómo citar el artículo
- Número completo
- Más información del artículo
- Página de la revista en redalyc.org

redalyc.org

Sistema de Información Científica Redalyc
Red de Revistas Científicas de América Latina y el Caribe, España y Portugal
Proyecto académico sin fines de lucro, desarrollado bajo la iniciativa de acceso
abierto

A CRITICAL REVIEW OF THE RODENT SOCIAL RELEASE PARADIGM: EMPATHY OR SOCIAL REINFORCEMENT

UNA REVISION CRÍTICA DEL PARADIGMA DE LIBERACIÓN SOCIAL EN ROEDORES: EMPATÍA O REFORZAMIENTO SOCIAL

Magnus H. Blystad
Oslo Metropolitan University

Abstract

Research on social animal behavior is growing within social neuroscience. Basic research on behavioral processes in animals has always been the forte of behavior analysis, but the collaboration and crossover between the fields are minimal. This is illustrated with the well-established rodent social-release paradigm, which features two conflicting explanations: empathic motivations from social neuroscience, and social reinforcement from a behaviorist point of view. A three-term contingency analysis identifies areas within the studies of social release where more research is needed, and which is neutral regarding explanatory causes. This analysis allows for

Magnus H. Blystad. OsloMet – Oslo Metropolitan University. Department of Behavioural Science.

The author thanks the “Experimental Analysis of Behavior – Translational and Conceptual Research” group at Oslo Metropolitan University’s Department of Behavioral Science. Øystein Vogt, for comments on conceptual and experimental aspects of the paper and Professor Espen Borgå Johansen for continuous support during the whole writing process, fruitful discussions and constructive criticism. In addition, thanks are due to Dr Eilifsen for valuable input in the latter part of the writing process. Email: mblyst@oslomet.no

the integration of data from both the empathy and the social reinforcement point of view. This neutrality opens the way for collaborations and invites joint efforts to study and increase understanding of different variables in the rodent social-release paradigm.

Keywords: Social Neuroscience, three-term contingency, prosociality, animal models, rats

Resumen

La investigación sobre conducta social animal está creciendo dentro de la neurociencia social. La investigación básica sobre procesos conductuales en animales ha sido siempre el fuerte del análisis de la conducta pero la colaboración y traslape entre ambos campos es mínima. Esto puede ilustrarse con el bien establecido paradigma de liberación social, que involucra dos explicaciones en conflicto: motivaciones empáticas desde de la neurociencia social y reforzamiento social desde un punto de vista conductual. Un análisis basado en la contingencia de tres términos identifica áreas dentro de los estudios de liberación social donde hace falta más investigación y que es neutral respecto a las causas en las explicaciones. Este análisis permite la integración de datos desde los puntos de vista de la empatía y el reforzamiento social. Esta neutralidad abre el camino para colaboraciones e invita esfuerzos conjuntos para estudiar y aumentar la comprensión de las variables involucradas en el paradigma de liberación social.

Palabras clave: Neurociencia social, contingencia de tres términos, prosocial, modelos animales, ratas

Social behavior arises because one organism is useful to another as part of its environment. A first step, therefore, is an analysis of the social environment and any special features it may possess (Skinner, 1953, p. 298). The topic of this article is how the behavior-analytic three-term contingency could systematize studies and findings of animal models of social behavior. Additionally, the three-term contingency analysis reveals important areas for future research.

Modelling social behavior in animals is a topic of growing interest, especially in social neuroscience, the subfield of neuroscience focusing on the neural correlates of social behavior (Cacioppo & Berntson, 1992; Matusall, Kaufmann, & Christen, 2011). As a field of research, social neuroscience is marked by a multilevel integra-

tive analysis of social, behavioral and cognitive data, but it does not seek to replace either behavior or social science (Decety & Cacioppo, 2010). This subfield of neuroscience traditionally has worked mainly with humans, but investigators acknowledge that data from animal studies should validate findings from humans (Decety & Christen, 2014), and that they are necessary when using the more invasive techniques that are needed to better understand topics such as empathy (Keysers & Gazzola, 2016). Not all social behavior can be modeled in animals (i.e., behavior reliant on language, or with human-specific features). However, several classes of behavior relevant to the field of social neuroscience (e.g., empathy, pro-sociality) show degrees of evolutionary conservation (de Waal, 2012; Decety, Bartal, Uzevovsky, & Knafo-Noam, 2016; Decety, Norman, Berntson, & Cacioppo, 2012; Pérez-Manrique & Gomila, 2018), inviting investigation in nonhuman animals. While prosocial is defined as “actions that are intended to benefit another” in both the most relevant experimental paper on social release (Bartal, Decety, & Mason, 2011, p. 1427) and in recent conceptual work (Jensen, 2016), empathy is more broadly used. As many as eight different phenomena have been identified as empathy in social-neuroscience, but a conceptual discussion of the term is beyond the scope of this review. Readers are advised to see Cuff, Brown, Taylor, & Howat (2016) or Pérez-Manrique & Gomila (2018) for further discussion. The most relevant use of empathy is in the first social-release paper, which used empathic concern described as “an other-oriented emotional response elicited by and congruent with the perceived welfare of an individual in distress” (Bartal et al., 2011, p. 1427).

Within social neuroscience, behavioral animal studies are the point of origin, and once the behavior is adequately understood, the social neuroscientist moves on to investigating neural correlates of the behavior. For instance, mutual reward preference in rats was demonstrated (Hernandez-Lallement, van Wingerden, Marx, Srejjic, & Kalenscher, 2014) before neural correlates were investigated (Hernandez-Lallement, van Wingerden, Schäble, & Kalenscher, 2016). However, the step from behavior to neural correlates can be problematic.

Whereas a molecular level of understanding of both behavior and influencing factors is necessary to avoid causal mistakes in neuroscience (Krakauer, Ghazanfar, Gomez-Marin, MacIver, & Poeppel, 2017), behavior is often a neglected part of modern neuroscience that has focused more on technological than conceptual advancement (Le Moal & Swendsen, 2015). This present review elucidates that problem with a selected literature review of a specific animal model using the behav-

ior analytic three-term contingency. This approach continues the implementation of behavior analysis into neuroscience and vice versa. Such implementation is important to properly understand behavior (Moore, 2002; Skinner, 1974), and some even argue that both fields are subfields of biology with a logical fitness (Donahoe, 1996, 2002, 2017). That is not to say it is unproblematic. As Schaal (2005) stated, some of the concerns about neuroscience are with studies that retain mentalistic explanations, disregard the learning history of the organism being studied, and how the past necessarily has shaped the brain. However, the current critical review uses the three-term contingency to systematize selected studies and findings with a recent animal model, and thus will avoid mentalism that otherwise could prove problematic.

The exemplar animal model that is the subject of this review is one suggested for prosocial behavior: the rodent social-release paradigm (Bartal et al., 2011); however, the approach should prove useful with any behavioral animal model. Prosociality, with its related topic of empathy, has not been studied much within behavior analysis (however, for a presentation see Schlinger, 1995), but is important and relevant within social neuroscience (Batson, 2009; Decety & Lamm, 2006). Using rats instead of humans to investigate social behavior allows a broader range of neuroscientific tools, and even if the animal subjects cannot self-report, rats do exhibit specific responses to social situations with conspecifics. Two examples are social facilitation (i.e., the mere presence of conspecific influences responses; Weiss, Segev, & Eilam, 2014) and emotional contagion (i.e., an emotional, behavioral reaction that occurs on perceiving the emotion of others, as when witnessing conspecifics in pain; Carrillo et al., 2015). Additionally, rats communicate positive and negative affect via ultrasonic vocalizations (USVs) (Kim, Kim, Covey, & Kim, 2010; Willadsen, Seffer, Schwarting, & Wöhr, 2014), reviewed by Brudzynski (2013). They also use odor-based communications (Debiec & Sullivan, 2014).

In addition to investigating important topics within social neuroscience, the social-release paradigm was chosen as it has been subjected to critical replication from a behavioral perspective (Hachiga et al., 2018; Hiura, Tan, & Hackenberg, 2018; Schwartz, Silberberg, Casey, Kearns, & Slotnick, 2017; Silberberg et al., 2013), which offered an alternative explanation of social release based on social reinforcement. The present review offers a framework for integrating all previous research, regardless of causal explanations (empathy vs social reinforcement). This review makes a similar claim to that of earlier researchers that to understand the brain it is

necessary to understand behavior (Catania, 2000; Krakauer et al., 2017; Le Moal & Swendsen, 2015). Before presenting and discussing the three-term contingency analysis, however, it is necessary to describe the social-release paradigm in detail.

Animal Models of Social Behavior: The Social-Release Paradigm

The social-release paradigm features a pair of cage mates, where one rat is trapped inside a clear plastic tube (Bartal et al., 2011) known as a restrainer. Being thus trapped causes both behavioral and physiological stress-like effects in rats (Ely et al., 1997; Paré & Glavin, 1986). The restrainer can be opened from the outside either by manual interaction with the door (e.g., tipping it open with the head and/or forelimbs) or by leaning on a counterweight extending from the top of the door. One rat is trapped in the restrainer, and the trial begins once the second rat is put into the experimental space. The dependent variable is latency to door opening. The free rat is removed if door opening does not occur within a predetermined time. In the original experiment, 60 min max time was allowed before removing the rat if it did not open the restrainer door (Bartal et al., 2011), but our research with a different habituation and training design indicates that a much lower (<10 min) max time can be used (Blystad, Andersen, & Johansen, 2019). A latency analysis showed that (1) after first opening the door the latency goes down and remains short throughout the remainder of the trials, (2) latency goes down and remains short even if the released cage mate cannot physically interact with the free rat after being released (Bartal et al., 2011). The main interpretation of the latency results has been empathic concern; perceiving the trapped cage mate motivated prosocial door opening. A role of social stimuli is indicated by the result showing that the number of rats that opened increased when the restrainer contained a cage mate when compared to an empty restrainer. Independent variables in this procedure are different manipulations of the experimental environment such as social learning history (Bartal et al., 2014), drugs (Tomek, Stegmann, & Olive, 2018) or stress (Sato, Tan, Tate, & Okada, 2015).

In a second variant of the social-release paradigm, the experimental arrangement described above was slightly modified. Sato et al. (2015) trapped and soaked one cage mate in a water-filled area and separated the soaked cage mate from a free rat with a transparent plastic wall. The wall contained a door that could only be opened from the free rat's side. The side of the trapped rat contained water, from which

the trapped rat would try to escape. Again, the free rat could approach the door to open and release the trapped rat, thus creating a similar design to that of Bartal et al. (2011). Sato et al.'s results were consistent with Bartal et al. (2011) in that the free rat opened the door, releasing the soaked cage mate. Claims of rodent empathy by Sato et al. (2015) and Bartal et al. (2011), however, have not gone uncontested. In a commentary on Bartal et al. (2011), Vasconcelos, Hollis, Nowbahari, & Kacelnik (2012) suggested that prosocial behavior could be described without including elements of empathy; namely without any sharing of emotions. This was the case for explaining similar helping behavior in ants. In that study, ants released a tied down ant from the same colony (Nowbahari, Scohier, Durand, & Hollis, 2009). Furthermore, in a replication of Bartal et al. (2011), Silberberg et al. (2013) suggested that social contact and time-dependent degradation of neophobia, a fear of new objects, could explain the observed release of the cage mate. Similarly, in a replication of Sato et al. (2015), Schwartz et al. (2017) found that the helping behavior also could be explained by the reinforcing property of proximity to water in addition to the effects of social reinforcement.

This criticism has spurred another approach to the social-release paradigm spearheaded by behaviorists. Focusing on social contact and social reinforcement, Hiura et al. (2018) used the social-release paradigm to investigate social reinforcement. They set out to do an "... analysis of social contact as a reinforcer, measured in multiple ways, relative to food reinforcers, and as a function of price and motivational variables" (p. 5). To this, they added that empathy-based explanations would be made superfluous if the behavior could be explained in terms of social reinforcement (Hiura et al., 2018). Thus, Hiura et al. echoed Silberberg et al.'s (2013) assertion that social contact after the trapped conspecific was released was a necessity for such releasing to occur.

Empathic concern vs. social reinforcement

Terminology and design have differed greatly between social-release experiments rooted in behaviorism (Hiura et al., 2018) or social neuroscience (Bartal et al., 2011; Sato et al., 2015; Tomek et al., 2018). Although reviews of rodent models of empathy exist (e.g., Sivaselvachandran, Acland, Abdallah, & Martin, 2016), no attempts have been made to integrate and review both social reinforcement and empathy-based studies of rodent social release. Research from either field contrib-

utes little to the other. The criticism of the empathy explanation might be addressed briefly before being discarded (Tomek et al., 2018) or not even mentioned at all (Shan, Bartal, & Mason, 2016). Thus, the three-term contingency will be used to analyze and systematize selected data from the social-release paradigm. With the three-term contingency, these two main approaches to the problem can be included in a manner that remains neutral regarding causality, but which elucidates what has been investigated and what is lacking.

A Three-Term Contingency Systematization

The traditional three-term contingency consists of behavior antecedents (stimulus, A), behavior (the response occasioned by a stimulus, B) and consequences (reinforcement, C) (Skinner, 1953). However, research on the social-release model also focuses on previous conditions of the organism itself. To add this level of analysis, an organism (O) is included in Table 1, which summarizes the social-release research. From a neuroscience perspective, the O is where future neural manipulations will occur (such as in Hernandez-Lallement et al., 2016); however, for the behavior analyst the O could perhaps be removed in that antecedents encompass the organism's learning history (i.e., neural manipulations or neuroactive drugs).

The O term also encompasses the motivating operations (MO) concept. In fact, the MO began as an expansion of the three-term contingency, originating within Skinner's radical behaviorism (Nosik & Carr, 2015). The MO concept has been expanded considerably in recent years. According to Laraway, Snyckerski, Olson, Becker, & Poling (2014. pp. 3) MOs "... (a) influence the capacity of operant consequences (reinforcers and punishers) to alter the strength of future behavior (the value altering effect) and (b) change the current strength of behaviors related to the consequences affected by the MO (the behavior altering effect)." As an aside, there is also the related concept of setting events, which too is used to describe variables outside of the three-term contingency. However, although setting events could be relevant as a more complex version of the MO or establishing operations (EO) (Danforth, 2013), setting events are not functionally defined (Nosik & Carr, 2015). Lack of a functional definition can serve to confuse, and for that reason, the MO concept serves a better purpose in the present analysis. This is not to say that others will not find a purpose for setting events in research on social animal models. It is simply beyond the scope of the current paper.

Table 1. Three-term contingency analysis applied to social-release paradigm research

Research papers	O: Organism level manipulations	A: Antecedent recordings/Sd	B: Behavioral recordings	C: Consequence
Bartal et al., 2011a	No manipulation	23kHz USV (L=), Undefined stimuli emitted by trapped rat (L-)	Latency to open and release, Choice between release of cage mate and chocolate	Socialization after release (L-), Release without socialization (L-), Access to chocolate treats (L=)
Silberberg et al., 2013b	Group based learning histories. Group 1: Learning to open without trapped cage mate, Group 2: Learning to open with trapped cage mate	Undefined stimuli emitted by trapped rat (L-)	Latency to open and release	Socialization after release (L-), No socialization after opening for more time, (L+). Group 1 did not learn to open.
Bartal et al., 2014a	Social Learning History (L+ / L-)	Undefined stimuli emitted by trapped rat (L-)	Latency to open and release	Socialization with: Familiar trapped rat (L-), Unfamiliar trapped rat (L+)
Sato et al., 2015a	No manipulation	Undefined stimuli emitted by stressed, soaked, trapped rat (L-)	Latency to open and release	Socialization after release (L-)
Bartal et al., 2016a	Anxiolytics (L+)	Undefined stimuli emitted by trapped rat (L-)	Latency to open and release	Socialization after release (L-)
Schwartz et al., 2017b	No manipulation	Undefined stimuli emitted by stressed, soaked, trapped rat (L-)	Choice between different boxes (empty, water filled, trapped rat)	Access to content in box (water, empty area, rat)
Hiura et al., 2018b	No manipulation	Undefined stimuli emitted by trapped rat (L-)	Lever press for access to socialization	Socialization after release (L-) with schedules for social reinforcement
Tomek et al., 2018a	Heroin (L+)	Undefined stimuli emitted by trapped rat (L+)	Latency to open and release	Socialization after release (L-)

^a Empathy as cause

^b Social Reinforcement as cause

L+ : Increase in latency

L- : Decrease in latency

L= : No effect

Table 1 organizes data from experiments using the social release paradigm into a three-term contingency, with the added O to specify organism level manipulations.

Table 1 shows that the focus of previous investigations using the social-release paradigm has been on the consequences of opening, with additional investigations into effects of organism-based manipulations (i.e., social learning history, anxiolytics and opioids). Only Bartal et al. (2011) have investigated specific antecedent stimuli, and in that case only in terms of the role of stress-induced 23kHz ultrasonic vocalizations. However, considering that no control experiments were performed in either their experiment or in subsequent replications, it is uncertain whether 23kHz USVs have a central role or not. In other words, little is currently known about discriminative stimuli for opening behavior in the social-release paradigm, which is necessary for investigating the relevant parts of the central nervous system. This bridge between social behavior and neural activity is not only the concern of social neuroscience (Cacioppo & Berntson, 1992; Matusall et al., 2011) but also the behaviorist seeking to more fully understand behavior-environment relations (Moore, 2002; Skinner, 1974). Without knowing which stimuli serve as SDs for social release, moving on to neural investigations is troublesome, as the behavioral observations lack necessary detail (Krakauer et al., 2017); “If we fail to understand the behavior, we will probably also fail to understand how the brain serves it” (Catania, 2000).

The following sections explore how to increase knowledge about antecedent stimuli missing from Table 1, which is where special features of the social environment relevant to the organism will be found (Skinner, 1953). Based on these explorations, suggestions are made on how to improve measurements via technical equipment and design. Following this, other terms in the three-term contingency are given the same treatment. Necessary, or relevant, parts of each of these terms will be suggested for both empathy and social reinforcement explanation of social release. For the sake of clarity, antecedent social stimuli are divided into three categories; auditory, visual and olfactory.

Antecedents to Social Release: USV

Although separated by the restrainer, rats still can communicate via different categories of USVs. These USVs are especially interesting for social neuroscience as they seem to have different points of origin within the rat brain depending on whether they are emitted in appetitive or aversive situations (Sadananda, Wöhr, &

Schwarting, 2008). This makes them prime targets for neural manipulation. These USVs have been investigated in one experiment. Those in the category of 23kHz were recorded in the original experiment (Bartal et al., 2011). These 23kHz USVs are expressed in stressful and aversive situations (Brudzynski, 2013), and primarily occur when rats have conspecifics nearby (Kim et al., 2010). Although Bartal et al. (2011) claimed that they did not record enough USVs to influence opening behavior (i.e., that the rats acted to stop these sounds), a control experiment was not performed (e.g., playing back the recorded sound to measure increase or decrease in latency to prosocial action). Furthermore, USV recording was not included in any of the replications (Bartal et al., 2014; Bartal et al., 2016; Silberberg et al., 2013; Tomek et al., 2018). The aversive 23kHz vocalization is one of many sonic and ultrasonic modes of vocal communication in rats. Another category of USVs is in the range of 50kHz, and these sounds are associated with different social behavior than those in the 23kHz range (Seffer, Rippberger, Schwarting, & Wöhr, 2015; Willadsen et al., 2014). These occur primarily in positive situations (Brudzynski, 2013). Although it would be speculative to assign one category of USV importance over the other in social-release paradigms, the existence of multiple categories should not be subjected to negligence as the degree to which they are involved in the measured behavior remains unknown. Control experiments with animals' incapable of making USVs are one way to control for the influence of these social stimuli (e.g., via surgical devocalization, or optogenetic interventions to turn the brain areas responsible for vocalization on and off). Another way would be to undertake playback experiments. Playing back USVs could either begin or stop after prosocial action to assess whether USVs act as positive reinforcers (prosocial action produces appetitive USVs and thereby becomes more probable) or negative reinforcers (prosocial action terminates aversive USVs and thereby becomes more probable) for prosocial behavior. Optimally, these playback experiments allow for measuring USVs in the previously mentioned categories, as these categories may have different roles in the social-release paradigm.

Antecedents to Social Release: Odorants

Odors as social stimuli are common in rats and serve many different social functions such as searching for a mate (Ferkin, 2018), discriminating between conspecifics (Carr, Yee, Gable, & Marasco, 1976), and communicating fear (Debiec & Sullivan, 2014). The behavior that brings rats in contact with odorants, sniffing,

functions to communicate the rat's role in the social hierarchy (Wesson, 2013). Additionally, albeit in mice, odor alone recently was reported to induce hypersensitivity to pain (Smith, Hostetler, Heinricher, & Ryabinin, 2016).

Although it is technically challenging to experimentally control and measure, the significance of odorants for prosocial behavior invites investigation. For example, the experimental arrangement could involve giving the conspecific time in the restrainer and then removing it before testing the free rat for opening behavior. The restrainer would then be empty but retain odorants from the previously trapped rat. Another approach would be to block the sense of smell entirely via surgical interventions, similar to what recently was shown in mice to impact health and obesity (Riera et al., 2017). No investigation of the possible role of odor has been undertaken in the social-release paradigm. For that reason, whether odor is an antecedent or a consequence and can influence social release, remains an empirical question.

Antecedents to Social Release: Visible Behavior

While USVs and odorants are stimuli that require advanced technical equipment to manipulate, measure, and analyze, visible behavior is more readily accessible for experimental manipulation and recording. It is also the only social stimulus that has been experimentally shown to affect prosocial behavior: displayed behavior in one rat is known to influence behavior in the experiments on prosocial reward sharing (Marquez, Rennie, Costa, & Moita, 2015). That observed behavior influences actions in the observer rat is described in the research literature: emotional contagion in rats (Atsak et al., 2011; Carrillo et al., 2015), social fear learning (reviewed in Debiec & Olsson, 2017) and other behavior learned via observation (Galef, 1982). This leads to the conclusion that the displayed behavior, perhaps especially of the recipient of prosocial action, should be monitored closely.

Antecedents to Social Release Summarized

It is currently not known which social stimuli have the most significant influence on prosocial or empathy-like behavior. Possibly, it is not one single stimulus but a combination of them that controls or influences prosocial behavior. The reviewed literature on USVs, odorants and visible behavior shows the potential importance of these stimuli for social and possibly also prosocial behavior. Thus, these stimuli should be investigated in future experiments and added to Table 1 to make a more

comprehensive understanding of the controlling variables of social release. These improvements are necessary because of the proclaimed goal in social neuroscience of understanding neural correlates of social behavior (Cacioppo & Berntson, 1992; Matusall et al., 2011).

In order for an empathy explanation of the behavior to hold in the social-release paradigm, the relevant antecedents will be those that communicate negative emotions (i.e. distress) from the trapped rat. A theoretical experiment could make use of trapped rats that are unable to communicate via one or two modalities (i.e. USVs, odors). If no known emotional communication is relevant for social release, then that would severely discredit the interpretation of empathic concern made by Bartal et al. (2011). In fact, an empathic concern account with the three terms would need an SD such as aversive USV or visible behavioral distress, without which social release does not occur. If the trapped rat does not emit any stimuli that would indicate aversiveness towards entrapment, then releasing it could hardly be described as either prosocial or empathic. Such a description is not found in any research that appeals to an empathy account of social release (Bartal et al., 2011, 2014, 2016; Sato et al., 2015; Tomek et al., 2018).

Social reinforcement, however, does not require the discriminative stimulus for social release to be indications of aversiveness towards entrapment from the trapped rat; the consequence (i.e. social interaction) is what matters. Nonetheless, the existence of social reinforcement in rats (demonstrated in Hachiga et al., 2018, Schwartz et al., 2017 and Silberberg et al., 2013), does not exclude empathic distress. However, the empathy account currently remains the least causally proven one.

Behavioral Recordings in Studies of Social Release in Rats

Table 1 does not list considerable variation in behavioral recordings of the responses in the social-release paradigm. Although different experiments used slightly different response requirements from opening by tipping over a door (Bartal et al., 2011; Sato et al., 2015) to door opening upon activation of a sensor bar (Silberberg et al., 2013), these different topographies have not themselves been investigated. Some behavior will be more similar to existing behavior in the animal's repertoire (tipping open a door by using claws or head versus activating a sensor bar). Although the function of the response is the same—opening the restrainer—the difference in topography could affect latency and other measures of behavior. The importance of requirements is illustrated by Blystad et al. (2019). Even if the

rats had lever pressed for door opening before testing with food inside the restrainer, they manually interacted with the door to open it and access the food (Blystad et al., 2019). The reinforced response was subjected to topographical drift in which the function remains the same, but the response topography changes (Breland & Breland, 1961). When the food was replaced with a cage mate, the animals persisted in the manual interaction topography instead of lever pressing (Blystad et al., 2019). Summarizing, no comparisons are made thus far, and so any effect of different topographies is unknown.

A related issue is that the baseline response latency needs to be established before testing for social release. Establishing the baseline, and even the existence of a response topography within the behavioral repertoire, often is found in the procedure section where descriptions of magazine training or habituation are made. Following response shaping or training, the animal demonstrates the operant response (examples can be found in Hiura et al., 2018; Tan & Hackenberg, 2015; and Vandbakk, Olaff, & Holth, 2018). Although door opening was shown to be in the behavioral repertoire in the soaked-rat model before testing prosocial action (Sato et al., 2015), this was not the case in Bartal et al. (2011). The latter found that the rats opened to release a cage mate after several days (± 7), even if the rats had not been subject to any prior conditioning. Door opening was not trained in the follow-up experiments of Bartal and colleagues either (Bartal et al., 2014; Bartal et al., 2016). In one instance, the finding that rats open to release a trapped cage mate is referred to as *natural behavior* (Bartal et al., 2016, abstract). Whether or not laboratory experiments have much ecological validity has been debated (e.g., Schmuckler, 2001), and as such the term *natural behavior* is perhaps not fitting. Using a lay term like *natural behavior* also bears the risk of falling into the language trap, because the description of *natural behavior* is an unempirical language construction (Harzem, 1986). In other words; the term “natural” is merely an artifact of language, it does not exist in a measurable or objective manner. A consequence of using “natural” can be that other descriptors are smuggled along with it, such as normal, or robust, as no word from ordinary languages has a singular meaning (Harzem, 1986). Additionally, such operationism of lay words run the risk of introducing claims not warranted by the data or observations themselves (Harzem, 1984). Category mistakes may also occur, where *natural behavior* is caused by other reasons than behavior that is not *natural* when it belongs to the same logical category (Ryle & Tanney, 2009). For instance, opening the restrainer with a directly reinforced behavior (Blystad et al., 2019), may not belong to a different category than *natural* opening after repeated exposure

to the restrainer with a trapped cage mate (Bartal et al., 2011). A consequence is the category mistake where *natural* behavior becomes evidence for a phylogenetic empathy, while directly reinforced behavior is caused by the organisms learning history. Additionally, the *natural* description can be used to justify not measuring environmental variables, which lowers experimental control and predictability. Furthermore, the term “natural” holds little explanatory power (Hempel & Oppenheim, 1948). Describing behavior as “natural” does not contribute to understanding why the observed behavior happens. The term “natural” lacks the focus of the pragmatic selectionism inherent in behavior analysis, as pragmatic selectionism guides the researchers in answering “how things comes to be”-questions (Moxley, 2003). Pragmatic selectionism then circumvents the need to describe the occurring behavior as natural; accounts of experiments will be technical and observable descriptions of the environment (i.e., social stimuli) and the behavior.

Consequences

The experiment by Hiura et al. (2018) on the effects of social reinforcement is one of the most thorough with respect to design and terminology. One useful detail in their design is the use of schedules of reinforcement (Hiura et al., 2018). Different schedules of reinforcement generate different response rates and patterns (Ferster & Skinner, 1957). The study of social behavior by using schedules of reinforcement allows for investigating the strength of the social reinforcement by comparing one kind of reinforcement with another in the same schedule (Hiura et al., 2018) such as alcohol and narcotics (Caine & Koob, 1994; Spoelder et al., 2015). Table 1 illustrates that differences in the consequence of opening has been investigated, but aside from Hiura et al. (2018) the choices have been binary (i.e., another rat or an empty restrainer). Implementing different schedules of reinforcement could provide more information regarding the reinforcing value of the consequence. No social-release experiment with an empathy explanation has investigated reinforcement strength of the claimed empathic response. The closest is perhaps an experiment in Bartal et al. (2011) in which the rats could open the door to a restrainer with a cage mate or open a second door to access chocolate chips. More than half of the female rats opened the restrainer with the cage mate first, and chocolate chips second (Bartal et al., 2011). However, binary choices combined with a latency measure are poorly suited for measuring reinforcement strength. A social-release experiment to investigate reinforcement strength properly would require a response rate mea-

sure; single responses (such as those in Bartal et al., 2011, 2014, 2016; Sato et al., 2015) are less than optimal. Topographies could be restricted so that only multiple lever presses will open the restrainer door (i.e. using an intermittent reinforcement schedule). The rate of the door opening could be compared between changes in restrainer content (i.e. cage mate, empty or food). This resonates with Hiura et al. (2018), who showed that food had a stronger reinforcement value than social contact, but that the reinforcement strength of social contact increased with social deprivation. Additionally, latency to open for food in food deprived rats is also lower than for a cage mate (Blystad et al., 2019). If social release is governed by reinforcement in the same way as behavior in general is controlled by other reinforcers (e.g. food, water), then it follows that patterns of social release responses during different schedules of reinforcement (e.g. continuous, intermittent) should be lawful as well and follow the same regularity as observed for food or water reinforcers. Finding the same regularity support the interpretation that social release is controlled and maintained by social consequences (e.g. social contact). However, if the same regularity is *not* found, then two options present themselves. Either the reinforcer in the social-release paradigm is incorrectly identified, or the behavior is not controlled by reinforcers in the same manner as with traditional reinforcers such as food or water. Regardless of outcome, this would be a valuable contribution to the research field.

Summary of the Three Terms and Strategies for Further Experiments

The social reinforcement and empathy approaches both attempt to explain observations in the social-release paradigm. A three-term contingency analysis systematizes requirements for these two approaches. Antecedents in the social reinforcement approach do not have to be social, but the consequences do. Additionally, prior social deprivation is expected to increase social reinforcement preference. Indeed, this has been shown by Hiura et al. (2018). In that experiment, involving rats pressing levers for social reinforcement, there was a higher production of social reinforcement during social deprivation. Social reinforcement, however, does not exclude an empathy interpretation since the social interactions are not incompatible with prosocial behavior.

An empathy account of social release predicts that the SD is a stimulus that communicate distress of the trapped rat (e.g. stressful USVs, visually observable behavior, odors). Visual and auditory stimuli of distress affect rat behavior (Brudzynski & Chiu, 1995; Carrillo et al., 2015), but whether these stimuli function as SDs for

social release remains unclear. That the trapped rat emits stressful 23kHz USVs has been shown (Bartal et al., 2011), but it has not been shown that this specific stimulus is necessary for social release. On a related note, there has been no attempt to record positive USVs. An empathy account of social release further predicts that positive USVs should not serve as SDs for opening since they are not expressing distress, but appetitive situations (Brudzynski, 2013).

The consequence must be fewer distressing stimuli (i.e., the previously trapped rat stops expressing 23kHz USVs or showing visible behavior/emitting odors indicating stress, after it has been released). In other words, empathy in social release is negative reinforcement, where the reinforcer is removal of distress. A stronger account of empathy would have additional requirements regarding how the free rat perceives the trapped rat, which is a part of the empathic concern definition used in Bartal et al. (2011). This is closer to the cognitive variant of empathy that uses the theory of mind (ToM) concept of visualizing the point of view of others (Baron-Cohen, Leslie, & Frith, 1985). However, ToM is not investigated, or measured in any way, during research on social release. In other words, the cognitive aspects of empathy in social release should probably be discarded, but the version of empathy similar to negative reinforcement can be preserved.

One prediction of an empathy interpretation, without cognitive aspects, is less distress stimuli post release. This could easily be tested with an experiment in which release causes more distress stimuli than entrapment (e.g., the release activates electrical grids which shocks the trapped rat). Under such circumstances, being trapped might be “preferable”, and empathic concern could not explain opening. No such experiment has been conducted. From a social reinforcement approach, while it would seem likely that the free rat would continue to release the trapped rat for social interactions, this may not be so because of shock effects on the released rat (i.e. freezing or in other ways displaying discomfort). In other words, social interaction with a rat that has just been shocked may not be positive reinforcement, and failure to open seem possible.

Conclusions

A framework for systematizing and integrating previous research on social release, regardless of causal explanations (empathy vs social reinforcement), has been presented. Social reinforcement is relevant for social release (Hachiga et al., 2018; Hiura et al., 2018; Silberberg et al., 2013), but this relevance does not exclude a pos-

sible effect of empathy. An empathy account would predict that the SD for social release are stimuli indicating distress in the trapped rat and that this distress ends upon release. Thus, an empathy account, without cognitive constructs, for opening behavior in the social-release procedure is negative reinforcement. However, when prior research was analyzed within a three-term contingency framework, it was suggested that little is known regarding antecedent stimuli, social or otherwise. A full survey of relevant antecedent stimuli (i.e. stimuli related to distress) seems to be needed. This systematization with a three-term contingency also could be used on other animal models, perhaps especially those subjected to different theoretical and experimental approaches. In brief, the presented three-term contingency approach allows for behavior- analytical contributions to the field of social neuroscience to improve both existing and new animal models.

References

- Atsak, P., Orre, M., Bakker, P., Cerliani, L., Roozendaal, B., Gazzola, V., ... Keysers, C. (2011). Experience modulates vicarious freezing in rats: a model for empathy. *PLoS One*, 6(7), e21855. <https://doi.org/10.1371/journal.pone.0021855>
- Baron-Cohen, S., Leslie, A. M., & Frith, U. (1985). Does the autistic child have a "theory of mind"? *Cognition*, 21(1), 37–46. [https://doi.org/10.1016/0010-0277\(85\)90022-8](https://doi.org/10.1016/0010-0277(85)90022-8)
- Bartal, I. B.-A., Decety, J., & Mason, P. (2011). Empathy and pro-social behavior in rats. *Science*, 334(December 2011), 1427–1431. <https://doi.org/10.1126/science.1210789>
- Bartal, I. B.-A., Rodgers, D. A., Bernardez Sarria, M. S., Decety, J., Mason, P., Sarria, M. S. B., ... Mason, P. (2014). Pro-social behavior in rats is modulated by social experience. *Elife*, 3(e01385), 1–16. <https://doi.org/10.7554/eLife.01385>
- Bartal, I. B. A., Shan, H., Molasky, N. M. R., Murray, T. M., Williams, J. Z., Decety, J., & Mason, P. (2016). Anxiolytic treatment impairs helping behavior in rats. *Frontiers in Psychology*, 7(JUN), 1–14. <https://doi.org/10.3389/fpsyg.2016.00850>
- Batson, C. D. (2009). These Things Called Empathy: Eight Related but Distinct Phenomena. In J. Decety & W. Ickes (Eds.), *The Social Neuroscience Of Empathy* (1st ed., pp. 3–17). London: The MIT Press, Cambridge, Massachusetts, London, England. Retrieved from <http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2009.04418.x/full>

- Blystad, M. H., Andersen, D., & Johansen, E. B. (2019). Female rats release a trapped cage mate following shaping of the door opening response: Opening latency when the restrainer was baited with food, was empty, or contained a cage mate. *PLOS ONE*, 14(10), e0223039. <https://doi.org/10.1371/journal.pone.0223039>
- Breland, K., & Breland, M. (1961). The misbehavior of organisms. *American Psychologist*, 16(11), 681–684. <https://doi.org/10.1037/h0040090>
- Brudzynski, S. M. (2013). Ethotransmission: communication of emotional states through ultrasonic vocalization in rats. *Current Opinion in Neurobiology*, 23(3), 310–317. <https://doi.org/10.1016/j.conb.2013.01.014>
- Brudzynski, S. M., & Chiu, E. M. . C. (1995). Behavioral Responses of Laboratory Rats to Playback of 22 Khz Ultrasonic Calls. *Physiology & Behavior*, 57(6), 1039–1044.
- Cacioppo, J. T., & Berntson, G. G. (1992). Social psychological contributions to the decade of the brain. Doctrine of multilevel analysis. *The American Psychologist*, 47(8), 1019–1028. <https://doi.org/10.1037/0003-066X.47.8.1019>
- Caine, S. B., & Koob, G. F. (1994). Effects of dopamine D-1 and D-2 antagonists on cocaine self-administration under different schedules of reinforcement in the rat. *J Pharmacol Exp Ther*, 270(1), 209–218. Retrieved from http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=8035317%255Cnhttp://jpet.aspetjournals.org/content/270/1/209.full.pdf
- Carr, W. J., Yee, L., Gable, D., & Marasco, E. (1976). Olfactory recognition of conspecifics by domestic Norway rats. *Journal of Comparative and Physiological Psychology*, 90(9), 821–828. <https://doi.org/10.1037/h0077266>
- Carrillo, M., Migliorati, F., Bruls, R., Han, Y., Heinemans, M., Pruis, I., ... Keyzers, C. (2015). Repeated Witnessing of Conspecifics in Pain: Effects on Emotional Contagion. *PloS One*, 10(9), e0136979. <https://doi.org/10.1371/journal.pone.0136979>
- Catania, C. (2000). From behavior to brain and back again. *HyperPSYCOLOQUY*, 11.
- Church, R. M. (1959). Emotional reactions of rats to the pain of others. *Journal of Comparative and Physiological Psychology*, 52(2), 132–134. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/13654562>
- Cuff, B. M. P., Brown, S. J., Taylor, L., & Howat, D. J. (2016). Empathy: A Review of the Concept. *Emotion Review*, 8(2), 144–153. <https://doi.org/10.1177/1754073914558466>

- Danforth, J. (2013). Setting Events. In F. Volkmar (Ed.), *Encyclopedia of Autism Spectrum Disorders* (pp. 203–207). New York, NY: Springer New York. <https://doi.org/10.1007/978-1-4419-1698-3>
- de Waal, F. B. M. (2012). Empathy in primates and other mammals. In J. Decety (Ed.), *Empathy from bench to bedside* (1st ed., pp. 100–101). London: The MIT Press, Cambridge, Massachusetts, London, England.
- Debiec, J., & Olsson, A. (2017). Social fear learning: from animal models to human function. *Trends in Cognitive Sciences*, 21(7), 546–555. <https://doi.org/10.1016/j.tics.2017.04.010>
- Debiec, J., & Sullivan, R. M. (2014). Intergenerational transmission of emotional trauma through amygdala-dependent mother-to-infant transfer of specific fear. *Proceedings of the National Academy of Sciences*, 111(33), 12222–12227. <https://doi.org/10.1073/pnas.1316740111>
- Decety, J., Bartal, I. B.-A., Uzevovsky, F., & Knafo-Noam, A. (2016). Empathy as a driver of prosocial behaviour: highly conserved neurobehavioural mechanisms across species. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 371(1686), 20150077. <https://doi.org/10.1098/rstb.2015.0077>
- Decety, J., & Cacioppo, J. T. (2010). Problems and prospects in social neuroscience. *Japanese Journal of Physiological Psychology and Psychophysiology*, 28(1), 5–16. <https://doi.org/http://doi.org/10.5674/jjppp.28.5>
- Decety, J., & Christen, Y. (2014). Foreword: *The scope of social neuroscience: From cells to societies*. (J. Decety & Y. Christen, Eds.), *New frontiers in social neuroscience* (Vol. 21). Cham: Springer International Publishing. <https://doi.org/10.1007/978-3-319-02904-7>
- Decety, J., & Lamm, C. (2006). Human empathy through the lens of social neuroscience. *The Scientific World JOURNAL*, 6, 1146–1163. <https://doi.org/10.1100/tsw.2006.221>
- Decety, J., Norman, G. J., Berntson, G. G., & Cacioppo, J. T. (2012). A neurobehavioral evolutionary perspective on the mechanisms underlying empathy. *Progress in Neurobiology*, 98(1), 38–48. <https://doi.org/10.1016/j.pneurobio.2012.05.001>
- Donahoe, J. W. (1996). On the relation between behavior analysis and biology. *The Behavior Analyst*, 19(1), 71–73. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/22478241>
- Donahoe, J. W. (2002). Behavior analysis and neuroscience. *Behavioural Processes*, 57(2–3), 241–259. [https://doi.org/10.1016/S0376-6357\(02\)00017-7](https://doi.org/10.1016/S0376-6357(02)00017-7)

- Donahoe, J. W. (2017). Behavior analysis and neuroscience: Complementary disciplines. *Journal of the Experimental Analysis of Behavior*, 107(3), 301–320. [https://doi.org/10.1016/S0376-6357\(02\)00017-7](https://doi.org/10.1016/S0376-6357(02)00017-7)
- Ely, D. R., Dapper, V., Marasca, J., Corrêa, J. B., Gamaro, G. D., Xavier, M. H.,... Dalmaz, C. (1997). Effect of restraint stress on feeding behavior of rats. *Physiology and Behavior*, 61(3), 395–398. [https://doi.org/10.1016/S0031-9384\(96\)00450-7](https://doi.org/10.1016/S0031-9384(96)00450-7)
- Ferkin, M. (2018). Odor Communication and Mate Choice in Rodents. *Biology*, 7(1), 13. <https://doi.org/10.3390/biology7010013>
- Ferster, C. B., & Skinner, B. F. (1957). *Schedules of reinforcement*. Cambridge, Massachusetts: B. F. Skinner Foundation. Retrieved from <https://www.bfskinner.org/product/schedules-of-reinforcement-pdf/>
- Galef, B. G. (1982). Studies of social learning in norway rats: A brief review. *Developmental Psychobiology*, 15(4), 279–295. <https://doi.org/10.1002/dev.420150402>
- Hachiga, Y., Schwartz, L. P., Silberberg, A., Kearns, D. N., Gomez, M., & Slotnick, B. (2018). Does a rat free a trapped rat due to empathy or for sociality? *Journal of the Experimental Analysis of Behavior*, 110(2), 267–274. <https://doi.org/10.1002/jeab.464>
- Harzem, P. (1984). Operationism, smuggled connotations, and the nothing-else clause. *Behavioral and Brain Sciences*, 7(4), 547–553. <https://doi.org/10.1017/S0140525X00027187>
- Harzem, P. (1986). The language trap and the study of patterns in human action. In T. Thompson, M. D. Zeiler, & K. MacCorquodale (Eds.), *Analysis and integration of behavioral units* (1st ed., pp. 45–53). Hillsdale, N.J.: Lawrence Erlbaum Associates, Publishers.
- Hempel, C. G., & Oppenheim, P. (1948). Studies in the logic of explanation. *Philosophy of Science*, 15(2), 135–175. <https://doi.org/10.1007/s11098-017-1023-1>
- Hernandez-Lallement, J., van Wingerden, M., Schäble, S., & Kalenscher, T. (2016). Basolateral amygdala lesions abolish mutual reward preferences in rats. *Neurobiology of Learning and Memory*, 127, 1–9. <https://doi.org/10.1016/j.nlm.2015.11.004>
- Hiura, L. C., Tan, L., & Hackenberg, T. D. (2018). To free, or not to free: Social reinforcement effects in the social release paradigm with rats. *Behavioural Processes*, 152(March), 37–46. <https://doi.org/10.1016/j.beproc.2018.03.014>

- Jensen, K. (2016). Prosociality. *Current Biology*, 26(16), R748–R752. <https://doi.org/10.1016/j.cub.2016.07.025>
- Keyzers, C., & Gazzola, V. (2016). A plea for cross-species social neuroscience. In M. Wöhr & S. Krach (Eds.), *Social Behavior from Rodents to Humans: Neural Foundations and Clinical Implications* (Vol. 11, pp. 179–191). Cham: Springer International Publishing. https://doi.org/10.1007/7854_2016_439
- Kim, E. J., Kim, E. S., Covey, E., & Kim, J. J. (2010). Social transmission of fear in rats: the role of 22-kHz ultrasonic distress vocalization. *PloS One*, 5(12), e15077. <https://doi.org/10.1371/journal.pone.0015077>
- Krakauer, J. W., Ghazanfar, A. A., Gomez-Marin, A., MacIver, M. A., & Poeppel, D. (2017). Neuroscience needs behavior: correcting a reductionist bias. *Neuron*, 93(3), 480–490. <https://doi.org/10.1016/j.neuron.2016.12.041>
- Laraway, S., Snyckerski, S., Olson, R., Becker, B., & Poling, A. (2014). The motivating operations concept: Current status and critical response. *Psychological Record*, 64(3), 601–623. <https://doi.org/10.1007/s40732-014-0080-5>
- Le Moal, M., & Swendsen, J. (2015). Sciences of the brain: The long road to scientific maturity and to present-day reductionism. *Comptes Rendus–Biologies*, 338(8–9), 593–601. <https://doi.org/10.1016/j.crv.2015.06.014>
- Marquez, C., Rennie, S. M., Costa, D. F., & Moita, M. A. (2015). Prosocial choice in rats depends on food-seeking behavior displayed by recipients. *Current Biology*, 25, 1–10. <https://doi.org/10.1016/j.cub.2015.05.018>
- Matusall, S., Kaufmann, I. M., & Christen, M. (2011). The emergence of social neuroscience as an academic discipline. In J. Decety & J. T. Cacioppo (Eds.), *The Oxford handbook of social neuroscience*. (1st ed., pp. 9–27). New York: Oxford University Press. <https://doi.org/10.1093/oxfordhb/9780195342161.013.0002>
- Moore, J. (2002). Some thoughts on the relation between behavior analysis and behavioral neuroscience. *The Psychological Record*, 52(3), 261–279. Retrieved from <http://search.proquest.com/openview/9b9e5189eeda25db4c5d1c87158fa69a/1?pq-origsite=gscholar>
- Moxley, R. A. (2003). Pragmatic selectionism: The philosophy of behavior analysis. *The Behavior Analyst Today*, 4(3), 289–305. <https://doi.org/10.1037/h0100020>
- Nosik, M. R., & Carr, J. E. (2015). On the distinction between the motivating operation and setting event concepts. *Behavior Analyst*, 38(2), 219–223. <https://doi.org/10.1007/s40614-015-0042-5>

- Nowbahari, E., Scohier, A., Durand, J.-L., & Hollis, K. L. (2009). Ants, *cataglyphis cursor*, use precisely directed rescue behavior to free entrapped relatives. *PLoS ONE*, 4(8), e6573. <https://doi.org/10.1371/journal.pone.0006573>
- Paré, W., & Glavin, G. (1986). Restraint stress in biomedical research: a review. *Neuroscience & Biobehavioral Reviews*, 10(3), 339–370. Retrieved from <http://www.sciencedirect.com/science/article/pii/0149763486900175>
- Pérez-Manrique, A., & Gomila, A. (2018). The comparative study of empathy: sympathetic concern and empathic perspective-taking in non-human animals. *Biological Reviews*, 93(1), 248–269. <https://doi.org/10.1111/brv.12342>
- Riera, C. E., Tsaousidou, E., Halloran, J., Follett, P., Hahn, O., Pereira, M. M. A., ... Dillin, A. (2017). The sense of smell impacts metabolic health and obesity. *Cell Metabolism*, 26(1), 198–211.e5. <https://doi.org/10.1016/j.cmet.2017.06.015>
- Ryle, G., & Tanney, J. (2009). *The concept of mind* (60th Anniv). Milton Park, Abingdon: Routledge.
- Sadananda, M., Wöhr, M., & Schwarting, R. K. W. (2008). Playback of 22-kHz and 50-kHz ultrasonic vocalizations induces differential c-fos expression in rat brain. *Neuroscience Letters*, 435(1), 17–23. <https://doi.org/10.1016/j.neulet.2008.02.002>
- Sato, N., Tan, L., Tate, K., & Okada, M. (2015). Rats demonstrate helping behavior toward a soaked conspecific. *Animal Cognition*. <https://doi.org/10.1007/s10071-015-0872-2>
- Schaal, D. W. (2005). Naming our concerns about neuroscience: A review of Bennett and Hacker's philosophical foundations of neuroscience. *Journal of the Experimental Analysis of Behavior*, 84(3), 683–692. <https://doi.org/10.1901/jeab.2005.83-05>
- Schlinger, H. D. (1995). *A behavior-analytic view of child development* (1st ed.). Springer Science & Business Media.
- Schmuckler, M. A. (2001). What is ecological validity? a dimensional analysis. *Infancy*, 2(4), 419–436. https://doi.org/10.1207/S15327078IN0204_02
- Schwartz, L. P., Silberberg, A., Casey, A. H., Kearns, D. N., & Slotnick, B. (2017). Does a rat release a soaked conspecific due to empathy? *Animal Cognition*, 20(2), 299–308. <https://doi.org/10.1007/s10071-016-1052-8>
- Seffer, D., Rippberger, H., Schwarting, R. K. W., & Wöhr, M. (2015). Pro-social 50-kHz ultrasonic communication in rats: post-weaning but not post-adolescent social isolation leads to social impairments-phenotypic rescue by re-socializa-

- tion. *Frontiers in Behavioral Neuroscience*, 9(May), 102. <https://doi.org/10.3389/fnbeh.2015.00102>
- Shan, H., Bartal, I. B.-A., & Mason, P. (2016). A rodent model of social rejection. *BioRxiv*. <https://doi.org/http://dx.doi.org/10.1101/066993>
- Silberberg, A., Allouch, C., Sandfort, S., Kearns, D., Karpel, H., & Slotnick, B. (2013). Desire for social contact, not empathy, may explain “rescue” behavior in rats. *Animal Cognition*, 17(3), 609–618. <https://doi.org/10.1007/s10071-013-0692-1>
- Sivaselvachandran, S., Acland, E. L., Abdallah, S., & Martin, L. J. (2016). Behavioral and Mechanistic Insight into Rodent Empathy. *Neuroscience & Biobehavioral Reviews*, 1–8. <https://doi.org/10.1016/j.neubiorev.2016.06.007>
- Skinner, B. F. (1953a). Operant discrimination. In *Science and Human Behavior* (1st ed., p. 204). New York: Macmillan.
- Skinner, B. F. (1953b). Social behavior. In *Science and Human Behavior* (1st ed., p. 298). New York: Macmillan.
- Skinner, B. F. (1974). What is inside the skin? In *About Behaviorism* (VINTAGE BO, p. 282). New York: Vintage House.
- Smith, M. L., Hostetler, C. M., Heinricher, M. M., & Ryabinin, A. E. (2016). Social transfer of pain in mice. *Science Advances*, 2. <https://doi.org/10.1126/sciadv.1600855>
- Spoelder, M., Hesseling, P., Baars, A. M., Lozeman-van ’t Klooster, J. G., Rotte, M. D., Vanderschuren, L. J. M. J., & Lesscher, H. M. B. (2015). Individual variation in alcohol intake predicts reinforcement, motivation, and compulsive alcohol use in rats. *Alcoholism: Clinical and Experimental Research*, 39(12), 2427–2437. <https://doi.org/10.1111/acer.12891>
- Tan, L., & Hackenberg, T. D. (2015). Functional analysis of mutual behavior in laboratory rats. *Journal of Comparative Psychology*, 130(1), 1–11. <https://doi.org/http://dx.doi.org/10.1037/com0000015>
- Tomek, S. E., Stegmann, G. M., & Olive, M. F. (2018). Effects of heroin on rat pro-social behavior. *Addiction Biology*. <https://doi.org/10.1111/adb.12633>
- Vandbakk, M., Olaff, H. S., & Holth, P. (2019). Conditioned reinforcement: The effectiveness of stimulus–stimulus pairing and operant discrimination procedures. *Psychological Record*, 69(1), 67–81. <https://doi.org/10.1007/s40732-018-0318-8>
- Vasconcelos, M., Hollis, K., Nowbahari, E., & Kacelnik, A. (2012). Pro-sociality without empathy. *Biology Letters*, 8(6), 910–912. <https://doi.org/10.1098/rsbl.2012.0554>

- Weiss, O., Segev, E., & Eilam, D. (2014). "Shall two walk together except they be agreed?" Spatial behavior in rat dyads. *Animal Cognition*, 18(1), 39–51. <https://doi.org/10.1007/s10071-014-0775-7>
- Wesson, D. W. (2013). Sniffing behavior communicates social hierarchy. *Current Biology*, 23(7), 575–580. <https://doi.org/10.1016/j.cub.2013.02.012>
- Willadsen, M., Seffer, D., Schwarting, R. K. W., & Wöhr, M. (2014). Rodent ultrasonic communication: Male prosocial 50-kHz ultrasonic vocalizations elicit social approach behavior in female rats (*Rattus norvegicus*). *Journal of Comparative Psychology*, 128(1), 56–64. <https://doi.org/10.1037/a0034778>

Recibido Octubre 25, 2019 /

Received October 25, 2019

Aceptado Febrero 19, 2020 /

Accepted February 19, 2020