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Delving into Darting

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Fear response is critical. A single failure to defend against predation can exact an extreme toll on the survival and adaptive fitness of an organism. Therefore, mammals have evolved a fear system to rapidly allocate defensive reactions, which include fight, flight, and freezing (Bolles, 1970; Fanselow, 1980; Poulos et al., 2009). Under conditions of imminent threat such as predatory contact or a painful stimulus, rodents will engage in fight or flight responses, while environmental signals of potential threat often engage conditional freezing reactions (Bolles & Fanselow, 1980; Lester & Fanselow, 1988). Freezing is the best characterized of these defensive behaviors and is defined by the complete cessation of movement with the exception of those related to respiration (Blanchard & Blanchard, 1969; Fanselow, 1980). Freezing can be elicited in rodents experimentally using auditory cue fear conditioning, wherein a tone precedes the onset of an aversive stimulus such as a mild footshock. After this tone-shock pairing, rodents learn the association between tone and shock, such that presentation of the tone alone will elicit freezing. Recent work by Shansky and colleagues proposes that auditory fear conditioning, may also result in the expression of a sexually divergent defensive behavior that goes beyond "passive" conditional freezing to include a more "active", "escape-like" darting response that is more prominent in a small subset of female rats (Gruene et al., 2015). Presently, little is known about darting behavior and its potential relationship with other affectively motivated behaviors. Just as any new area of research emerges, basic questions raised from these studies often spawn further lines of questions.

A new article by Shansky and colleagues examines whether the propensity to engage in active over passive fear responses in female rats represents a trait-like behavioral strategy that translates to an animal model of stress and/or depression, known as the forced swim test (FST). Although the authors failed to demonstrate that darting in female (or male) rats corresponds to an "active" behavioral strategy in the FST, these experiments highlight the importance of exploring sex differences in classic models of affect-related behaviors. Here, we highlight and examine a fundamental premise of this article: that darting represents a sexually dimorphic Pavlovian conditioned defensive behavior.

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“Darter” and darting as conditional responses:

In the initial darting study, Shansky and colleagues defined darting as a rapid, forward movement across the (testing) chamber that resembles an escape-like response (Gruene et al., 2015) a behavior somewhat similar to footshock elicited activity bursts. Importantly, for these responses to be defined as conditional darts they must occur during within a 30 second period of the tone presentation. Gruene et al., (2015) showed that overall dart rates (number of darts/tone period) in females, but not males, increase with the number of tone-shock pairings and peak at a relatively low rate (~0.6), comparable to pre-learning levels. Upon memory testing prior to initial tone test trials, baseline dart rates were expressed at ~0.35 and upon initial tone presentation dart rates were at nearly 0.45. While the overall rates of darting in all females rats tested was not largely impressive, Gruene et al. (2015) focused their analysis on the subset of female rats (~40%) that exhibited at least a single dart within the 3rd to 5th tone-shock pairing by categorizing them as a “darters.” As established by their criterion, darting during 3rd to 5th tone-shock conditioning trial was significantly elevated in “darters” compared to “non-darters”. However, even upon this strict criterion, retention tests of darting rates between “darters” and “non-darters” was only different upon the first tone presentation. In addition, the authors found that female, but not male darters exhibited an increased and prolonged response to footshock that was qualitatively similar to darting. This greater sensitivity to footshock in darter’s raises the possibility that repeated footshocks may sensitize orienting or startle responses toward the tone that appear as darts (Groves and Thompson, 1970; Mackintosh, 1974). This possibility and the relatively low retention level of darting could be facilitated by modifying future experimental designs to include a between-subjects design, that incorporate key comparison groups, such as tone alone, footshock alone, and unpaired tone-shock can that can lend to a further elucidation of the nature of fear-related darting.

Strain differences:

The authors raise an additional important issue that darting may be more common in specific strains. The authors both in the current and Gruene et al., (2015) study used Sprague-Dawley rats, and have not analyzed other strains. Our laboratory, for example, recently examined fear conditioning in male and female Long-Evans rats at different developmental stages, including adulthood, and failed to identify a single occurrence of darting (Colon et al., 2018). Freezing, rearing, grooming and “darting” like behaviors were assessed by a human observer. Moreover, we also employed automated measures of motion and did not detect any acceleration in motion during tone tests. It should be noted that we employed 3 or 5 conditioning trial procedures. As the authors suggest, “darting” may be strain specific, and/or it may require a larger number of conditioning trials for it to emerge more robustly.

Considering a large body of research has examined the behavioral topography, learning parameters, and neural circuits that promote Pavlovian freezing responses, the authors bring to light the importance of considering other fear-related behaviors that may be more prominent in female than male rats. Although not much is known about darting, the current work has shed more light on its sex dependent expression. A continued use of behavioral-based experimental rigor applied toward male and female subjects and use of additional rodent strains may facilitate the further exploration of the behavioral and brain basis of fear-associated darting.

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