More than just a reward molecule, dopamine helps us avoid harm

It is well known that the mesocorticolimbic dopamine system guides behavior as animals seek rewards from their environment. During the pursuit of reward, subsecond dopamine release events within this pathway represent information related to the rewarding outcome being sought. One piece of information these transient dopamine signals represent is reward value. If a reward predictive cue (e.g., McDonald's arches) predicts a good bargain (e.g., value meal), than both the reward predictive cue and the rewarding outcome evoke high-concentration dopamine value signals. As price is increased, the dopamine value signal decreases.

These dopamine value signals can then influence the motivation to pursue reward, particularly when there is a mismatch between the value of reward predicted vs. received. Using optogenetics, a tool that lets us turn dopamine neurons on/off like a lightswitch, we first demonstrated that amplifying dopamine release at a reward predictive cue made animals more sensitive to price. We believe the animals became more sensitive to price because of a negative reward prediction error (i.e., they perceived receiving a worse value than expected). By contrast, amplifying dopamine release at reward delivery made animals less sensitive to price because of a positive reward prediction error (i.e., they perceived receiving a better value than expected).

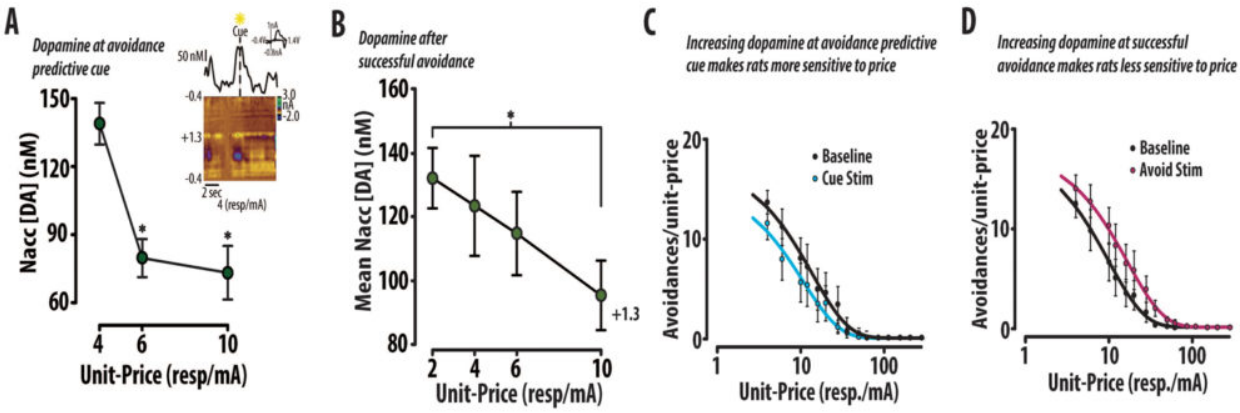

Fig. 1. reward molecule, dopamine helps us avoid harm.

While it is well accepted that dopamine value signals guide reward seeking, much less is known about the role dopamine plays when avoiding harm. Parsing the role dopamine plays in reward seeking vs. avoidance has both ethological and clinical implications. Making sound decisions about the pursuit of reward vs. the avoidance of harm is necessary to optimize behavioral fitness and survival. And, dysregulated hedonic processing might contribute to disorders like addiction; whereas, dysregulated avoidance processing might contribute to anxiety disorders.

To investigate whether dopamine represents the value of avoidance, we implemented an economics-based shock avoidance task in which rats were given the opportunity to avoid electrical foot-shock by responding on a lever. The opportunity to avoid footshock was signaled by a cue light placed above the lever. We modified the price of avoidance by increasing the number of lever presses required to avoid footshock delivery.

As in reward seeking, we found that dopamine concentration scaled inversely with price. Dopamine at the avoidance predictive cue decreased with price irrespective of the avoidance outcome (Fig. 1A); however, dopamine only decreased with price following successful avoidance (Fig. 1B). We interpret these distinct outcome-specific responses to suggest that dopamine concentration prior to the behavioral action is predictive of value; whereas, dopamine concentration following action is reflective of outcome value.

We also performed an optogenetic assessment, augmenting dopamine release at either the avoidance predictive cue or upon successful avoidance. As in reward seeking, augmenting dopamine release at an avoidance predictive cue rendered animals more sensitive to price (Fig. 1C), consistent with a negative reward prediction error. We infer that heightened release at the predictive cue signaled a beneficial outcome, a prediction that was then violated by the occurrence of previously-experienced footshock outcomes. Optically increasing release at successful avoidance made animals less sensitive to price (Fig. 1D), consistent with a positive reward prediction error. We infer that heightened release at successful avoidance signaled the outcome was better than predicted, indicating a good value worth seeking. To conclude, these data build upon the notion that transient dopamine release events represent subjective value and further clarify that these value signals not only represent the value of pursuing reward, but also the value of avoiding harm.

Jonte B. Roberts, Erik B. Oleson
University of Colorado Denver, USA

Publication

A Transient Dopamine Signal Represents Avoidance Value and Causally Influences the Demand to Avoid.
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