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Two dimensions of value: Dopamine neurons represent reward but not aversiveness

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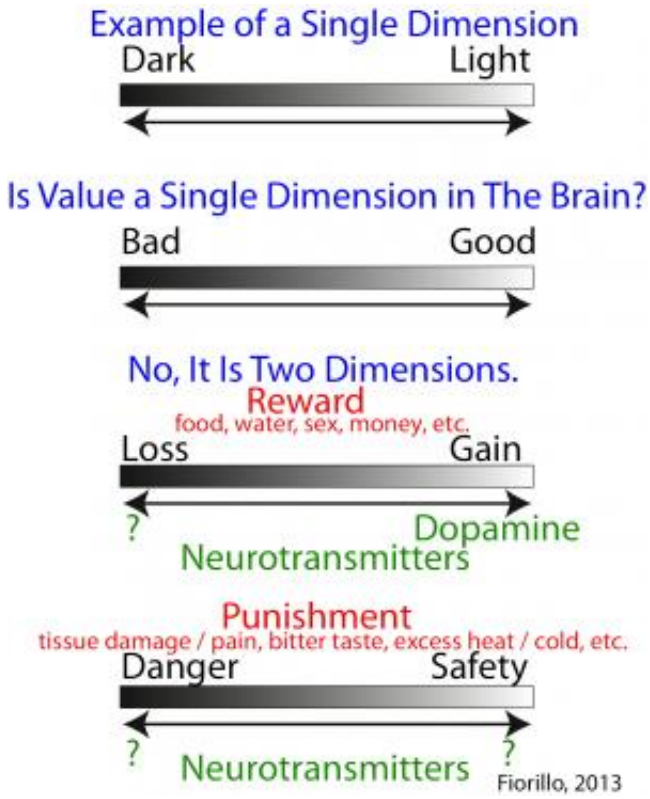

An example of a single dimension is illustrated. Credit: Christopher D. Fiorillo, KAIST

To make decisions, we need to estimate the value of sensory stimuli and motor actions, their "goodness" and "badness." We can imagine that good and bad are two ends of a single continuum, or dimension, of value. This would be analogous to the single dimension of light intensity, which

ranges from dark on one end to bright light on the other, with many shades of gray in between. Past models of behavior and learning have been based on a single continuum of value, and it has been proposed that a particular group of neurons (brain cells) that use dopamine as a neurotransmitter (chemical messenger) represent the single dimension of value, signaling both good and bad.

The experiments reported here show that dopamine neurons are sensitive to the value of reward but not punishment (like the aversiveness of a bitter taste). This demonstrates that reward and aversiveness are represented as two discrete dimensions (or categories) in the brain. "Reward" refers to the category of good things (food, water, sex, money, etc.), and "punishment" to the category of bad things (stimuli associated with harm to the body and that cause pain or other unpleasant sensations or emotions).

Rather than having one neurotransmitter (dopamine) to represent a single dimension of value, the present results imply the existence of four neurotransmitters to represent two dimensions of value. Dopamine signals evidence for reward ("gains") and some other neurotransmitter presumably signals evidence against reward ("losses"). Likewise, there should be a neurotransmitter for evidence of danger and another for evidence of safety. It is interesting that there are three other neurotransmitters that are analogous to dopamine in many respects (serotonin, norepinephrine, and acetylcholine), and it is possible that they could represent the other three value signals.

More information: "Two Dimensions of Value: Dopamine Neurons Represent Reward But Not Aversiveness," by C.D. Fiorillo et al *Science*, 2013.

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