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Behavioural inhibition and valuation of gain/loss are neurally distinct from approach/withdrawal

--Manuscript Draft--

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Abstract:	Gain or omission/termination of loss produce approach; while loss or omission/termination of gain produce withdrawal. Control of approach/withdrawal motivation is distinct from valuation of gain/loss and does not entail learning – making “reward” and “punishment” ambiguous. Approach-withdrawal goal conflict engages a neurally distinct Behavioural Inhibition System, which controls “anxiety” (conflict/passive avoidance), but not “fear” (withdrawal/active avoidance).

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Behavioural inhibition and valuation of gain/loss are neurally distinct from approach/withdrawal
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10. 60-word ABSTRACT

Gain or omission/termination of loss produce approach; while loss or omission/termination of gain produce withdrawal. Control of approach/withdrawal *motivation* is distinct from *valuation* of gain/loss and does not entail learning – making "reward" and "punishment" ambiguous. Approach-withdrawal goal conflict engages a neurally distinct Behavioural Inhibition System, which controls "anxiety" (conflict/passive avoidance), but not "fear" (withdrawal/active avoidance). [55 out of 60 words max]

11. 1000-word MAIN TEXT (with paragraphs separated by full blank lines, NOT tab indents)

In Section III.1, De Dreu & Gross contrast reward seeking with loss aversion and conflate behavioural inhibition with fear and active avoidance. We argue that this confuses: (a) valuation with motivation; (b) anxiety with fear; and (c) reinforcers with reinforcement. Making these distinctions has consequences for their proposed neuropsychology.

The expectation/availability (innate or learned) of gain elicits approach. However, omission/termination of expected gain elicits defensive withdrawal (Adelman & Maatsch, 1956) and attack (Gallup, 1965; Kelly & Hake, 1970), as does an *explicit* aversive stimulus, such as shock (Renfrew & Hutchinson, 1983). Importantly, even in the presence of loss aversion (Kahneman & Tversky, 1979; Novemsky & Kahneman, 2005; Tversky & Kahneman, 1991), approach tendencies can be stronger than withdrawal (Hall, Chong, McNaughton, & Corr, 2011) – likely as a result of their different goal gradients (Brown, 1948). So, approach/withdrawal motivations are controlled independently of gain/loss valuations (Hall et al., 2011); and it is important to keep valuation and motivation theoretically separate (Corr & McNaughton, 2012) and always take into account the role of contingency (Figure 1).

----- Figure 1 about here -----

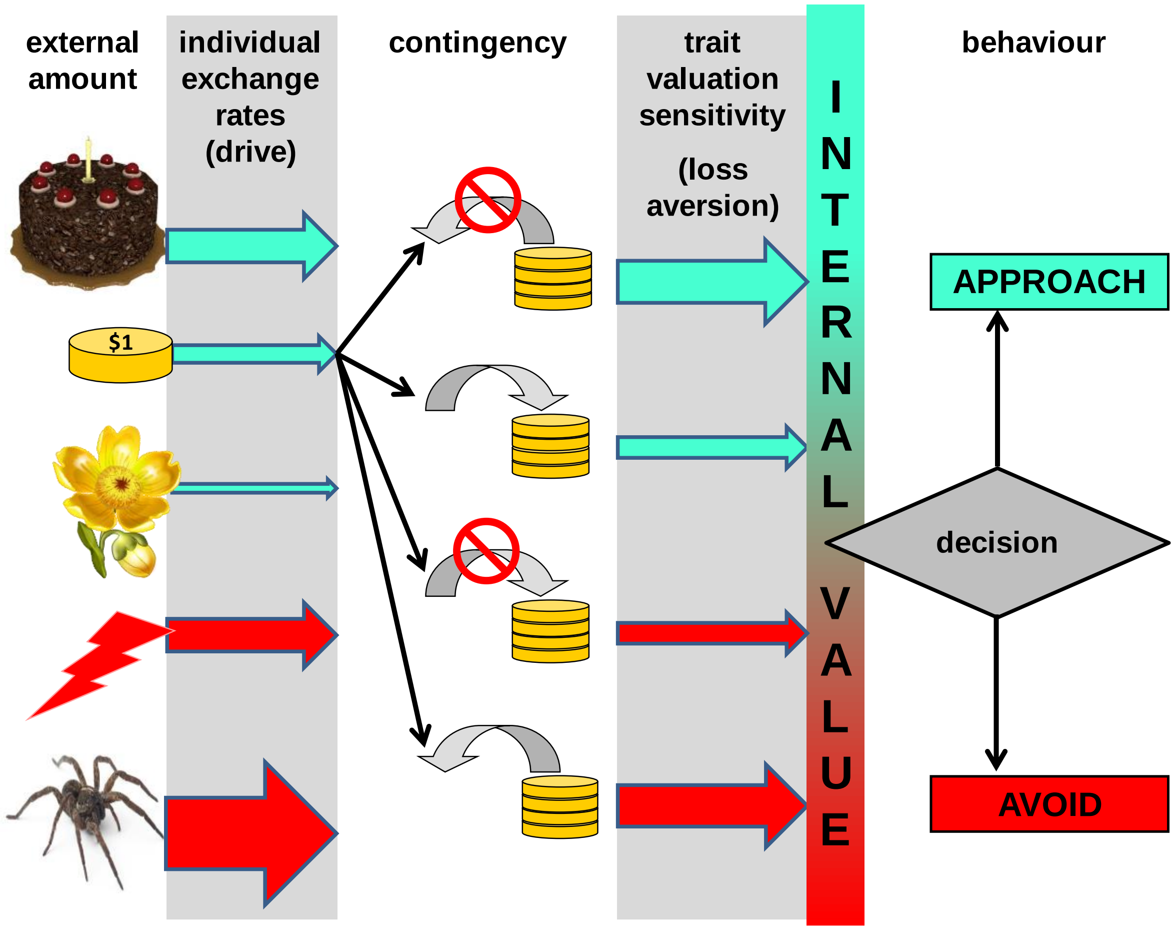

Figure 1. *Relations between external amount, contingency and value. An external item will have a specific amount (e.g., 1 entire cake) that, together with the current level of drive (which acts like a currency exchange rate) for that kind of item for that person, determines its primary internal value (thickness of arrows in first column). As shown for the case of $1, this interacts with whether the item will be gained or lost to determine the direction and size of its internal value as ultimately measured by the effect on behaviour. The direction of this effect is reversed if the [expected] gain or loss is omitted. Loss (removal from a store of items) is most easily controlled with money but will also occur when, for example, one rat steals the food from another rat. Figure and legend from McNaughton, DeYoung, and Corr (2016)*

It is also important to keep “anxiety” separate from “fear”. Despite their frequent semantic conflation (McNaughton, 2018), the neuropsychology and psychometric evidence is clear on their differences (Corr, DeYoung, & McNaughton, 2013). In contrast to a fear/withdrawal system which is sensitive to threat, the anxiolytic-sensitive Behavioural Inhibition System (Gray, 1977) processes goal-conflict and amplifies behavioural inhibition/passive avoidance/defensive quiescence, attention, arousal, and negative bias (Gray & McNaughton, 2000; McNaughton & Corr, 2004). This is neurally distinct from the panicolytic-sensitive systems that mediate fight, flight, freezing, and withdrawal/active avoidance (Figure 2), collectively known as the Fight-Flight-Freeze System (FFFS). Note that “fight” in this context is a defensive response and quite distinct as a behaviour from the predatory “attack” that is contrasted with “defense” in the target article – although in human personality questionnaire studies the relations between withdrawal, defensive attack, and predation are unclear (Corr, 2016). Contrary to the picture painted by De Dreu & Gross, it is anxiety rather than fear that is linked to the release of stress hormones like cortisol (see McNaughton, 1989, pp 57-59); and, while $5HT_{1A}$ agonists are anxiolytic but not panicolytic, the serotonin system as a whole innervates and affects not only the Behavioural Inhibition System but also the withdrawal and the approach systems, with quite high-level consequences (Carver, Johnson, & Joormann, 2008).

----- Figure 2 about here -----

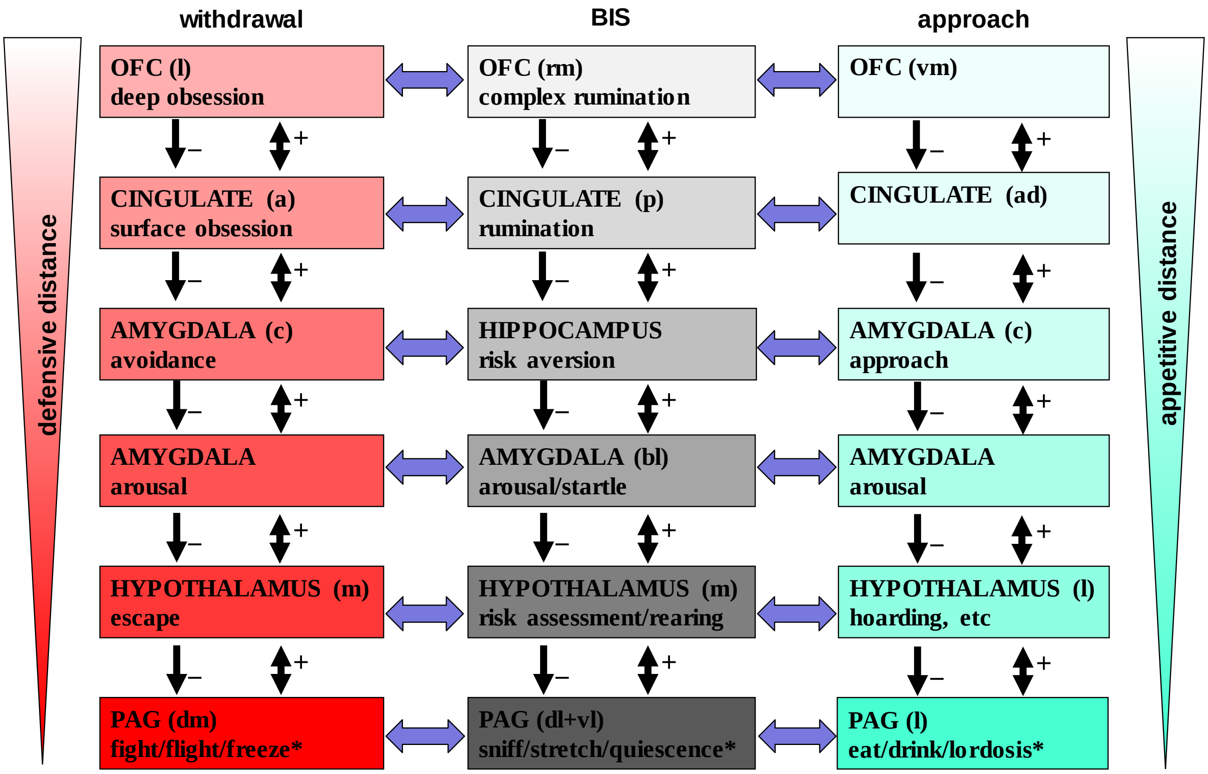

Figure 2. *Hierarchical organization of approach, withdrawal and behavioural inhibition (BIS) in terms of behaviour and neural level. Lower levels process small defensive distances; higher levels process greater ones (i.e., negative events that are more distant in space or time). Activation tends to spread through the whole system (double-headed black arrows) but strong activation of a higher level (e.g., avoidance) inhibits (single-headed arrows) the behavioural output from (but not the activation of) lower levels (e.g., escape). * = static postures that achieve withdrawal, conflict resolution, or approach, respectively. Abbreviations: PAG = periaqueductal grey; OFC = orbital frontal cortex. Figure and legend from McNaughton and Corr (2018)*

For the same reasons, we think their picture of prefrontal control networks should be split and extended to subcortex. We agree that anxiety involves the inferior frontal gyrus (Shadli, McIntosh, Glue, & McNaughton, 2015), basolateral amygdala, hippocampus, ventromedial orbital cortex (Figure 2), and insula (Paulus & Stein, 2006); however, we would add the posterior cingulate cortex and, with risk assessment in particular (McNaughton & Corr, 2018), there is an important role for subcortical "survival circuits" (Mobbs & LeDoux, 2018) that include the dorso-lateral and ventro-lateral periaqueductal grey, anterior and lateral hypothalamus, and lateral septum (Motta, Carobrez, & Canteras, 2017). Critically, we see fear as neurally distinct, involving lateral orbital cortex, anterior cingulate, central amygdala, medial hypothalamus, and dorso-medial periaqueductal gray.

The 3-system (approach, withdrawal, conflict) hierarchical neuropsychology we have described is also relevant to the trait considerations of section III.6. "These systems mediate fluid moment-by-moment reactions to changing stimuli, with relatively stable person-specific sensitivities to these stimuli manifested in personality traits" (Corr et al., 2013, p. 158); and are the basis for the Reinforcement Sensitivity Theory of personality (see Corr, 2008). Our perspective (avoiding the ambiguity of "reward") suggests that attack (as a predatory approach tendency) and defense (functioning to allow withdrawal) likely depend on fundamentally similar hierarchical system architectures. Apparent prefrontal versus subcortical control differences between them likely depend on the usual difference in "motivational distance" in their eliciting situations. Initially, at least, a predator will be at a large appetitive distance from the prey, requiring extensive planning of its attack. Especially where an ambush is involved, the defensive response by the prey will be immediate and even (at zero defensive distance) undirected. Impulse control also involves a balance between approach motivation and inhibition. The strength of inhibition can be affected by variations in conflict sensitivity (Gray & McNaughton, 2000) and in loss aversion (Tversky & Kahneman, 1991); and approach can vary with the strength of delay discounting (Frost & McNaughton, 2017). The effects of traits on attack and defense clearly require a highly nuanced approach.

12. ALPHABETICAL REFERENCE LIST (APA STANDARD)

Adelman, H. M., & Maatsch, J. L. (1956). Learning and extinction based upon frustration, food reward, and exploratory tendency. *Journal of Experimental Psychology, 52*, 311-315.

Brown, J. S. (1948). Gradients of approach and avoidance responses and their relation to level of motivation. *Journal of Comparative and Physiological Psychology, 41*, 450-465.

Carver, C. S., Johnson, S. L., & Joormann, J. (2008). Serotonergic function, two-mode models of self-regulation, and vulnerability to depression: What depression has in common with impulsive aggression. *Psychological Bulletin, 134*(6), 912-943. doi:10.1037/a0013740

Corr, P. J. (2016). Reinforcement Sensitivity Theory of Personality Questionnaires: Structural survey with recommendations. *Personality and Individual Differences, 89*, 60-64. doi:10.1016/j.paid.2015.09.045

Corr, P. J. (Ed.) (2008). *The Reinforcement Sensitivity Theory of Personality*. Cambridge: Cambridge University Press.

Corr, P. J., DeYoung, C. G., & McNaughton, N. (2013). Motivation and Personality: A Neuropsychological Perspective. *Social and Personality Psychology Compass, 7*, 158-175

Corr, P. J., & McNaughton, N. (2012). Neuroscience and approach/avoidance personality traits: A two stage (valuation-motivation) approach. *Neuroscience and Biobehavioral Reviews, 36*, 2339-2354. doi:10.1016/j.neubiorev.2012.09.013

Frost, R., & McNaughton, N. (2017). The neural basis of delay discounting: A review and preliminary model. *Neuroscience and Biobehavioral Reviews, 79*, 48-65. doi:10.1016/j.neubiorev.2017.04.022

Gallup, G. G. (1965). Aggression in rats as a function of frustrative nonreward in a straight alley. *Psychonomic Science, 3*, 99-100.

Gray, J. A. (1977). Drug effects on fear and frustration: Possible limbic site of action of minor tranquilizers. In L. L. Iversen, S. D. Iversen, & S. H. Snyder (Eds.), *Handbook of* *psychopharmacology. Vol 8: Drugs, neurotransmitters and behaviour* (pp. 433-529). New York: Plenum Press.

Gray, J. A., & McNaughton, N. (2000). *The Neuropsychology of Anxiety: An Enquiry into the Functions of the Septo-Hippocampal System (2 ed.)*. Oxford: Oxford University Press.

Hall, P. J., Chong, W., McNaughton, N., & Corr, P. J. (2011). A economic perspective on the reinforcement sensitivity theory of personality. *Personality and Individual Differences, 51*, 242-247.

Kahneman, D., & Tversky, A. (1979). Prospect theory: an analysis of decision under risk. *Econometrica, 47*, 263-291.

Kelly, J. F., & Hake, D. F. (1970). An extinction-induced increase in an aggressive response with humans. *Journal of the Experimental Analysis of Behavior, 14*, 153-164.

McNaughton, N. (1989). *Biology and Emotion*. Cambridge: Cambridge University Press.

McNaughton, N. (2018). What do you mean "anxiety"? Developing the first anxiety syndrome biomarker. *Journal of the Royal Society of New Zealand, 48*, 177-190. doi:10.1080/03036758.2017.1358184

McNaughton, N., & Corr, P. J. (2004). A two-dimensional neuropsychology of defense: Fear/anxiety and defensive distance. *Neuroscience and Biobehavioral Reviews, 28*, 285-305. doi:10.1016/j.neubiorev.2004.03.005

McNaughton, N., & Corr, P. J. (2018). Survival circuits and risk assessment. *Current Opinion in Behavioral Sciences, 24*, 14-20. doi:10.1016/j.cobeha.2018.01.018

McNaughton, N., DeYoung, C. G., & Corr, P. J. (2016). Approach/avoidance. In J. R. Absher & J. Cloutier (Eds.), *Neuroimaging personality, social cognition and character* (pp. 25-49). San Diego: Elsevier.

Mobbs, D., & LeDoux, J. E. (2018). Editorial overview: Survival behaviors and circuits. *Current Opinion in Behavioral Sciences, 24*, 168-171. doi:10.1016/j.cobeha.2018.10.004

Motta, S. C., Carobrez, A. P., & Canteras, N. S. (2017). The periaqueductal gray and primal emotional processing critical to influence complex defensive responses, fear learning and reward seeking. *Neuroscience and Biobehavioral Reviews, 76*, 39-47. doi:10.1016/j.neubiorev.2016.10.012

Novemsky, N., & Kahneman, D. (2005). The boundaries of loss aversion. *Journal of Marketing Research, 42*, 119–128.

Paulus, M. P., & Stein, M. B. (2006). An Insular View of Anxiety. *Biological Psychiatry, 60*(4), 383-387. doi:10.1016/j.biopsych.2006.03.042

Renfrew, J. W., & Hutchinson, R. R. (1983). The motivation of aggression. In E. Satinoff & P. Teitelbaum (Eds.), *Motivation* (Vol. 6): Plenum Press.

Shadli, S. M., McIntosh, J., Glue, P., & McNaughton, N. (2015). An improved human anxiety process biomarker: Characterisation of frequency band, personality, and pharmacology. *Translational Psychiatry, 5*, e699. doi:10.1038/tp.2015.188

Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference dependent model. *The Quarterly Journal of Economics, 106*, 1039-1061.

Figure 1

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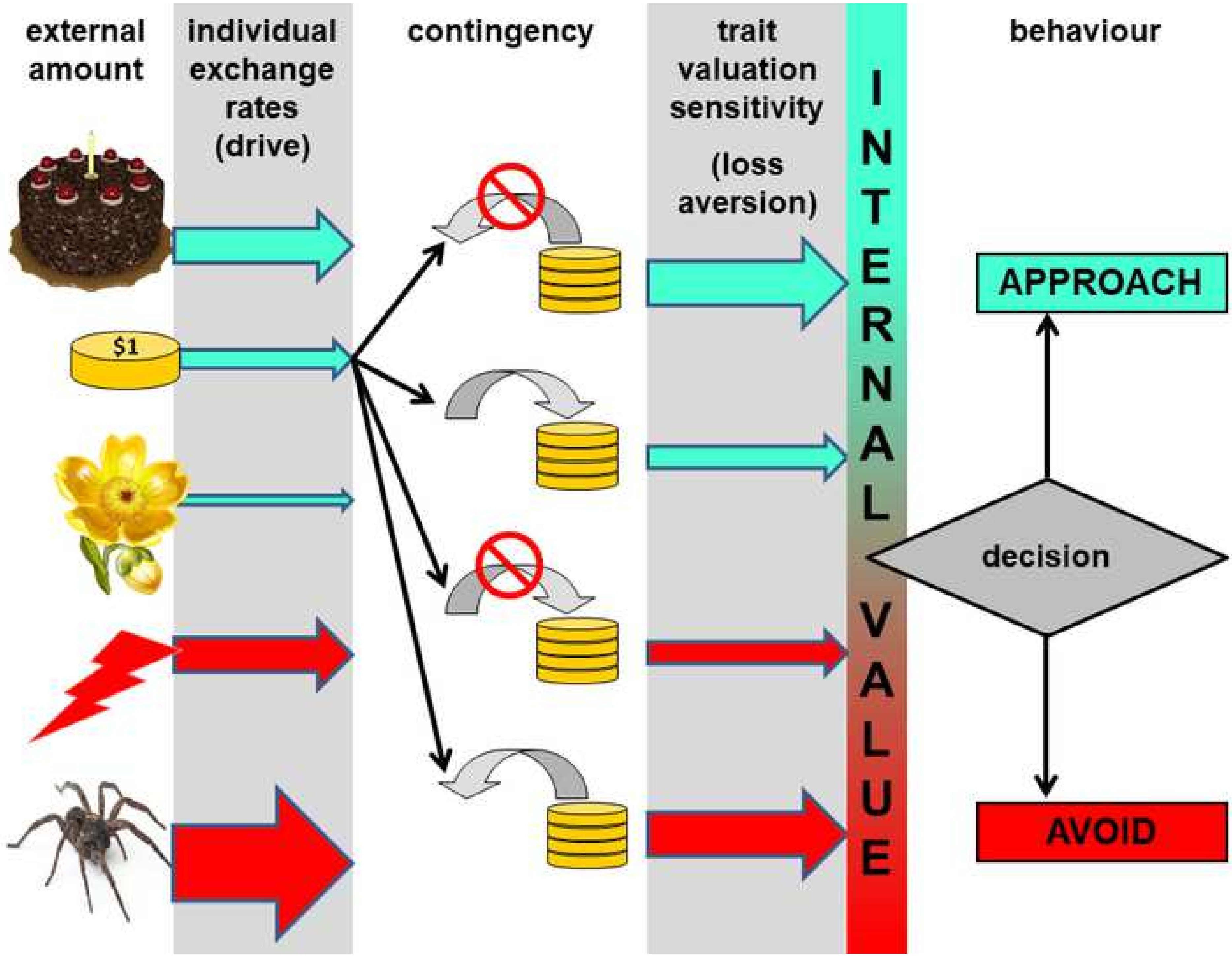
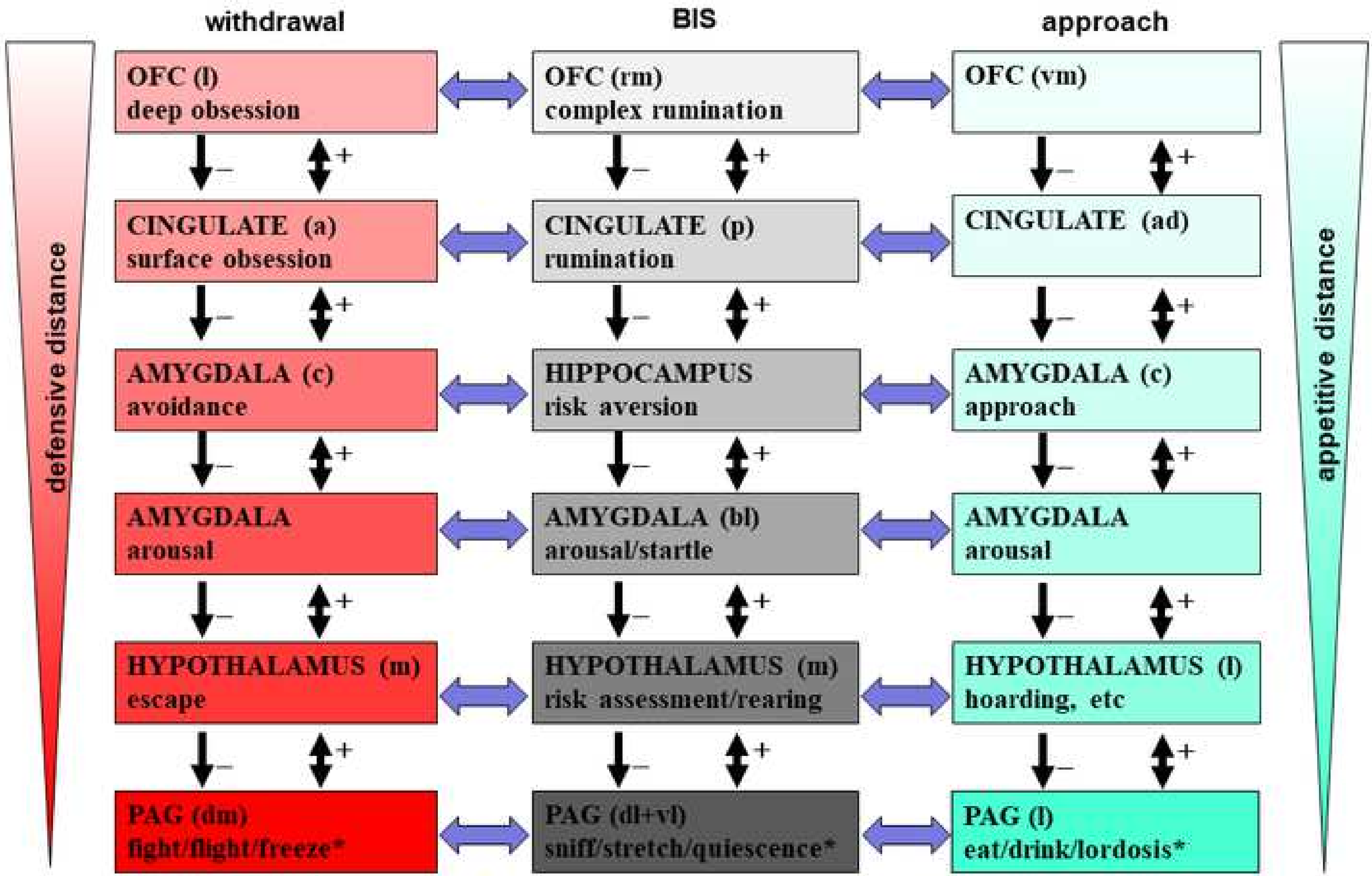


Figure 2


withdrawal
BIS
approach
defensive distance
appetitive distance
OFC (l)
deep obsession
OFC (rm)
complex rumination
OFC (vm)
CINGULATE (a)
surface obsession
CINGULATE (p)
rumination
CINGULATE (ad)
AMYGDALA (c)
avoidance
HIPPOCAMPUS
risk aversion
AMYGDALA (c)
approach
AMYGDALA
arousal
AMYGDALA (bl)
arousal/startle
AMYGDALA
arousal
HYPOTHALAMUS (m)
escape
HYPOTHALAMUS (m)
risk assessment/rearing
HYPOTHALAMUS (l)
hoarding, etc
PAG (dm)
fight/flight/freeze*
PAG (dl+vl)
sniff/stretch/quiescence*
PAG (l)
eat/drink/lordosis*
–
+