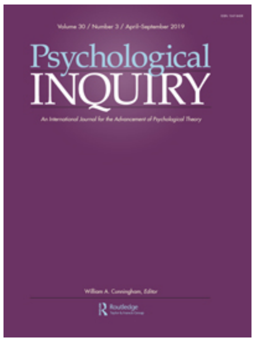

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Hierarchical Levels of Control: The State-Trait Distinction

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Scholer, Cornwell, and Higgins highlight the complexity inherent in superficially simple "approach/avoidance" behavior. We think they are right to make distinctions between levels of analysis (system, strategy, tactics)—and to relate them to parallel distinctions between what they refer to as goals, strategies, and behaviors, respectively. They are also surely right that "approach motivation is not always beneficial and avoidance motivation is not always problematic" and that analysis must take into account "which level in the hierarchy approach and avoidance is manifested," "what types of outcome are being examined," and particularly the effects of "specific situational demands" (p. 111; see Kahneman & Tversky, 1979; Novemsky & Kahneman, 2005).

Although agreeing with Scholer et al. in general terms, we offer some changes in emphasis and perspective that on occasion lead to different detailed conclusions. Here, we focus on levels and add to the implications of "simultaneous approach and avoidance tendencies" (p. 111). In particular, we divide avoidance into two distinct components: withdrawal motivation (active avoidance) and conflict resolution (passive avoidance). We see Scholer et al. as, in fact, discussing three, not two, distinct types of system (and so three distinct types of motivation), each involving a hierarchy of neural modules. Our preferred hierarchies have a larger number of levels (reflecting a cognitive parameter of "motivational distance" corresponding to the perceived immediacy of the need to respond); but these levels are important more for state than trait control. With this as background, we are particularly interested in exploring Scholer et al.'s proposal for the distinction between *states* and *traits*. We believe that consideration of this distinction impacts how we view system, strategy, and tactical levels of explanation. In addressing this issue, we are interested in how the three levels of their hierarchy relate to other conceptual schemes of hierarchical control of approach and avoidance behaviors, and particularly approach–avoidance conflict, for which we use reinforcement sensitivity theory (RST) as a conceptual guide.

But before considering conflict and hierarchies, it may be useful to stand back and take a broader view of the basic approach and withdrawal systems.

Approach and Withdrawal: BAS and FFFS

Appropriate approach and withdrawal are fundamental adaptive processes that are phylogenetically very old. In terms of approach and withdrawal goals (as well, separately, as actions) they are controlled by conserved systems, the most primitive elements of which are found in the periaqueductal gray (Silva & McNaughton 2019); and where we can view mammalian, and particularly human, systems as having a large number of ever more sophisticated processing modules added progressively on top of this primordial core.

Approach to positive goals (attractors) is controlled by the Behavioral Approach System (BAS), which processes stimuli that elicit approach (those that signal a gain as well as those that signal omission of a loss). The BAS is associated with anticipatory pleasure and hopeful anticipation but is more fundamentally related to "wanting" than "liking" (Berridge, 1996; Berridge, Robinson, & Aldridge, 2009). At normal levels of operation, activation of the BAS reflects what we usually term positive "motivation," or "drive."

Withdrawal from negative goals (repulsors) is controlled by the Fight, Fight, Freeze System (FFFS), which processes stimuli that elicit withdrawal (those that signal a loss, as well as those that signal omission of a gain—and so generate *frustration*). The FFFS is associated with distress and fear, and involves sensitivity/reactivity to aversive stimuli of all kinds. At normal levels of operation, FFFS reflects what we usually term negative "motivation," or "drive." (Note that on the few occasions where "BIS" (either as the Behavioural Inhibition System itself; or as a questionnaire identifier) is referred to by Scholer et al., the neural system involved will most likely be the FFFS as defined here; or, with most "BIS" questionnaire scales, a mixture of BIS and FFFS components; see Corr, 2016.)

Stimuli that are evaluated *exclusively* as either an attractor or repulsor activate solely the BAS or FFFS, respectively; and they take control of affect, behavior, cognition, and desire. When the BAS and FFFS are both activated *unequally*, the direction of behavior will reflect the *subtraction* of one motivational impulse from the other, but the intensity of the behavior can be amplified (Gray & Smith, 1969)—each opposing goal representation remains fully activated; it is their capacity to release behavioral output that is modified.

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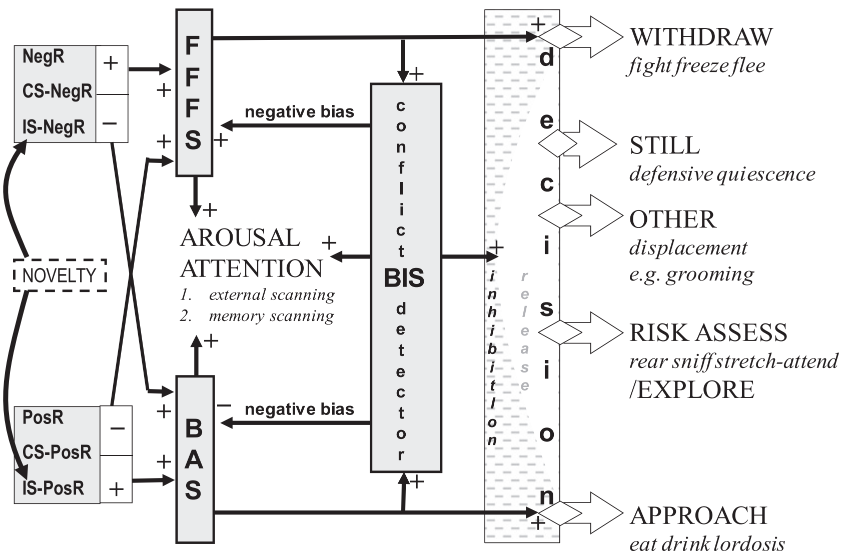

Figure 1. Overall relation of approach (BAS), avoidance (FFFS = fight, freeze, flee), and conflict (BIS = behavioral inhibition) systems—an updated model. *Note.* The inputs to the system are classified in terms of the delivery (+) or omission (−) of primary positive reinforcers (PosR) or primary negative reinforcers (NegR) or conditional stimuli (CS) or innate stimuli (IS) that predict such primary events. The BIS is activated when it detects approach–avoidance conflict—suppressing prepotent responses and eliciting risk assessment and displacement behaviors. The systems interact in a variety of ways to generate behavior. The shaded areas are all points at which traits appear to operate. Figure and legend from McNaughton and Corr (2014).

Resolution of Goal-Conflict: BIS

But what can you do, faced with a strong attractor *and* an equally strong repulsor? With such "goal-conflict," a simple subtractive decision mechanism cannot choose between approach and withdrawal and, worse, neither are appropriate. A third system has evolved to cope, namely, the BIS—detailed by Gray (1976, 1982) and substantially updated by Gray and McNaughton (2000), and further elaborated (see Corr & McNaughton, 2012; Silva & McNaughton, 2019).

The function of the BIS is to inhibit ongoing behavior (and so producing passive avoidance), increase arousal and attention (generating exploration and displacement activities), and increase the strength of withdrawal tendencies (i.e., increasing fear and risk aversion). Although this BIS-related increase in avoidance seems similar to the basic avoidance seen with FFFS activation, they are quite different in terms of neurophysiology, pharmacology, and functions.

When the BAS and FFFS are both activated *equally*, the BIS blocks their normal behavioral output (hence the name), replaces it with risk assessment and related conflict-resolving behavior (including increased negative emotional bias), and adds yet more arousal to that already produced by the summation of BAS and FFFS activations.

The simplest form of goal-conflict, described in the previous paragraph, is when the same situation is linked to opposing motivations. For example, you may have both a strong desire to enter a social situation (to gain positive interactions) and a strong desire to withdraw from it (because you are afraid of making a fool of yourself). The resultant goal-conflict will activate the BIS and generate social anxiety. However, goal-conflict can also occur when distinct situations are linked to the same motivation. For example, you might receive two similarly attractive job offers. Accepting one will automatically mean rejecting the other and so losing any benefits you might have obtained from it. The dithering we experience when making such uncertain choices is no different to the dithering that occurs before entry into the challenging social situation: Both are designed to eliminate goal-conflict.

In summary, as well as one approach system (BAS), RST assumes two "avoidance" systems, one for withdrawal (simple active avoidance/escape; FFFS) and one for resolving goal-conflict (passive avoidance/risk assessment; BIS). These systems interact primarily negatively to control decisions: FFFS activation and BAS activation subtract; and BIS inhibits both FFFS and BAS. Conversely coactivation of any of the systems increases the overall level of arousal. The relationships between, and functions of, the BAS, FFFS, and BIS are shown in Figure 1.

Defensive Distance and Hierarchical System Control

An important feature of neural systems is that they are hierarchically organized—if this were not the case, then behavior in complex situations would be disorderly. This maps to the extended psychological hierarchy on which Scholer et al. base their discussion: from the tactical and strategic (on which they focus) to what they label dispositional. (If dispositional is meant to have a trait rather than state meaning, then "intentional" might be a better term.) As detailed next, we would see traits—such as a general approach tendency/disposition—to impact on all levels of the neural hierarchy.

It is important to note that whether behavior is controlled by a quick-and-dirty or a slow-and- sophisticated circuit can depend on time pressure. Both types of circuit can be primed in parallel and behavior released from the most appropriate one given the relevant urgency. A key mechanism for this control is the inhibition of elements of lower levels by higher levels to prevent inappropriate quick-and-dirty responses when more appropriate slow-and-sophisticated ones are available. As all levels of the

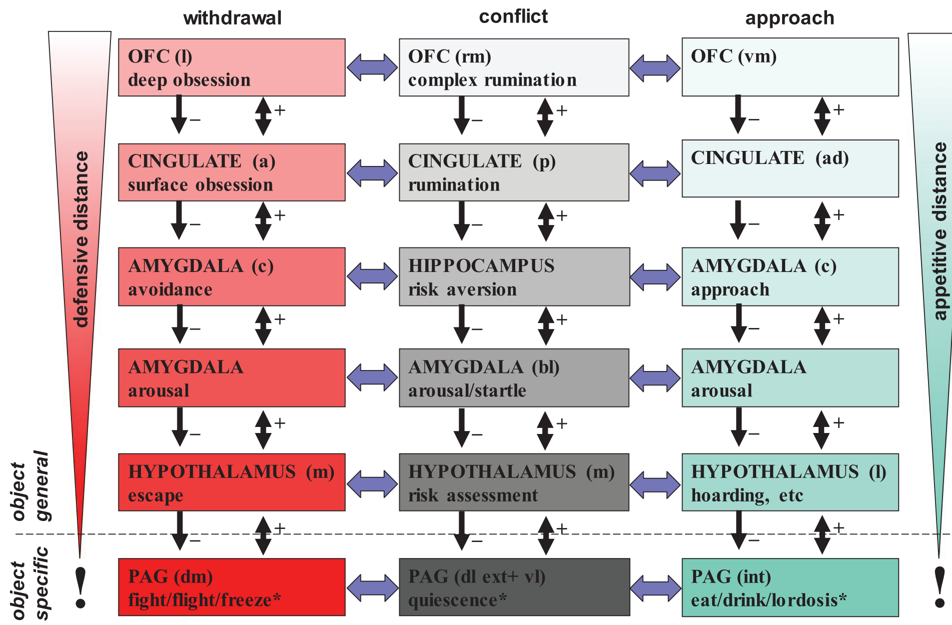

Figure 2. A. Hierarchical organization of each of approach (BAS), withdrawal (FFFS), and conflict (BIS) in terms of behavior and neural level. *Note.* Lower levels process small defensive distances, higher levels process greater ones (i.e., events that are more distant in space or time). Activation tends to spread through the whole system (double-headed black arrows) but strong activation of a higher level, for example, avoidance, inhibits (single-headed arrows) the behavioral output from (but not the activation of) lower levels (e.g., escape). Figure from Silva and McNaughton (2019); used with permission. OFC = orbital frontal cortex; PAG = periaqueductal gray.

system process goals, this hierarchy, together with descending inhibition, provides a means for higher (more cognitively distant) goals to shape the processing of lower order goals—in a cascade of supergoals, goals, subgoals, and so on.

To give an example, stimuli can be evaluated quickly, but approximately, in the thalamus. If an apparent danger is detected, a signal can be sent directly to the amygdala, which can start taking action. Information then passes to the cortex, where it receives more detailed (and so slower) analysis. If the cortex confirms the thalamic evaluation, action (e.g., avoidance) is continued, whereas if it disconfirms, then avoidance can be terminated and different action selected. An unnecessary quick-and-dirty escape response will not impair survival; a slow-and-sophisticated one, when speed is of the essence, can be catastrophic (Ledoux, 1994).

We know from careful analysis of the behaviors of rats faced with cats in the laboratory that specific avoidance-related behaviors occur when the distances between the rat and the cat (and so response urgency) vary. This "defensive distance" (see Blanchard et al., 2001) reflects (a) a negative goal gradient (see next), so that the appropriate level of fear decreases as distance from the cat increases, and (b) a hierarchy of behavioral responses ranging from quick-and-dirty to slow-and-sophisticated.

This behavioral hierarchy maps to a similar hierarchy of neural structures ranging from caudal (and phylogenetically old) to rostral (and phylogenetically recent). The systems controlling approach, withdrawal, and behavioral inhibition can be seen as having a parallel hierarchical organization of this type. Thus, approach and withdrawal *behaviors* are the outputs of interactions within and among hierarchical systems, all levels of which process "goals" (Figure 2) albeit with varying degrees of sophistication.

It clearly makes sense to distinguish between multilevel systems, as here defined, and strategic and tactical levels. The three systems differ in terms of the general type of motivation of the associated goals, but all consist of the largest number of possible processing levels (caudal to rostral) for the species in question. So we would argue that, for all of them, the highest levels of the system subserve what could be labeled *intention* (which could encompass more than one depth of anticipation), the next levels down subserve strategy, then lower levels subserve tactics; and the lowest levels represent more reactive than predictive object-specific control that occurs when the goal is very close and often tangible (Figure 2). These lower reactive levels have been termed *survival circuits*, with the lower levels being more conserved in evolution (LeDoux, 2012; see Mobbs & Ledoux, 2018, for an editorial on a special issue devoted to survival circuits).

Strategy and Tactics Map to Hierarchical Levels, Not Motivations

Let us take a close look at the hierarchical organization and control of the systems, strategies, and tactics, as emphasized by Scholer et al. These levels seem understandable, but with a somewhat different emphasis, within the well-established hierarchical control of behavior that we have just discussed. What we say next can be viewed largely as a form of remapping, rather than revision—it would be disappointing if proposals for hierarchical organization and control from different theories did not relate to one another.

However, we would argue that the two approaches also represent a substantive point of difference—but perhaps more a matter of emphasis than of a categorical disagreement. Scholer et al. state in their abstract that "approach and avoidance motivation manifest at different levels in a self-regulatory hierarchy" (p. 111). But they also seem to locate both types of motivation not only at all the levels of the hierarchy that they specifically discuss but also at the higher levels (which we have called intentional) that they explicitly do not discuss. Critically, in our view, all three systems are present (and with roughly similar amounts of brain dedicated to them) at all levels. Most important, output from all three systems has, from an evolutionary point of view, been a good thing (adaptive) throughout phylogeny. It is not clear if this perspective is different in terms of its fundamentals from the position of Scholer et al., but it does negate any direct link between approach and strategy and avoidance and tactics.

As noted by Scholer et al., different forms of approach and avoidance behavior can be recruited to meet different approach and avoidance goals and motivation. This is an important point that we believe has not previously been sufficiently emphasized. For example, one may have a goal of accumulating as much money as possible and so try avoiding unnecessary expenditure or approaching investment opportunities, or both. We can, therefore, see that the nature of a goal at one level does not entail the nature of a related superordinate or subgoal at another level—thus system/strategic/tactical levels cannot be the same. From this point of view, it is clear that specific behaviors are much less interesting than higher order goals or types of higher order motivation, although—being the measured variables—they are the key foundation for our scientific analysis of all levels of the systems.

As discussed by Corr and Krupic (2017), "motivation" reflects the internal processes *between* (a) the evaluation of stimuli that form the classes of attractors/repulsors (see Corr & McNaughton, 2012) and (b) their *influence on* behavior (and feelings, cognitions, etc.) but not necessarily the behavior itself, which is flexible and can entail approach or withdrawal in response to *either* positive of negative goals—depending on the local contingencies linking action to outcome. This is an example of where notions of "approach" and "avoidance" get confused: It may not be simple to read off the system/strategic/tactical level from the behavior (see also the following discussion of gradients).

It follows that the approach/avoidance behaviors that we see as meeting any goal or motivational state will be influenced (as Scholer et al. point out) by context and situational factors—another reason not to "read-off" goals and motivation from observed approach/avoidance behaviors (Corr, 2009). Consider the goal of getting a pay raise. What is the best way to garner the favor of the boss: approach behavior to achieve success; avoidance behavior to mitigate the chances of failure; or some strategic combination of the two, with nuanced tactical maneuvers along the way? (This example highlights a form of "goal-conflict" we discuss next and serves to highlight its importance in any discussion of approach/avoidance behavior.) Thus, the terms *approach* and *avoidance* need to be seen in the light of the affordances and constraints of the situation and context, and the broader "environment."

We can now see that discussion of approach or avoidance can get terribly confused if we do not first distinguish between intentions/strategies/tactics, and this is before we even consider the special context/situation of "goal-conflict." Scholer et al. are right to highlight this fact. But before discussing conflict, let us look at the implications of the simple neural hierarchical approach for analysis of the cognitive level—where rostro-caudal neural level translates into motivational distance.

Motivational Distance

Defense Distance and Direction

The idea of motivational distance originates in the concept of "defensive distance," developed by Robert and Caroline Blanchard (see Blanchard et al., 2001, for a recent human-oriented perspective). They carried out careful analysis of unconstrained rodent responses to predators and found that they could account for detailed variation in the nature of defensive responses by reference to variation in the perceived level of threat. In terms of direct observation of any individual rat, a specific distance determined the specific behavior observed. However, consistent variation in the specific distances among rats showed that defensive distance was, in essence, a cognitive construct—akin to *perceived* level of threat. Important to note, defensive distance (reflecting a hierarchy of behaviors) maps to neural levels of processing (Figure 2).

This concept of defensive distance is applied equally well (but with different behavioral hierarchies) whether the cat was definitely present or simply might be there (based on memory, odor cues, etc.). This maps to a distinction in Figure 2, the FFFS and BIS, which can be seen as varying in "defensive direction": The FFFS controls behaviors that have evolved to remove the animal from danger, whereas the BIS controls behaviors that have evolved to allow the animal to (cautiously) approach danger (Gray and McNaughton 2000; McNaughton & Corr, 2004, 2008). In support of this distinction, the BIS as a whole is sensitive to the anxiolytic drugs (Gray & McNaughton 2000, Appendix 1), whereas the FFFS is *relatively* insensitive to anxiolytic drugs (or doses) but sensitive to panicolytic ones. The FFFS/BIS distinction is an important departure of RST from other approach/avoidance theories. As already noted, it assumes not one but two "avoidance" systems, one related to simple negative goals and one related to goal-conflict. This distinction identifies the FFFS with fear and the BIS with anxiety, and it will become important when we discuss next the distinction between states and traits in hierarchical organization and control.

Approach

The concept of defensive distance translates perfectly to a concept of appetitive distance linked to approach behavior and allows us to talk in more general terms about "motivational distance." This, we hope, makes clear that we are talking about a cognitive construct but one requiring behavioral evidence for our inferences about it. It is in relation to approach motivation that it is most easy to deal with the concept of "subgoal scaffolding," to which Corr (2008) drew attention. This may be why Scholer et al. see approach as operating at a higher level than avoidance.

Subgoal scaffolding relates to the fact that although the primary function of attractor motivation is to move the animal up the temporo-spatial gradient, from a start state toward the final biological reinforcer, this primary function must be subserved by a number of subprocesses:

1. Identifying the biological reinforcer.
2. Planning behavior.
3. Executing the plan (i.e., "problem solving") at each stage of the temporo-spatial gradient.

These steps imply organization that is not only hierarchical but interactive and dynamic.

In terms of personality *traits*, these three processes relate to "reward interest," goal-planning, and "drive-persistence" that characterize the early stages of approach (it is relevant to note here that this may include some degree of caution, i.e., avoidance). In addition, the behavioral and emotional excitement experienced as the animal reaches the final biological reinforcer relates to "reward responsivity" or "impulsivity" (Corr & Cooper, 2016)—where restraint/avoidance is no longer necessary and may well be deleterious to obtaining the stimuli associated with the motivational goal state. Once more we see the need to consider different levels.

Goal Interactions, Gradients, and Goal-Conflict

There is often more than one goal in an environment and so more than one source of motivated behavior. This is likely to be especially the case in human social situations (whether real or imagined). Therefore, there is a need to consider the ways goals interact and how their motivational gradients affect the final outcome.

The nature of the goals controlling behavior can change dynamically. Consider a rat fleeing from a cat and then running into its burrow. As detailed elsewhere (Corr, DeYoung, & McNaughton, 2013), the cat, as a negative goal (danger), initially elicits withdrawal (escape), but then control of behavior passes to the burrow, as a positive goal (safety), which will now elicit approach. The effect of these two goals on behavior is complementary, and superficial observation of momentary behavior will not tell us which is in control. At any one moment, which goal is controlling the behavioral machinery depends on the goals' gradients (i.e., differences in the strength of the effect of the goal on behavior as distance increases/decreases)—we suppose these gradients to impact on the systems, strategies, and tactics. At a very short distance, the effect of the cat is strong and so produces strong active escape; but the effect of very distant safety is weak and so produces minimal approach. The reverse is the case at the other end of the rat's trajectory. This is Neal Miller's (1959) approach–avoidance gradient-dependent behavior. The superordinate goal does not change, but the strategies (motivation) and tactics (behavior) do. In this case, the tactics will be evident only from subtle change in the trajectory of behavior—often producing a nonlinear path, first pointed away from the cat and then toward the burrow (Corr, DeYoung, & McNaughton, 2013).

Important to note, the nature of the goals may be functionally opposed in approach–avoidance conflict. To understand approach–avoidance conflict, it is necessary to look at the nature and interaction of the positive and negative goal gradients impacting on the animal. Based on ample experimental evidence, we should expect that the fall-off with distance of the power of a goal is much greater for a negative one than a positive one (see Corr, DeYoung, & McNaughton, 2013). So, initially an animal will approach a location where it has previously experienced both positive and negative reinforcers. When a point is reached where the effect of the positive and negative goals are balanced, as described earlier, the BIS will take control replacing approach and withdrawal with risk assessment behavior and dithering.

In addition to explaining the ubiquity of goal-conflict, goal gradients have another important feature. Because approach gradients are shallow, animals will frequently be affected by attractors at considerable distances. Also, on a daily frequency basis, an animal in the wild (e.g., a human hunter-gatherer) will meet many more attractors than repulsors (primarily predators). Thus, at the observational level, it may indeed appear that "approach and avoidance motivation manifest at different levels in a self-regulatory hierarchy" (Scholer et al., this issue, p. 111), but this is only a quantitative appearance under the contingencies that are usual in common circumstances, not a necessity.

The State-Trait Distinction

Whether approach or avoidance is good or bad (adaptive or dysfunctional) at the intentional, strategic, tactical, or reactive level depends—but on what? One major consideration here is the crucial distinction between immediate *states* and long-term *traits*. There is no a priori reason to think that much state avoidance (FFFS) and conflict (BIS) behavior is maladaptive when dealing with specific challenges. Because they determine immediate survival, they should take precedence over approach, which will only pay off in the long term (e.g., by preventing starvation, allowing success at reproduction, etc.). But this state-level preeminence of avoidance is a quite different thing from having a general propensity for long-term avoidance/conflict strategies and tactics—and it is seriously maladaptive if, at the system level, goals are dominated by sensitivity to repulsor stimuli *to the neglect of* attractor stimuli. At this extreme end, we find internalizing clinical disorders, such as depression (with its often accompanying anhedonia). Therefore, personality traits are important, as are the circumstances under which avoidance strategies/tactics are elicited.

Critically, in our view, many traits operate on whole systems—they generate similar biases at all levels. As noted by McNaughton and Corr (2004), for a particular individual in a particular situation, defensive distance equates with real distance. However, in a more dangerous situation, the perceived defensive distance is shortened. In other words, a defensive behavior (e.g., active avoidance) will be elicited at a longer (objective) distance with a highly dangerous stimulus (corresponding to short perceived distance), as compared to the same behavior with a less dangerous stimulus. According to the theory, neurotic individuals have a much shorter perceived defensive distance, and thus react more intensely to relatively innocuous (distant in reality) stimuli. For this reason, weak aversive stimuli are sufficient to trigger a defensive reaction in highly neurotic individuals; but for a less neurotic individual, aversive stimuli would need to be much closer (and/or much more intense) to elicit a comparable reaction.

In this way, defensive distance operationalizes an internal cognitive construct of intensity of perceived threat (as we emphasized earlier for the simple rat data). It is a dimension controlling the type of defensive behavior observed. In the case of defensive avoidance, the smallest defensive distances result in explosive attack, intermediate defensive distances result in freezing and flight, and very great defensive distances result in normal nondefensive behavior. Thus, defensive distance maps to different levels of the FFFS (McNaughton & Corr, 2004).

In terms of (dysfunctional) activation, the state-trait distinction is clearly important, as it would seem to be for any approach/avoidance theory that is not exclusively focused on *immediate* state reactions. The occasional state avoidance overreaction may be of little consequence, but a chronic trait tendency is very likely to rob avoidance of its adaptive value—and the same is true of approach behavior to attractor stimuli.

Conclusion

We believe that Scholer et al.'s proposals enrich our understanding of approach/avoidance behavior. We agree that avoidance goals and motivation are "a good thing" and need to be accorded equal priority to approach ones—after all, they have kept *all* of our ancestors alive long enough to reproduce. We also agree that a hierarchical approach to system/strategy/tactics is advantageous. But we see the mapping of approach and avoidance to these levels as very much dependent on circumstances. Approach goals are just more often, not necessarily, linked to strategy. Critically, we would see intention/strategy/tactics/reaction/consummation mapping to rostral-caudal neural levels—and so parceling the nature of those levels in a way that RST has not done before. We also see traits as independent of levels but states very much controlled by them.

In this commentary, we have tried to tie discussion of strategies and tactics to what is already known about the neural hierarchical organizational and control of behavior, including the different goal gradients generated by attractors and repulsors, and we have emphasized the existence of a separate system that resolves conflict between goals, namely, the BIS. We have also made a distinction between short-term (acute) state activation and longer term (chronic) trait sensitivity—both of which will determine the level of neural system and so type of processing involved. This emphasizes the importance of the suggestion by Scholer et al. that we should focus on hierarchical levels of analysis and all that these entail for both approach and avoidance equally.

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