CHAPTER 3

DISSIMILARITY FOCUS AS AN ATTENTIONAL MODE OF BIS-RELATED COMPARATOR FUNCTION

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INTRODUCTION

The notion of a comparator has been popular in behavioral psychology, especially in accounts couched in terms of a cybernetic system. The function of a comparator is to control processes related to the regulation of behavior. This takes the form of comparing input states with desired reference states, and when a discrepancy is detected the system switches to control mode and activates cognitive processes designed to reduce disparity (Carver & Scheier, 1998; Corr, 2010).

This chapter is concerned with the comparator function of the behavioral inhibition system (BIS). To date the postulated comparator function of the BIS (i.e., conflict detection and resolution) has been largely dedicated to theoretical speculation rather than empirical validation (a few exceptions are Amodio, Master, Yee, & Taylor, 2008; Leue, Lange, & Beauducel, 2012; Moore, Mills, Marshman, & Corr, 2012). Moreover, sufficient empirical validation—especially of those parts of the model that postulate the cognitive processes and mechanisms underlying the BIS comparator function—is lacking.

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In this chapter we offer proposals to advance understanding of BIS theory in these various respects. More precisely, we suggest that the comparator function of the BIS at the cognitive level is associated with the dissimilarity-oriented attentional mode. The theoretical arguments stem from the analysis of the regulative function of the BIS as a comparator, which is based on the negative feedback loop (Carver & Scheier, 1998) and governed by the detected discrepancy to the no-conflict standard (Corr, 2010). It is assumed that if conflict resolution processes are aimed at reduction of discrepancy, then selective attention to signals that are divergent from the standard should be expected to exert control over information processing and facilitate conflict monitoring and ultimately resolution. Additionally, the theoretical advances presented in this chapter are supported by empirical data.

The Behavioral Inhibition System: New Approach or Revised Approach?

The theory of the BIS has been elaborated (Corr, 2010; Corr & McNaughton, 2008) and new theoretical considerations are offered by this revision. Revised reinforcement sensitivity theory, of which the BIS is the most reformulated part, highlights the importance of a greater variety of cognitive processes (e.g., Hoffmann, 2010; Matthews, 2008; Revelle & Wilt, 2008). These elaborated processes are especially important since the BIS as a comparator is engaged in detection of conflict and discrepancy and its activation is aimed at conflict resolution (Corr, 2008). Conflict detection and conflict resolution processes are the parts of cognitive control theory (Botvinick, Cohen, & Carter, 2004) or executive system of attention (Rueda, Posner, & Rothbart, 2004) that are viewed by some researchers as meta-cognition (executive system) or related to the generation and contents of consciousness (Corr, 2010; Fernandez-Duque, Barid, & Posner, 2000). Dealing with conflict is exerted under cognitive control supervision, where some higher-order cognitive processes (e.g., cognitive inhibition, top-down selective attention, planning, resource allocation) are activated to monitor and resolve the conflict.

In the revised approach to the BIS (see Figure 1), the only cognitive characteristic that is considered is the biased processing of threatening stimuli (stimuli based as well as memory based) governed by the mechanisms of selective attention and selective retrieval. Such a bias controls the level of the perception of threat in incoming stimulation and is used in risk assessment. It is believed that these processes are a crucial part of conflict resolution processes. In this chapter we propose that selective attention toward dissimilarity might be another important mechanism that facilitates control processes of conflict monitoring and resolution.

The chapter is organized into four parts. The first part describes the BIS and biological basis of its comparator function. The second and most important part presents the idea that the effective operation of the BIS as a comparator requires specific organization of cognitive processes: information processing (atten-

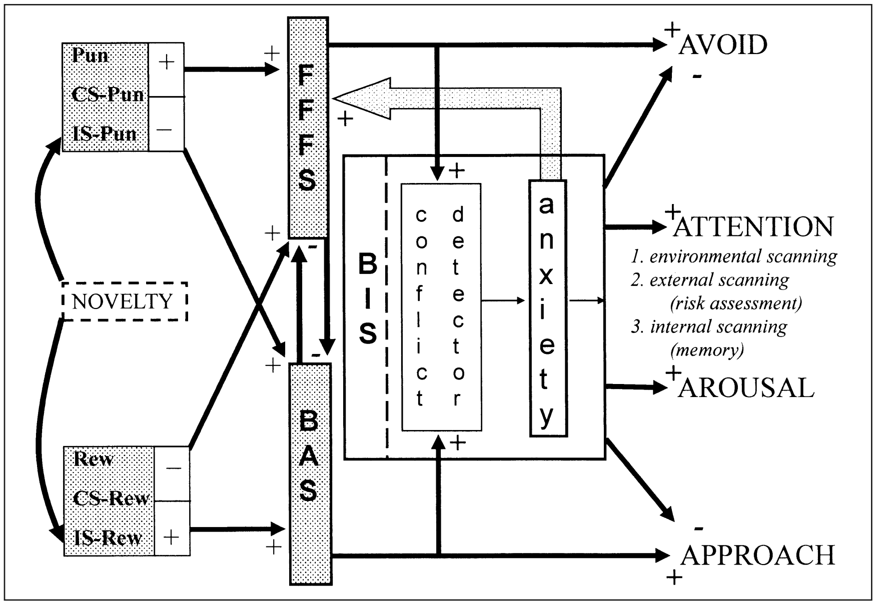

Figure 1. Relations of the behavioral inhibition system (BIS), fight-flight-freeze system (FFFS), and behavioral approach system (BAS). The simplest way to activate the BIS is concurrently to activate the FFFS and BAS (i.e., face the animal with an approach-avoidance conflict). In this case both simple approach and simple avoidance are inhibited and replaced with environmental scanning (in the form of altered attention), external scanning (risk assessment behavior), and internal scanning of memory. All these scanning operations are aimed at detecting affectively negative information and involve an increase in the salience of such information. As a result, a secondary consequence of activation of the BIS is normally a shift of the balance between approach and avoidance tendencies in the direction of avoidance. The inputs to the system are classified in terms of the delivery (+) or omission (−) of primary rewards (Rew) or punishments (Pun) or conditional stimuli (CS) or innate stimuli (IS) that predict such primary events. (Adapted from Corr & McNaughton, 2012; Gray & McNaughton, 2000.)

tion/perception) oriented toward dissimilarity. The third part demonstrates the empirical evidence on the relation between the BIS and dissimilarity focus. The fourth part comprises a discussion of the necessity of further empirical validation of the location and role of the orientation to dissimilarity within the whole model of the BIS, and on the specificity of the behavioral regulation under BIS control. Finally, we discuss the limitations of the studies presented.

THE BEHAVIORAL INHIBITION SYSTEM AS A COMPARATOR

The BIS in the reinforcement sensitivity theory of personality is thought to operate as a comparator (e.g., Corr, 2008, 2010; McNaughton & Gray, 2000), examining incoming sensory information in relation to expectation. This comparison function yields one of two outputs: either the values being compared are demonstrably different from one another or they are not (Carver & Scheier, 1998). When the comparison process indicates that the incoming stimulus matches the expected value, the system does not change anything and the comparator works in a relatively passive, "just checking" mode. The current behavior runs unchanged, mainly under automatic regulation. However, when a discrepancy is registered between the actual and expected state of the environment, the comparator changes into an active control mode to detect and resolve the source of error (Corr, 2010). Therefore the BIS operates actively when a mismatch between expectation and input is detected—at a more general level, when goal conflict (which implies that there are opposing forces that cannot be readily resolved by mere approach or avoidance) is detected.

This error-triggering mechanism results in switching from automatic to controlled information processing and is likely to engage the awareness of salient features of the conflicting stimuli (cf. Corr, 2010). However, the processing of mismatch, errors, or goal conflict itself is an automatic, pre-attentive process (detection of conflict information during reasoning is an implicit and effortless process; Franssens & de Neys, 2009). According to the BIS model (see Figure 1 above), detection of discrepancy between the actual and reference values generates specific outputs at the cognitive, emotional, and behavioral levels—all of which are directed at reducing the discrepancy and potential negative consequences, as well as restoring the state of conformity (no-discrepancy state; Corr, 2010).

The BIS is thought to resolve conflict elicited by simultaneous incompatible goals by (a) suppressing ongoing approach or avoidance behaviors; (b) increasing cognitive processing of and attention toward potential sources of threat; and (c) increasing the negative affective valence of stimulus encoding. In addition, arousal is increased that serves to strengthen any resulting defensive fight, flight, or freeze response. It also serves to potentiate behaviors related to the behavioral approach system (BAS) if the outcome of BIS conflict resolution is a return to approach behavior, which can lead to a seemingly paradoxical effect of conflict detection—namely, strengthened BAS behavior (Corr, 2010).

Therefore, at the cognitive level information processing (attentional and memory processes) is pressed into the service of the control of any negative consequences resulting from the possible means of goal conflict resolution (Corr, 2010; McNaughton & Corr, 2008; McNaughton & Gray, 2000). Such emotionally biased cognitive processing related to the BIS (trait anxiety) is well documented (see, e.g., Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg & van IJzendoorn, 2007; Gomez & Gomez, 2002; Rutherford, MacLeod, & Campbell, 2004) and is not discussed further in this chapter.

Since the main focus of this chapter is on the cognitive aspects of BIS activation, we propose that in addition to the emotionally biased cognition noted above, there is another specific organization of attentional processing—namely, dissimilarity focus that may be the mechanism that facilitates fulfilling the control function of the BIS as a comparator.

Standard BIS theory refers to anxiety as the result of conflict detection and to the behavioral, emotional, and cognitive consequences of anxiety. The standard version, however, does not point to any specific cognitive processes or mechanisms that would be directly related to the comparator function of the BIS. Therefore what seems to be missing in standard BIS theory is the cognitive process that would reflect more directly the comparator function of the BIS. We propose that the early attentional mechanism related to sensitivity to discrepancies results in controlled attentional processing reflected in orientation to dissimilarity. We believe that studying the proposed attentional mechanism could help fill this gap.

We want to highlight the biological basis as well as the cognitive and affective mechanisms and processes as especially important in developing the BIS-dependent orientation to dissimilarity.

CONFLICT DETECTION RELATED TO THE BIS AS A COMPARATOR: BIOLOGICAL PROCESSES AND MECHANISMS

According to Corr (2004) and Gray and McNaughton (2000), the neurobiological basis of the BIS is related to hierarchically linked neural structures involving the periaqueductal gray, septo-hippocampal system, amygdala, anterior cingulate cortex (ACC), and dorsal prefrontal cortex. The simple comparison of the sensory input with the expected one is fulfilled by the septo-hippocampal system, whereas the amygdala system is associated with the increased arousal output of the BIS (Gray & McNaughton, 2000). In the revised theory, the ACC involved in conflict processing in the form of error detection (Corr, 2010) and the dorsolateral prefrontal cortex as a part engaged in conflict resolution (Corr, 2010) start to play an important role (Krug & Carter, 2010).

Neurocognitive studies confirm that neurobiological structures associated with the BIS are also engaged in mismatch detection. For example, Kumaran and Maguire (2006) demonstrated that detection of associative mismatches between expectations that are based on retrieval of past experience and current sensory input engages the hippocampus. They investigated brain responses to novel sequences of objects using functional magnetic resonance imaging while subjects performed an incidental target detection task. The results showed that hippocampal activation was maximal when predictions concerning which objects would appear next in a sequence were violated by sensory reality. These authors suggested that the hippocampus might generate predictions about how future events would unfold and critically detect when these expectancies are violated, even when the task did not require it (Kumaran & Maguire, 2006).

These findings are in line with the postulated function of the BIS as a comparator, which is engaged in "what if" simulations of future behavior (Corr, 2008, 2010). When the process of error detection is involved in more cognitively demanding tasks, such as monitoring of ongoing performance errors or response conflicts that demand cognitive control, then the dorsal ACC is engaged (e.g., Ridderinkhof, Ullsperger, Crone, & Nieuwenhuis, 2004; Spunt, Lieberman, Cohen, & Eisenberger, 2012). This error processing is reflected in error-related negativity (ERN), registered as a sharp negative deflection in the event-related potential that peaks approximately 50 ms after an unintended response (Falkenstein, Hoormann, Christ, & Hohnsbein, 2000) and is generated in the ACC. Thus the ACC generates ERN immediately after the commission of an error or whenever the outcomes are worse than expected (Holroyd & Coles, 2002).

However, ACC activity was also registered during correct responses in the course of a Go/NoGo task, where the participant had to respond to the letter *X* after an *A* was presented and ignore all other letter combinations. The results showed that the more competitive stimuli were presented (producing conflict between response tendencies), the more the ACC was activated (Carter et al., 1998). Conflict that induces the dorsal part of ACC activation conveys competing response tendencies or semantic or conceptual representations (Badre & Wagner, 2004; van Veen & Carter, 2005; Weissman, Giesbrecht, Song, Mangun, & Woldorff, 2003). In the literature the error detection function of the ACC (reinforcement learning approach) is closely related to ACC conflict theory (Carter & van Veen, 2007; for a review see Krug & Carter, 2010). However, the ACC is also associated with experiencing negative emotional states.

Affective Consequences of Conflict Detection

It is proposed that the rostral areas of the ACC are involved in emotional processing, including emotional aspects of error monitoring (through its strong connections to other structures related to emotional processing, like the amygdala), while the dorsal areas of the ACC are related to cognitive processes linked to error or conflict detection (Bush, Luu, & Posner, 2000). Indeed, recently collected neurocognitive data show that conflict detection produced a state of negative affect (NA; Compton et al., 2007; Dreisbach & Fischer, 2012; Hajcak & Foti, 2008; Wiswede, Munte, Goschke, & Rüsseler, 2009). The ERN reflected affective response to errors detected (Hajcak and Foti, 2008; Luu, Collins, & Tucker, 2000) or motivational value of ongoing events (Bush et al., 2000; Hajcak, Moser, Yeung, & Simons, 2005). If ERN response indicates increased negative affect as a reaction to error detection, then we should expect that BIS sensitivity should increase ERN amplitude in response to errors. Compared with subjects with low BIS scores, Boksem, Tops, Wester, Meijman, and Lorist (2006) confirmed that high-scoring BIS subjects (measured by the BIS/BAS scale of Carver & White, 1994) showed larger ERN amplitudes in response to error trials in the flanker task.

Since the number of studies directly examining the relation between the BIS and ERN amplitude are limited, we will refer further to the anxiety-related analysis. Anxiety and rumination were examined by Hajcak, McDonald, and Simons (2003). They confirmed that worry and anxiety enhance the ERN in response to errors and the same relation was replicated for generalized anxiety disorder (Weinberg, Olvet, & Hajcak, 2010). Moser, Moran, Schroeder, Donnellan, and Yeung (2013) recently conducted a meta-analysis of studies on anxiety and error-related negativity amplitude, which showed that anxious apprehension/worry—rather than anxious arousal—is the dimension of anxiety closely associated with error monitoring. These authors argued that a content analysis of the BIS scale (Carver & White, 1994) suggests its strong relation to the apprehension type of anxiety, which supports linking the BIS with the ACC function of error monitoring and emotional reaction to error or conflict detection.

Etkin, Enger, and Kalisch (2011) showed that both regions of the ACC and medial prefrontal cortex are engaged in emotional processing like appraisal processes and generation of emotional responses. The confluence of cognitive and emotional processing within the ACC seems to support the biological basis of the comparator function related to the BIS, encompassing mismatch or conflict detection and the state of anxiety as a consequence. However, more empirical data are needed to validate this assumption.

CONTROL PROCESSES RELATED TO THE BIS: BIOLOGICAL BASES

In the reformulated model (Corr, 2008; see Figure 1 above), activation of the BIS as a result of conflict detection leads to initiation of several cognitive processes (e.g., emotionally biased attention and memory) aimed at conflict resolution. The biological bases for these processes are not very clearly established within BIS theory. Corr (2010), based on the Miller and Cohen (2001) model, proposed that the dorsal stream of the prefrontal cortex is the cortical area related to the control function of the BIS (McNaughton & Corr, 2008). The role of the prefrontal cortex in conflict resolution was also studied within the conflict-control model of Botvinick and others (Botvinick, Braver, Barch, Carter, & Cohen, 2001; Kerns, 2006; Krug & Carter, 2012).

According to the conflict-control model (Botvinick et al., 2001), conflict detected by the ACC recruits control from the dorsolateral prefrontal cortex to resolve the conflict. The role of the dorsolateral prefrontal cortex in conflict resolution (producing the correct reaction) was confirmed in several experiments, with the Stroop or flanker tasks used to induce the process of conflict detection and resolution (Kerns, 2006; Krug & Carter, 2012). Botvinick et al. (2001) proposed that in the conflicting trials of a Stroop task the conflict is resolved by enhancing attention to the task-relevant stimulus or stimulus dimension (Enger & Hirsch, 2005).

Also, Miller and Cohen (2001) analyzed the control processes engaged in Stroop and the Wisconsin Card Sorting Test performance guided by rules and requiring either selective attention, behavioral inhibition, or working memory. The control processes related to top-down processing, "when behavior must be guided by internal states or intentions" (Miller & Cohen, 2001, p. 168), are linked to the function of the prefrontal cortex. Therefore top-down attentional processing is one of the primary processes related to cognitive control (see also Rueda et al., 2004).

BIS-RELATED COGNITIVE CONSEQUENCES OF CONFLICT DETECTION: ATTENTIONAL PROCESSING

The BIS is thought to be a goal-conflict detection/resolution device and as such is related to cognitive control (Botvinick et al., 2001; Corr, 2010) links this comparator function to executive control on the basis of common neurological structures that share the BIS and executive control—namely, the prefrontal cortex (see Miller & Cohen, 2001). The concept of cognitive control contains a few higher-order cognitive processes related to "perceptual selection, response biasing, and the online maintenance of contextual information" (Botvinick et al., 2001, p. 624).

In the literature there are some other approaches referring to the notion of cognitive control, such as the concepts of executive attention (Rueda et al., 2004) and attentional control (Derryberry & Reed, 2002), all of which emphasize an important role of the attentional mechanisms in cognitive, emotional, and behavioral regulation. The concept of executive attention is one of the three attentional systems, in addition to the orienting and alerting systems, proposed by Rueda et al. (2004). Neurocognitive data support the role of the executive system of attention in conflict detection (Walsh, Buonocore, Carter, & Mangun, 2011), conflict-monitoring processes (Botvinick, 2007), and conflict resolution (Fernadez-Duque et al., 2000).

The processes of selective attention related to the executive system of attention are the main focus of this chapter. The control mechanism of selective attention guides the process of perception to filter out the stimulus salient for the sake of an active goal. To highlight the superior role of attentional processes over perception in cognitive control, the attentional processes are termed "perceptual attention" (Derryberry, 2002).

We postulate that if the BIS is related to conflict detection and monitoring, then the attention that selectively monitors and filters out the information about the state of discrepancy to the standard (current level of conflict) is a manifestation of the control mechanism related to the BIS. In other words, we suggest that discrepancy detection as a bottom-up attentional process establishes the top-down selective attention aimed at discrepancy or conflict monitoring. The detection of discrepancy occurs at an early stage of information processing, at the automatic level (see more evidence in the biological section of this chapter) involving a pre-attentive memory-based comparison process, with involuntary shift of attention (e.g., Yantis, 2008).

The discrepancy/conflict as potentially evolutionary salient information catch/engage the orienting mechanism of attention toward the source of a mismatch (e.g., Fernadez-Duque et al., 2000; Posner, 1994). Such attentional engagement might simultaneously evoke activation, resulting in engagement of the executive mechanism of attention (Fernadez-Duque et al., 2000; Posner, 1994). Executive attention is mostly employed in situations requiring voluntary selection among competing items, resolution of conflict among responses, and monitoring and correcting errors (Posner & Rothbart, 1998). The vigilance and orienting systems of attention are more reactive and closely related to motivational processes. Automatic processes regulate them until the executive system of attention is activated and starts to exert control over them in the service of ongoing needs and goals. Therefore involvement of the executive mechanism of attention changes the nature of cognition from automatic to controlled (Fan, McCandliss, Fossella, Flombaum, & Posner, 2005; Fernadez-Duque et al., 2000; Kolańczyk, 2004), probably with prioritizing the control over stimulus input.

The BIS operating as a comparator runs as a negative feedback system, in which the change of the output (at any level: emotional, cognitive, or physical) is aimed at countering any deviation of the input function from the reference value (no-conflict state; see Carver & Scheier, 1998). Thus the BIS as a comparator monitors any deviation from the standard value of no conflict, and as a result all incoming stimuli—which are different and might increase the discrepancy or the conflict—should be attended. In other words, the dissimilarity orientation, being a result of the engagement of the orienting system of attention by discrepancy detection, is sustained by the executive system of attention—selective top-down processing of dissimilarity in the service of active goal-discrepancy monitoring. Thus top-down selective attention serves a control function over bottom-up perceptual processes, modulating them according to an active standard.

We should expect that high BIS-sensitive subjects should be especially motivated to orient their attention toward dissimilarity, since individual differences in BIS sensitivity determine the threshold for the error-triggering mechanism (Corr, 2010). High BIS sensitivity being related to lower threshold—a kind of oversensitive, error-triggering mechanism—results in detecting minor discrepancies and experiencing a higher level of anxiety. By contrast, low BIS sensitivity should lead to impeded capability to detect the mismatch between expected and actual stimuli, resulting in increased tolerance of discrepancy and an absence or a low level of anxiety. Recently collected data provide some support for this hypothesis. Leue et al. (2012) confirmed the earlier findings of Amodio et al. (2008), showing that high-BIS individuals display high conflict-monitoring intensity to a low conflict level and do not adequately regulate the conflict-monitoring sensitivity in response to the variations in intensity of conflict level (more negative N2 amplitude as a response to a Go/NoGo task with a low conflict level); on the contrary, low trait-BIS individuals effectively adapt the comparator function of BIS (conflict-monitoring intensity) to the level of conflict (discrepancy).

Orientation to Dissimilarity

Dissimilarity focus and similarity focus are two types of comparative processes that play a crucial role in many psychological domains (Hassin, 2001). Perception of similarities or dissimilarities can be shaped by several factors like stimuli characteristics, task formulation, direction of comparison, and effective context (Tversky & Gati, 1978). Perceiving similarities is a positive function of common properties and negative function of distinctive properties (Tversky & Gati, 1978). The more the compared objects have in common, the more they are perceived as similar (Shepard & Arabie, 1979). On the other hand, when one of the compared objects has a characteristic that the other does not, the objects are perceived as dissimilar. Differences are easier to find for similar pairs than for dissimilar pairs (Genter & Markman, 1994). Characteristics of the standard also shape comparative processes. Extreme characteristics of the standard initiate a search for dissimilarities, while moderate characteristics trigger a search for similarities (Damisch, Mussweiler, & Plessner, 2006).

The attentional processes that underlie the similarity and dissimilarity perception are best represented in the search asymmetries, a part of feature integration theory of Treisman and Gelade (1980) that shows differences between two search conditions. In the target+ condition, the target is given an additional feature not contained in any of the nontargets. In the target- condition, a critical feature is removed from one (target) element and this feature is retained in all other nontarget elements. Thus, for instance, a target+ condition would be one in which the target is a Q and the nontargets are O's. In the target- condition, the mapping is reversed such that now O is the target and Q's are the nontargets (Quinlan, 2003).

The crucial finding of the search asymmetries is that the target present condition is easier than the target absent condition. Performance of the discrimination task where the target feature absent is more capacity demanding because of the memory imperative (Warm, Parasuraman, & Matthews, 2008). This task engages a successive discrimination, where the observer needs to compare current input with the standard retained in working memory to separate critical signals from nonsignal stimulus events. In the discrimination task where the target is present, simultaneous processing is involved. All the information needed to distinguish signals from nonsignals is present in the stimuli themselves and there is little involvement of recent memory for the signal feature.

Similar predictions can be derived from the social models of comparative judgments. Mussweiler and Epstude (2009) and Corcoran, Epstude, Damisch, and Mussweiler (2011) demonstrated that judging the similarity of two stimuli is faster and related to searching for less target information than judging the dissimilarity of two stimuli. Focusing on similarities thus appears to be the more efficient comparative thinking style and is activated as nonintentional process, which occurs during the "normal" course of processing and appears early in cognitive development (see discussion in Markman & Genter, 2005). Thus dissimilarity focus seems to be a more cognitively demanding strategy of information processing.

Biases in comparative processes range from an attentional level of processing to a conceptual one (Friedman & Förster, 2010; Gardner, 1953). Bias means that we are selectively concentrating either on stimuli that are similar and congruent to the comparative standard or on those that are dissimilar and incongruent (Carver & Scheier, 1998; Friedman & Förster, 2010; Mussweiler & Epstude, 2009). In addition to the stimuli and task characteristics, there are motivational processes that could bias the comparison.

Nussinson, Seibt, Häfner, and Strack (2011) presented a hypothesis that avoidance motivation leads to perceiving more differences between objects in the environment. In two experiments both avoidance and approach motivation were induced using the arm flexion procedure. Subjects rated the similarities and differences between eighteen pairs of objects related differently to each other. Results showed that manipulation of motivation differentiated the ratings of similarity in such a way that motivational states related to avoidance are related to the reduction of similarities perception (similarities/dissimilarities were a one-dimensional characteristic of comparative objects).

More indirect evidence comes from the studies of Förster (2009). He manipulated promotion and prevention focus and asked subjects to rate the similarities and differences between two pictures. Results revealed that subjects in a prevention state perceived more differences between objects than subjects in a promotion state or in the control group. They also perceived more differences than similarities as a within-group effect.

Looking for differences means that we selectively concentrate on features that are different from the standard or from other objects. Differences in terms of the feedback processes signal that something does not meet the standard or the expected value or an error occurs in ongoing processes (Carver & Scheier, 1998). Discrepancy itself is a state that evokes arousal (MacDowall & Mandler, 1989), negative affect (Carver, & Scheier, 1998; Hajcack & Foti, 2008), or affective consequences like surprise—a nonpropositional signal of the output of schema-discrepancy detector (Reisenzein, 2000). Therefore affective processes are strongly related to discrepancy detection (see also the biological part of the chapter). What is the role of affect in dissimilarity orientation?

Affect is a reaction of the organism to any change in the environment or organism, and as a "proto-emotion" is characterized only by the strength of activation and by the valence (positive or negative) that is based on basic biological processes, causing the tendency to be oriented toward or away from the source of change (e.g., Chen & Bargh, 1999; Kolańczyk, 2004; Neuman & Starck, 2000; Smith & Neuman, 2005). The role of affective processes in an error-detection mechanism might consist of automatic evaluation of what is going around. Affect is triggered before any controlled cognitive operations have been engaged and therefore operates subconsciously, providing basic information about the state of the environment or the organism (e.g., theory-based appraisal proposed by Clore & Ortony, 2000; Schwarz, 2002; Winkielman, Berridge, & Wilbarger, 2005).

Thus it is possible that unconscious detection of errors (Franssens & de Neys, 2009; Yantis, 2008) generates sufficiently strong negative affect (the higher sensitivity of BIS, the stronger the negative affect) to strengthen attention toward errors. In other words, negative affect provides basic information ("Watch out!") that intensifies the orienting system of attention, and in response the executive mechanism of attention is engaged with selective attention to mismatch.

THE BIS AND ATTENTIONAL ORIENTATION TO DISSIMILARITY: SYNOPSIS

The BIS working as a comparator is engaged in conflict detection and resolution. Conflict detection results in activation of the affective mechanisms (e.g., Hajcak & Foti, 2008) as well as the multilevel attentional mechanisms conclusively related to the executive attention system (cognitive control; Fernadez-Duque et al., 2000). Both types of mechanisms are aimed at conflict monitoring and conflict resolution (Aarts & Pourtois, 2010).

Taking all these data into account, we propose that orientation to dissimilarity is an attentional mode developed as one of the cognitive tools that supports conflict monitoring, the BIS-related comparator function. Therefore orientation to dissimilarity can be viewed as a part of cognitive control processes. The arguments supporting the theoretical status of orientation to dissimilarity are based on biological data, as well as cognitive and affective consequences of conflict detection.

Based on the cognitive and affective mechanisms activated as a result of conflict detection, which might be responsible for developing the BIS/dissimilarity focus relationship, we first examine the role of negative affect as a potential moderator of to the BIS/dissimilarity focus relationship. If this is true, then especially the high BIS sensitivity related to high negative affect should result in dissimilarity focus (Study 1). It is not entirely clear whether the BIS/dissimilarity focus relationship is the cognitive mechanism developed as a consequence of comparator function related to BIS, or whether it developed as a consequence of affective reaction (anxiety) to conflict detection. The second hypothesis deals with the BIS relation to dissimilarity and similarity detection; we expect that BIS sensitivity should improve dissimilarity detection (Studies 2 and 3).

THE BIS AND ATTENTIONAL ORIENTATION TO DISSIMILARITY: SELECTED EMPIRICAL EVIDENCE

Below we present three empirical studies concerning the relation between the BIS as a dimension of individual differences and the attentional processes related to orientation to similarity versus dissimilarity.

To test selective attention to dissimilarity, we chose the d2 Test of Attention since it allows testing the process of objects selection according to the active goal provided by the instruction (select all objects similar or dissimilar to the target). During the process of objects selection, subjects need to focus on particular characteristics of objects while suppressing awareness of competing distractors (Brickenkamp & Zillmer, 1998). Moreover, studies on the structure of attention revealed that performing the d2 Test of Attention is related to the ability to switch the attentional focus from one stimulus dimension to another and the ability to divide attention between two stimulus dimensions (Goldhammer, Moosbruger, & Schweizer, 2007). Additionally, the condition of dissimilarity detection requires inhibition of the prompt reaction to signals similar to the target. All processes involved in the performance of the d2 Test are basic cognitive processes related to attentional control (Rueda et al., 2004).

Study 1. Does BIS Sensitivity or Negative Affect Improve Dissimilarity Orientation?

We hypothesized that the relation between the BIS and dissimilarity focus will be amplified by the intensity of negative affect.

The orientation to dissimilarity was tested with a paper-and-pencil d2 Test of Attention. The test consists of two subtests: objects selection of objects similar (d1) or dissimilar (d2) to the target (Brickenkamp & Zillmer, 1998; Polish adaptation by Dajek, 2003). In this study we used the second version—dissimilarity focus. Individual differences in BIS sensitivity were measured with the BIS/BAS scale (Carver & White, 1994; Polish adaptation by Müller & Wytykowska, 2005). First, 110 participants (64 females, $M = 21.\ 6$, $SD = 1.9$) completed the BIS/BAS scale and later were randomly assigned to either the experimental or control condition. Twelve subjects were excluded from the analysis as outliers (Asendorpf, 2010).

In the experimental (failure) condition, participants played the well-known computer game Tetris for four minutes, which was programmed in such a way to make it almost impossible to create a horizontal line of ten blocks without gaps—hence they were bound to fail. In the control condition, participants rated ten pictures according to their quality. After finishing the computer task, they completed the PANAS short version (Watson, Clark, & Tellegen, 1988) and took the d2 Test of Attention (dissimilarity searching part). Individuals were expected to scan fourteen lines with 47 characters in each line and cross out all occurrences different from the letter *d* with two dashes in four minutes (inhibition and focusing on the dissimilarities condition), and were asked to "work as quickly as you can without making mistakes."

As an index of dissimilarity focus, we took the hit rate index reflecting the proportion of items correctly processed to the total number of items scanned. To avoid using letter symbols, we will call this index effectiveness of detection. Since this index is sensitive to the speed/accuracy trade-off, to control it we also tested the strategy of the test performance like skipping strategy, which is characterized by extremely high scores for processing speed—total number of items processed—but a correspondingly high percentage of errors, especially errors of omission. The omission type of error is mainly related to the speed/accuracy trade-off, since increased processing speed at the expense of processing accuracy results in an increase in errors of omission (Lobaugh, Cole, & Rovet, 1998; Zenger & Fahle, 1997).

First, the correlations between BIS measure and the performance indices were tested to check whether the index of effectiveness of detection could be reliably used. Additionally, the total of items processed as an index of speed of processing was analyzed. Results showed that the BIS positively correlates with hit rate $r(98) = 0.414$, $p < 0.01$, and negatively with skipping strategy $r(98) = -0.401$, $p < 0.01$; there was no significant relation to speed but the direction was negative. Therefore it seems that BIS sensitivity is related to processing strategy, manifested in sacrificing speed for accuracy.

Experimental manipulation was successful; the ANOVA analysis revealed that negative affect significantly differed between conditions $F(1, 95) = 8.640$, $p < 0.01$, $\eta^2 = 0.085$. In the stress condition the mean negative affect was 24.57, while in the control condition it was 20.53.

The ANOVA analysis showed that the experimental condition did not influence the hit rate in dissimilarity searching task $F(1, 98) = 0.30$, $p = 0.83$, $\eta^2 = 0.002$. The failure experience itself had no impact on effectiveness of dissimilarity detection. To test whether the BIS/dissimilarity focus relationship is dependent on the intensity of negative affect (measured after the failure experience), a hierarchical regression analysis was used. In the first step the BIS, NA, and experimental condition were entered as predictors, followed by the interaction of the BIS and NA in the next step and finally the interaction of the BIS and experimental condition. Even when the experimental condition was included in the regression analysis, the ANOVA was not significant, aimed at controlling the cognitive (worry) or motivational effects that might be not picked up by the NA scale. The first step of the regression model accounted for a significant portion of variance ($R^2 = 0.21$), $F(3, 94) = 7.98$, $p < 0.001$, with BIS (ß = 0.509, $p < 0.001$) as a significant predictor and both NA (ß = –0.165, $p = 0.124$) and experimental condition (ß = 0.73, $p = 0.46$) as nonsignificant. The second and third steps of the model did not account for an additional portion of variance. Therefore neither mood nor failure (experimental conditions) seem to moderate the BIS/effectiveness of dissimilarity detection relationship.

Hierarchical regression for skipping strategy as a dependent variable revealed that only the BIS accounted for a significant portion of variance ($R^2 = 0.19$), $F(3, 94) = 7.76$, $p < 0.001$, with BIS (ß = –0.491 , $p < 0.001$). Neither NA and experimental conditions nor their interaction with the BIS appeared to be significant predictors.

Finally, we conducted hierarchical regression for speed (all items processed). Results showed again that only first model was significant ($R^2 = 0.08$), $F(3, 94) = 2.67$, $p < 0.05$. The significant predictors were BIS (ß = –0.22, $p < 0.05$) and NA (ß = 0.225, $p < 0.05$). The whole regression model appeared to be weak, however.

Results from the first study showed that BIS sensitivity promotes concentration on the accuracy rather than the speed of processing, which results in more effective detection of items different than the target. Negative affect appeared to be only slightly positively related to effectiveness of detection.

Studies 2 & 3. BIS Sensitivity and Dissimilarity Detection: A Stable Pattern of Relation?

The previous study suggests that the BIS is indeed related to orientation to dissimilarity. However, there are two modes of comparison processes: orientation to similarity versus orientation to dissimilarity. We hypothesized that the BIS should be particularly oriented to dissimilarity due to the fact that such orientation facilitates monitoring the discrepancies to the standard (no conflict) as one of the comparator functions. To test this prediction, we incorporated both types of detections—similarity and dissimilarity—into the next study.

The orientation to similarity versus dissimilarity was tested with the paper-and-pencil d2 Test of Attention and individual differences in BIS sensitivity were tested with the BIS/BAS scale. In Study 2, 99 participants after removing outliers (79 females, $M = 21.2$, $SD = 2.1$) across two sessions completed the BIS/BAS scale[1] and then took the first test of attention. Individuals were expected to scan fourteen lines with 47 characters in each line and cross out all occurrences of the letter *d* with two dashes while ignoring letters *d* or *p* marked with one, three, or four small dashes in four minutes (searching-for-similarities condition). After the distraction trial, they were asked to scan the lines and not cross out all occurrences of the letter *d* with two dashes while crossing out all other characters in four minutes (inhibition and focusing on the dissimilarities condition). The instruction again was "work as quickly as you can without making mistakes."

ANOVA with repeated measures within the hit rate as a within-subjects factor and BIS 3 (low vs. average vs. high) as a between-subjects factor was conducted. The significant result is shown in Figure 2.

Analysis of contrast effects showed that high BIS scores differ in effectiveness of detecting similarities versus dissimilarities, in such a way that high-BIS subjects are better at recognizing the items that are different than the target item (dissimilarity condition) than the items, which are the same as a target item (similarity condition) $F(1,96) = 5.41$, $p < 0.05$, $\eta^2 = 0.07$.

To control the speed/accuracy trade-off, the same ANOVA analysis was done for skipping strategy and speed. Analysis revealed the main effect of BIS for skipping strategy $F(2,95) = 3.61$, $p < 0.05$, $\eta^2 = 0.07$. Generally, the high-BIS ($M = 0.14$, $SD = 0.003$) and the average BIS ($M = 0.15$, $SD = 0.002$) subjects made less errors of omission than low-BIS subjects ($M = 0.23$, $SD = 0.003$). For the speed analysis, the results were nonsignificant.

The results partly confirmed predictions and suggested that high sensitivity of the BIS is related to more effective detection of dissimilar than similar signals.

[1] The sample was split into three groups according to the mean for the BIS scale (M = 20.8) and the 0.5 of the standard deviation (SD = 4.2) to the mean.

Such "specialization" was not observed in the groups with a low and medium level of BIS sensitivity. Nevertheless, this conclusion needs to be made with caution since the study design has one limitation. The search-for-similarities versus search-for-dissimilarities condition was not randomly distributed. All participants first completed the search-for-similarities task and after that the search-for-dissimilarities task; therefore the hit rate index might be a result of individual differences of the BIS, as well as the practice effect. However, even if the results mainly reflected the practice effect, this effect was significant only for the high-BIS group—which might suggest that subjects with high BIS sensitivity were particularly motivated to search for dissimilarities.

This line of reasoning is supported by the findings obtained by Nussinson et al. (2011). The effect of fatigue or ego-depletion processes is rather less, probably since the simple d2 Test takes only four minutes—in comparison with other popular tests that measure sustained attention (like the continuous performance test) that take five times longer. One more feature of the design of this study deserves our attention. There is a kind of set-switching element to the task since the second task required subjects to swap the stimulus-response mapping of the first task (G. Matthews, personal communication, 2014). Keeping in mind that the BIS is strongly related to the apprehension type of anxiety (Moser et al., 2013), the better detection of dissimilarity than similarity revealed only by high-BIS subjects seems to be inconsistent with Eysenck's attentional control theory (ACT; Eysenck & Derakshan, 2011).

Eysenck and Derakshan (2011) claimed that anxiety mainly impairs processes related to executive functions of working memory like inhibition, updating, and

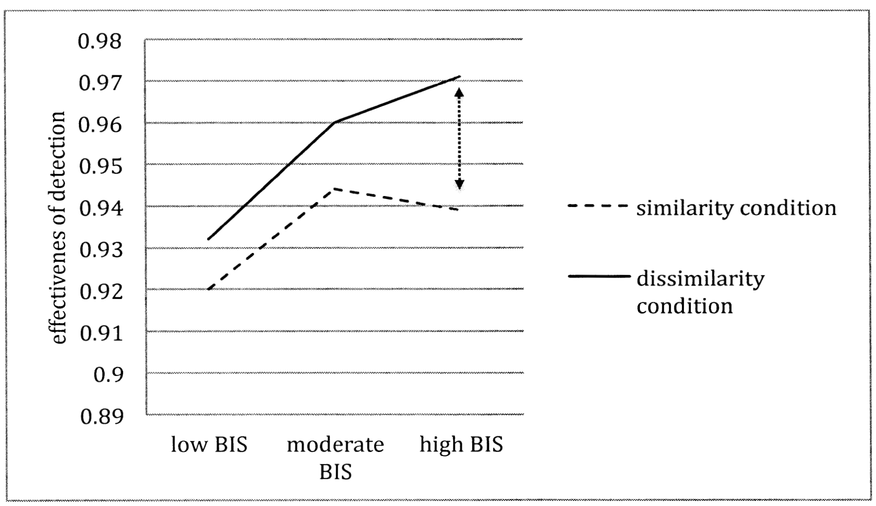

Figure 2. Effectiveness of similarity and dissimilarity detection as a within-group condition, depending on the BIS scores.

shifting. Therefore, in the case of shifting we should expect decreased—rather than improved—performance of the second task (dissimilarity detection) among high-BIS subjects. We might argue that the design of the study was not a standard design for testing the effectiveness of shifting (Eysenck & Derakshan, 2011) since there was a buffer task between both attentional tests. Therefore the 6–7 minutes of the buffer task might be long enough and sufficiently cognitively engaging to unlink the S–R association.

In the next study, the search for similarities and dissimilarities was a between-subject condition. A total of 108 participants (56 females, $M = 18.6$, $SD = 1.02$) across two sessions completed the BIS/BAS scale, then were randomly assigned to either the similarities or dissimilarities condition and took the Test of Attention.

Since the aim of the study was to test the relation between BIS sensitivity and effectiveness of similarities versus effectiveness of dissimilarity detection, two one-way ANOVA were conducted—one for the detection of similarities and the second for dissimilarities. The analysis of variance was chosen due to the fact that the BIS/dissimilarity detection relationship was curvilinear. The sample was split into three groups according to the mean for the BIS scale ($M = 20.25$) and the 0.5 of the standard deviation ($SD = 3.81$) to the mean.

Results showed that BIS sensitivity did not differentiate the effectiveness of similarity detection $F(2, 46) = 0.9$, $p = 0.4$. For the effectiveness of dissimilarity detection, the main effect of BIS was significant $F(2, 56) = 4.92$, $p < 0.05$, $\eta^2 = 0.18$. High-BIS subjects outperform ($M = 0.95$, $SD = 0.01$) moderate BIS subjects ($M = 0.91$, $SD = 0.01$), $p < 0.05$ and low-BIS subjects ($M = 0.93$, $SD = 0.01$), $p = 0.054$. In the similarities-detection condition, the BIS did not differentiate the effectiveness of similarity detection. The results are shown in Figure 3.

The results showed that indeed high BIS-sensitive subjects were more effective in detection of dissimilarities than their moderate and low BIS-sensitive counterparts. Additional analysis conducted for skipping strategy and speed did not reveal any significant results.

DISCUSSION

The main focus of this chapter is on the idea that, at the cognitive level, BIS sensitivity as a personality characteristic may result in developing the dissimilarity-oriented attentional mode that facilitates fulfilling the comparator function consisting of conflict detection and resolution. The idea is based on the analysis of the regulative function of the BIS operating according to the negative feedback loop.

We argued that if the BIS operates as a negative feedback system, then it needs to monitor any deviations from the standard value of the state of no conflict. As a result, all incoming stimuli (which are different than the standard and might increase the conflict) should be attended and therefore controlled. In other words, the dissimilarity orientation is a result of the engagement of the executive system of attention in the service of an ongoing goal—reduction of discrepancy to the state of no conflict to prevent a conflict (Botvinick et al., 2001).

We argued further that the data indicate two possible mechanisms responsible for the hypothesized dissimilarity focus/BIS relationship. The first mechanism is a cognitive one resulting from employment of the executive system of attention in response to conflict detection. The second mechanism is an affective one and stems from the affective response to conflict detection, in this case dissimilarity orientation developing as a consequence of the way in which negative affect shapes information processing. Finally, since we focus on the BIS as a personality characteristic, we claim that the mechanisms described above will develop into a relatively stable pattern of attentional processing mode.

The BIS and Dissimilarity Focus: Empirical Findings

We presented three studies more directly examining the relation between the attentional dissimilarity versus similarity focus and BIS sensitivity as a personality characteristic.

The pattern of the findings was generally in line with our proposal. High BIS-sensitive individuals, assigned according to the Carver and White (1994) scale, outperformed their low BIS-sensitive counterparts in the effectiveness of dissimi-

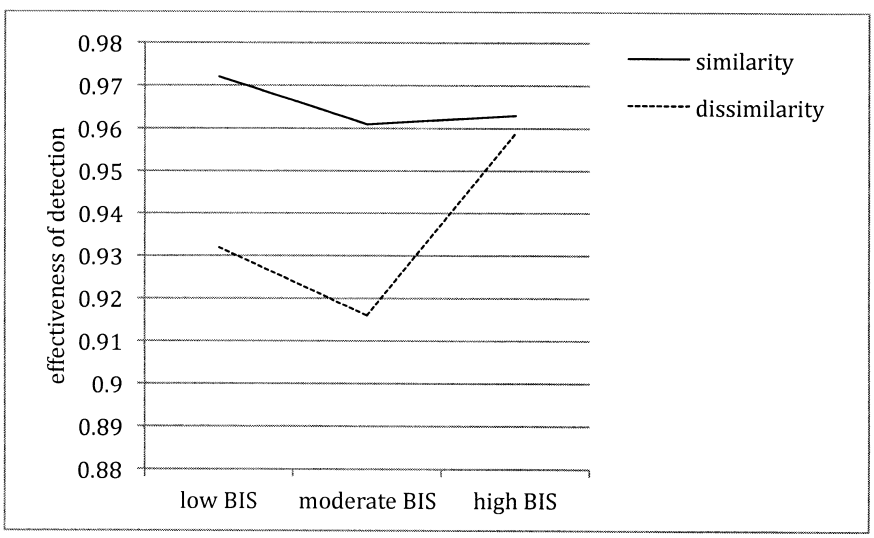

Figure 3. Effectiveness of similarity and dissimilarity detection, depending on the BIS scores.

larity detection across three studies. High-BIS individuals were more effective in detecting dissimilar stimuli to the target than low BIS-sensitive subjects (Studies 2 and 3). Also, Nussinson et al. (2011) recently collected data showing that avoidance motivation—induced by the arm flexion procedure—leads to perceiving more differences between objects. Keeping in mind that generally perceiving similarities is more imposed, quicker, and cognitively less demanding than perceiving dissimilarities (Förster, 2009; Markman & Gentner, 2005; Mussweiler & Epstude, 2009), we showed that high BIS sensitivity biased this rule toward dissimilarity preferences.

We hypothesized that the postulated BIS/dissimilarity orientation relationship may be developed as a result of the impact of the negative affect on information processing. The role of negative affect appeared to be statistically nonsignificant. However, the analysis suggests that to some extent negative affect might reinforce dissimilarity orientation, but only in low-BIS subjects since only those individuals benefited from intensive negative affect by improving the effectiveness of dissimilarity detection. Increase of negative affect for high BIS-sensitive individuals had no effect on their effectiveness to detect dissimilarities.

Therefore it seems that the affective mechanism might be important in developing dissimilarity orientation (e.g., Förster, Friedman, Özelsel, & Denzler, 2006) related to the BIS. However, it may not be reduced to it, which means that the BIS/dissimilarity focus relationship may not be explained only by the affective mechanisms. It is possible that for high-BIS individuals the low threshold for conflict detection results in engagement of cognitive and affective mechanisms at the same time. Since both mechanisms exert the same effect on attentional processing, they might mutually amplify their influence on attentional processing, resulting in development of the orientation to dissimilarity.

Neurocognitive data collected recently by Aarts and Poutois (2010) provide indirect support for this line of reasoning. They have showed that among high-anxious subjects (high BIS) the conflict created by a speeded Go/NoGo task produced higher sensitivity to errors (higher peak of error-related negativity), as well as an affective response to them at the very early stage of processing. Moreover, high-BIS participants felt more anxious. Aarts and Poutois concluded that this finding suggests that anxiety alters the configuration of the neural network activated during early error monitoring. The involvement of the rostral ACC may indicate that not only cognitive but also emotional monitoring effects were temporarily active in high-anxious participants during the early detection of response errors (Aarts & Poutois, 2010).

Dissimilarity Focus as a Control Function

For high-BIS subjects the dissimilarity orientation servers a control function over the stimulus incoming to the system. It enables monitoring any signals violating the standard but is also a more cognitively demanding method of information processing (Förster, 2009; Markman & Gentner, 2005; Mussweiler & Epstude, 2009).

Conditions in all the studies presented in this chapter were not highly demanding; hence high BIS could be more effective in dissimilarity detection. However, we could expect that when the experimental conditions are more stimulative, they would decrease the efficiency of dissimilarity detection (Wytykowska, 2011). Also, the studies on attentional control showed that trait anxiety does not impair attentional control processes until high cognitive demands (e.g., task difficulty) or high stimulating conditions (e.g., time pressure) are introduced (e.g., Derryberry, 2002; Eysenck, 2000; Eysenck, Derakshan, Santos, & Calvo, 2007).

The direct and indirect data presented concerning the BIS/dissimilarity focus relationship suggest that cognitive control is exerted primarily by control over an incoming stimulus. This suggestion is consistent with the part of ACT (Derakshan & Eysenck, 2009; Eysenck, Derakshan, Santos, & Calvo, 2007) where anxiety is proposed to be related largely to the stimulus-driven attention system and often at the expense of the goal-directed attention system. Moore et al. (2012) collected data showing the relation between individual differences in BIS sensitivity and theta waves during response to goal conflict. Subjects were presented with a continuous stream of digit sequences containing four single-integer digits in such a way that one digit was presented for one second, and after each digit sequence an *X* was presented. Subjects were asked to press the button containing four odd digits after each sequence. The registered pattern of theta responses seems to suggest that high- and low-BIS subjects might experience conflict within this task in a different manner. Specifically, low-BIS subjects seemed to experience conflict as a stimulus response, while for high-BIS subjects it was rather a stimulus-stimulus conflict.

Since we consider the dissimilarity orientation as an attentional control mechanism, we need to understand how it is related to ACT (Eysenck & Derakshan, 2011). Eysenck and Derakshan (2011) highlight three core components of attentional control: switching (mostly between the tasks), inhibition, and top-down selective attention. Based on empirical studies, they have demonstrated that anxiety impairs either processing efficacy (anxious individuals need to allocate more effort to perform the task) or impairs all three of these core components (performance effectiveness), mostly in more demanding situations. Also, BIS as a trait is negatively related to volitional attentional control (Fajkowska & Derryberry, 2010). The negative relation between anxiety and attentional control does not contradict the premise and empirical findings presented in this chapter. Dissimilarity orientation as a BIS-specific, selective top-down processing is governed by the need for control over the level of discrepancy (stimulation signaling standard disruption). The main regulative goal is to overcome the negative consequences resulting from the conflict. This positive relation is observed when the demands of the task do not exceed the cognitive resources of the individuals. However, if the task demands exceed the available cognitive resources, then the control mechanism becomes ineffective (Wytykowska, 2011).

Dissimilarity Focus: From the Attentional to the Conceptual Level of Processing

In a 1953 paper published in the *Journal of Personality*, Riley Gardner claimed that concentration on differences-dissimilarity focus is related to sensory judgment as well as conceptual judgment and is reflected in narrow categorization in free sorting tasks. Such a narrow categorization is suggested to be a mechanism to control external stimulation by

> attaching a greater importance to distinguishing between the objectively accurate and the more apparent qualities of stimuli (whichever is demanded at the moment) that result in building the representation of the world in terms of its reducible and classable features. (p. 230)

And Derryberry and Tucker (1994) observe that the detected relation between the BIS and dissimilarity orientation could have further consequences for information processing at the later stages, since the method of processing at the early stages (attentional processing) determines—to some extent—the method of processing at the later stages (conceptual processing).

The results supporting the control function of dissimilarity orientation at the conceptual level are presented by Mikulincer and associates (Mikulincer, Kedem, and Paz, 1990; Mikulincer, Paz, & Kedem, 1990). In their research anxious subjects formed not only narrower categories containing fewer objects in comparison with the breath of categories formed by nonanxious subjects, but they also perceived objects as less similar to the prototype (categorization task based on the approach by Rosch, 1978). High BIS sensitivity (BIS/BAS scale) also appeared to be related to concrete stimulus-based and narrow categorization (Wytykowska, 2005; Wytykowska & Smillie, 2009). These results showed that the BIS-dependent dissimilarity focus shapes more elaborate cognitive processes.

Limitations

First, there might be some reservations about using the d2 Test to examine dissimilarity orientation. Matthews (personal communication, 2014) pointed out that the difference between similarity and dissimilarity searching (especially in Study 1) might be a result of reversal of the S–R relationship rather than a change in stimulus processing—that is, when in the first test (similarity search) subjects had to detect all *d* with two dashes, then in the second test (dissimilarity search) the strategy might be "check whether it is *d* with two dashes and not respond." However, the results of Studies 2 and 3 suggest that the BIS-dissimilarity focus is not the case of the responding strategy. Nevertheless, more studies employing different attentional as well as more complex tasks are needed. Preliminary results of one study conducted by Wytykowska (in preparation) confirmed the BIS/dissimilarity focus relationship. Participants were asked to prepare a project according to some guidelines (standard) in limited time, after which they were provided with mixed feedback containing information that was both congruent and incongruent with the standard in their project. Results showed that the high-BIS subjects mainly focused on incongruent information.

Second, more studies are needed to clarify the exact status of dissimilarity orientation within the BIS model. On the one hand, it could be treated as a consequence of BIS activation and be placed beside the attentional and memory biases to threat. On the other hand, it could be a cognitive mechanism by which a comparator operates. If so, dissimilarity orientation should be placed within the model of the BIS as a comparator.

EPILOGUE: CHALLENGING ISSUES

The question now is how the relationship between the BIS and dissimilarity focus contributes to understanding the regulative role of the BIS as a comparator. The point on which we would like to focus is the standard value.

The standard of regulation is expressed as a state of no conflict. Corr (2008, 2010) claims that conflict detection results in BIS activation, which causes multilevel responses aimed at conflict resolution, returning to the state of no conflict. The function of dissimilarity orientation and negative biases in information processing is to monitor stimuli or action directions that might result in emerging and increasing conflict. These processes provide information about what needs to be avoided to prevent enlarging discrepancy. Cognitive control activated after the conflict detection contains conflict-monitoring and conflict resolution processes (e.g., Botvinick et al., 2004). Conflict-monitoring processes are reflected in "strategic adjustment of cognitive control, which serves to prevent conflict . . . and in detection of internal states signaling a need to intensify or redirect attention or control" (Botvinick et al., 2004, p. 539). Therefore it could be argued that dissimilarity orientation and negative biases in information processing initiated as a result of BIS activation might mainly control the inputs to prevent increasing the state of discrepancy or conflict, though they are related to conflict monitoring rather than conflict resolution.

There is also another aspect of conflict resolution related to the BIS that might be questioned. Provided that the BIS operates according to the negative feedback loop, the comparator should detect the state signaling conflict resolution to end the initiated process of regulation (Carver & Scheier, 1998). If so, the BIS should be sensitive to any input (external or internal) signaling the state of no conflict. For the sake of clarifying the argument presented, we will concentrate only on the emotional representation of the state of no conflict. If conflict detection is related to anxiety (Aarts & Pourtois, 2010; Hajcak, McDonald, & Simons, 2004), the state of conflict resolution or no conflict could be related to the emotion of relief or any other positive emotional state (e.g., joy). According to BIS theory (Corr, 2004, 2008), however, the BIS as a part of the punishment axis (along with the FFFS) is not sensitive to any state evaluated as positive or positive by the lack of negativity. Therefore it is difficult to show how the system knows that conflict is resolved. This creates a basic problem with the control function within the system (Carver & Scheier, 1998).

We may speculate that the BAS or FFFS might be responsible for conflict resolution. In this case the processes initiated after BIS activation (conflict detection) aiming at conflict monitoring reduce the discrepancy or anxiety to the extent that the inhibition of the BAS, exerted by the BIS, decreases enough to enable the BAS to take control over behavior. In other words, the regulatory function of the BIS would be based on confronting the circumstances to act quite safely under BAS regulation. In the other case, if the processes initiated by activation of the BIS are not processed successfully, the discrepancy will extend and the anxiety will increase—which reciprocally could enlarge activation within the FFFS (the BIS and FFFS are strongly connected and together form the punishment axis; Corr & McNaughton, 2008) and might result in the FFFS taking control over behavior. Thus, if the environment is not safe enough (discrepancy to the standard no conflict is still large, BIS regulation is not effective), it is better to run away (the FFFS controls the behavior).

The general line of argument given above suggests that the BIS is a system that monitors conflict and a system of prevention (like prevention regulatory focus; Higgins, 1997), while the conflict resolution process itself may be related either to the BAS or FFFS depending on the effectiveness of the regulatory function of the BIS and the state of the environment.

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PART II

COMPLEX MODELS OF CONTROL