Adaptive Health Behavior Inventory (AHBI): Cognitive-Behavior-Adaptive Dynamics

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The Adaptive Health Behavior Inventory (AHBI) is an inventory of adult response to health-related contexts reflecting embodied and self-regulatory dynamics motivated by self-interest. It is argued that the utility of AHBI statements are their ability to stimulate and prime engrained health related goal-directed actions, habits, and beliefs in response to health-related situational cues. A range of cognitive-behavior-adaptive dynamic elements including lexical and semantic processing, the priming of automatic cognitive processes and social behavior, the determination of cue self-relevance, variations in affective, emotional, and motivational intensity, the priming of goal-directed actions, schema, and habits, selective attention, and action semantics are suggested to be emulated in the response patterns captured in the AHBI. A detailed discussion of hypothesized cortical and subcortical involvement is offered.

Key words: health behavior, cognitive, affective, goal-directed actions

The Adaptive Health Behavior Inventory (AHBI) is an assessment of an adult's response to health-related contexts. It is not a scale of a single health behavior or state, but an indicator of many self-reported health behaviors and beliefs relative to specific situations. The behavioral responses to health-related contexts detected by the AHBI represent an embodied health phenomenon; that is, responses to health contexts represent a dynamic of the brain and body's function and expression of adaptive behavior.

The AHBI (Navarro, 2017) consists of 20 statements written at the third grade level. It was developed by the author with assistance from Leslie Hughes Lind back in 1986 and 1987, and to date over a quarter million adults have been assessed by it. The statements describe specific actions, reactions, or beliefs with respect to different health or health care related social/situational contexts. An example statement is: "When I get sick, I rely on others close to me to tell me where I should go or who I should see." The context is a person suffering from illness, and the actions reflect reliance on others., reflecting a tendency towards external locus of control when dealing with health matters. Individuals express their health goal-directed adaptive preference to such contexts through their agreement or disagreement with the 20 AHBI statements using a five point Likert scale with the levels strongly disagree, somewhat disagree, neither agree nor disagree or neutral, somewhat agree, and strongly agree.

Over the course of the past 25 years, I have watched hundreds of people responding to the AHBI statements in situations where the statements are read to them or they read the statements themselves and then respond. I have noted that individuals give their responses faster when they strongly disagree or strongly agree with each statement in the AHBI. The response time for statements that individuals somewhat disagree or somewhat agree with is generally a little slower than the "strongly" response.

"Neither agree nor disagree" or "neutral" responses are generally delivered a little slower than the "somewhat" responses. This variation in response time, which might be measured in the milliseconds, is clearly indicative of differential lexical and semantic processing times and behavioral response speeds.

I also have noted that the certainty, conviction, and self-relevance behind the response varies across the levels of strongly or somewhat agree or disagree, and neither agree nor disagree. For example, individuals who read or hear a AHBI statement and respond with a strongly agree or strongly disagree generally do so with a solid degree of certainty and conviction that the issue is highly self-relevant and represents a motivational imperative. Individuals who respond to a statement with a somewhat agree or somewhat disagree response generally do so with a good degree of certainty but not the same level of conviction as the "strongly" response, and degree of self-relevance. Finally, individuals who respond to a statement with a "neither agree nor disagree" or "neutral" response generally do so with certainty comparable to or slightly weaker than a "somewhat" response, but the lack of self-relevant certainty. The variations in certainty, self relevance, and arousal associated with Likert scale responses to each AHBI statement are indicative of differences in motivational and emotional participation associated with self relevant salience based on the described context of each situation and described action.

Given the insight into cortical and subcortical processes provided by neuroscience and cognitive neuroscience research using imaging tools such as computed tomography (CT) scans, magnetic resonance imaging (MRI), and functional magnetic resonance imaging (fMRI), I believe it is the responsibility of any developer of an assessment to ground individual response patterns to it, even if only theoretically, to neuro-cognitive processes, cortical/subcortical brain regions, and other neurologically-based constructs to both support and justify the interpretation of individual responses to assessment items. In other words, an assessment developer should be able to specify the neuro-psychodynamics which can be related to the items of an assessment and an individual's response to such assessment items.

The purpose of this paper, therefore, is to explore the AHBI's relationship with theory and published evidence regarding brain-behavior relationships in the context of lexical processing theory, syntactical sequential processing theory, the influence of contextual cues, non-conscious priming and goal pursuit, semantic (meaning) processing theory, affective intensity, action semantics theory, embodied cognition, self-relevance, reward or punishment, motivational intensity, goal-directed actions theory, habitual actions, schema theory, and beliefs. In addition, this paper will review peer-reviewed research which addresses and identifies the cortical regions which support these dynamics. Finally, this paper will explore brain-behavior relationships to key constructs assessed by the AHBI including trust/distrust, exercise, and family centeredness.

Likert Scale

As noted above, the AHBI utilizes a 5-point Likert scale to measure response patterns to the AHBI statements. There is a great deal of detail and research about the use of the Likert scale as it has been applied or researched in over 4,000 peer-reviewed research articles from 1946 to the present day. Even though a Likert scale does not qualify as a true interval level scale and does not always conform to the laws of a parametric measure (e.g., normality), it has proven to be a robust scale capable of delivering high-quality and meaningful results (Norman, 2010). Through research, it has been demonstrated that Likert scale responses to the AHBI statements conform to a normal distribution when the sample size is greater than or equal to 100 adults 18 years of age or older.

AHBI and Brain-Behavioral Dynamics

Lexical Processing Theory

Responding to the AHBI requires an individual to engage in lexical (language) processing as he or she reads the AHBI statements or listens to them being read. When adults self-administer the inventory, they indicate their agreement or disagreement with each statement by using a Likert scale from one to five, where 1 = strongly disagree, 2 = somewhat disagree, 3 = neutral, or neither agree nor disagree, 4 = somewhat agree, and 5 = strongly agree. When adults are administered the inventory by a clinician or interviewer, there are two ways they can answer which work equally well. In the first way, an interviewer or clinician reads one of the statements out loud, after which the respondent is asked if they agree or disagree. If the respondent says agree or disagree, the interviewer or clinician then ask "somewhat or strongly?" Thus, at the first step agreement or disagreement is obtained, and at the second step intensity of feeling is obtained.

The second way of administering the inventory is to read a statement out loud to the subject, than to tell the subject to indicate how strongly they agree or disagree with the statement by responding to a scale from one to five where five equals strongly agree and one equals strongly disagree. Using this method subjects are told they can respond using any number between one and five.

Cortical-Subcortical Associations. Research examining cortical involvement in lexical processing has identified the superior temporal sulcus (STS), Broca's area, Wernicke's area as central (Sternberg & Sternberg, 2012). Additional research has determined that the cerebellum has substantial sway in language processing and other related higher level affective/cognitive activities (Highnam & Bleile, 2011). The lexical processing includes reading and understanding each word one at a time, then groups of words, then sentences, including the differentiation of nouns, verbs, and other parts of speech.

For example, when reading the AHBI statement, "I am always on the lookout for information about nutrition and healthy diet," the respondent must distinguish the subject (I) from the verb (am) and the context (always on the lookout for information…" This processing of syntactical information and sequential processing are handled by the prefrontal cortex and Broca's area (Sternberg & Sternberg, 2012). Also, verbs are processed differently from nouns. Using functional magnetic resonance imaging (fMRI), verbs have been shown to elicit greater activation in the left middle temporal gyrus than nouns, and inflected verbs showed greater activation in the left inferior frontal gyrus than unmarked verbs, showing that the left inferior frontal cortex is related to the processing of verbal inflectional structure (Yokoyama, Miyamoto, Riera, Jungho, Akitsuki, Iwata et al., 2006).

Based on this research, individual's ability to read, hear, and respond to the AHBI statements requires those centers of the brain involved in lexical processing.

Contextual Cues

The AHBI statements describe different contexts ranging from actions toward nutrition information to actions around health care seeking. The AHBI's twenty statements capture eleven unique validated constructs that address a broad array of areas relevant to heath and health care (Navarro, 2008).

Given the relationship between contextual cues, language, and expressed adaptive patterns, the AHBI is in line with Alonzo (1985) who argued that health is influenced by situational adaptation. This is also affirmed by the role of a physical situation in priming automatic cognitive processes and social behavior. Cesario, Plaks, Hagiwara, Navarrete, and Higgins (2010) proposed a mechanism of motivated preparation where the priming of a social category prepares the individual to execute adaptive behavioral responses appropriate to that social category and the characteristics of the physical environment. Automaticity of cognition and behavior must take into account the situation and context in which it takes place (Cesario et al., 2010).

Applying this to the statements in the AHBI, it can be argued that agree or disagree responses to AHBI statements are due to familiarity with the context and actions portrayed in the statements such that strongly agree or disagree responses are associated with the most automatic behavior in the described context while somewhat agree or disagree responses are associated with less typical behavior in the described context.

Associated cortical and subcortical regions associated with these processes include the bilateral and medial frontal cortex, basal ganglia, and the left parietal and temporal lobe (Gennari, MacDonald, Postle, & Seidenberg, 2007).

Priming

Priming refers to the activation of areas within the brain in response to stimuli that has not been consciously perceived (Rose, Haider, & Büchel, 2005). Cognitive neuroscience has demonstrated priming with many functional magnetic resonance imaging (fMRI) studies (Kiefer & Brendal, 2006; Lau & Passingham; 2007; Levy, Stark, & Squire, 2004; Ortique, Bianchi-Demicheli, de C. Hamilton, & Grafton, 2007).

Priming is the process of stimulating the brain unconsciously to expect something which results in faster or more efficient processing of stimulus information related to the prime; it is a form of non-declarative (ND) memory.

Within about 75 ms the preconscious brain begins to react to stimuli. The sub cortical and cortical areas of the brain begin to activate based on the nature of the stimuli and the situation. Research has demonstrated that priming takes place in an integrative fashion so that patterns of cortical activation are appropriate to the encountered stimuli (Estes & Jones, 2009).

Salience and Motivation. Priming is influenced by the biological salience of stimuli. Ode, Winters, and Robinson (2012) experimented with priming effects in the context of negative and positive stimuli and found that judgments indicating boosted perceptual importance were heightened in the context of positive stimuli as compared to neutral or negative stimuli, and that priming with positive words were judged to have been presented for a longer period of time relative to neutral or negative word primes, suggesting an extended perceptual timeframe. According to Ode et al. (2012), affective priming is part of the *motivation-perception* interface. The priming of positive information more rapidly relative to neutral or negative information is also indicative of its higher reward, goal-directed value which may be due to a higher density of positive information in memory (Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008).

Relative to AHBI response patterns, it is reasonable to assume that AHBI statements which receive strongly agree responses are primed faster because they correspond to highly salient contexts associated with salient goal directed actions. It also seems reasonable to assume that statements which elicit neutral or strongly disagree responses, because of their association with irrelevant or disagreeable actions in context, are primed slower relative to positive stimuli.

*Previous Experience***.** When individuals provide agree-disagree responses to the context described in each AHBI statement, as noted below, it has been demonstrated that other outcomes are consistent with their self-attributed actions. If a person frequently engages in active or competitive sports, they will strongly agree with a statement that conveys the same self-descriptive information. The nature of the prior experience has a profound impact on how individuals respond to the statements in the inventory.

Lyons et al. (2010) examined to what extent the auditory processing of language is altered by a listener's prior experience with the exact activities described in the verbal communication. Specifically, the authors questioned if patterns of neural arousal related to language processing rely on an individual's experience with the action-based meaning of this language. Lyons et al. (2012) had experienced ice-hockey players and non-experienced individuals passively listen to sentences about ice-hockey and everyday situations while measuring their responses via fMRI.

Analysis of fMRI results demonstrated that when listening to action-related sentences, neural arousal in left inferior frontal gyrus and left dorsal premotor cortex was related to the individual's actual physical experience with the action described in the sentence (Lyons et al. (2012). In other words, hockey experts possessed higher levels of activation in these cortical regions when compared to non-experienced individuals when listening to sentences describing hockey. Thus, *personal experience with the content of language altered activity both in regions associated with language comprehension (i.e., inferior frontal gyrus) and in those related to complex action planning (dorsal premotor cortex).* Moreover, hockey experts (who have extensive experience with both hockey and everyday situations) showed greater activity in left inferior frontal gyrus regions for hockey relative to everyday sentences. This suggests that the degree to which one finds information personally relevant (i.e., over and above one's direct experience with it) also modulates processing in brain regions related to semantic-level processing.

This is particularly relevant to an individual's choice of a strongly or somewhat response after reading or hearing the AHBI statements. When an individual agrees or disagrees with a AHBI statement, the content of that statement qualifies as a personally relevant one

Semantic Processing Theory

The AHBI relies on an individual's ability to read, understand, and respond to the inventory statements. This human ability to process and understand words is called *semanticity*, or the property of language which allows it to symbolically represent different events, ideas, actions, and objects as well as communicate the meaning of them.

In general, ventral temporal lobes, middle and inferior temporal, anterior fusiform, anterior parahippocampal gyri, angular gyrus, par orbitalis of the inferior frontal gyrus, dorsal prefrontal cortex, posterior cingulate gyrus, and the N400 negative potential are all involved in processing semantic information. Medial frontal activity increases for autobiographical meaning, right middle frontal increases for episodic memory, and right inferior temporal increases for semantic retrieval (Sternberg et al., 2012).

Examining relationships found in cognitive neuroscience, Burianova and Grady (2007) studied the neural basis of autobiographical memory (e.g. memories that apply only to self), episodic memory (e.g., the memory of past events), and semantic memory and found both areas of overlap and independence. For example, a functional overlap was found for the retrieval of each memory types in the inferior frontal gyrus, the middle frontal gyrus, the caudate nucleus, the thalamus, and the lingual gyrus (Burianova et al., 2007). These types of memory also activated the left medial-temporal lobe (Burianova et al., 2007). The areas of functional separation included activation of the anterior and superior areas in episodic and semantic retrieval, but more posterior and inferior activation in autobiographical retrieval (Burianova et al., 2007).

In terms of uniquely identified areas, the cortex showed increase response to autobiographical memory similar to brain regions including the medial prefrontal (David, Bewernick, Cohen, Newen, Lux, Fink et al., 2006), medial parietal, and lateral temporoparietal cortex activated when recognizing a first-person-perspective (Vogeley & Fink, 2003), right middle frontal showed increase for episodic memory, while the right inferior temporal cortex showed increase for semantic retrieval (Burianova, et al). Going back to the "I eat cheese" sentence, the autobiographical component "I" activates aspects of the medial frontal cortex, the medial prefrontal, medial parietal, and lateral temporoparietal cortex, the "eat" action activates a left frontoparietal network including the intraparietal sulcus, the inferior parietal lobule, and the dorsal premotor cortex (Canessa, Borgo, Cappa, Perani, Falini, Buccino, et al., 2008), and the "cheese" word activates the right inferior temporal cortex.

Semantic Memory. Semantic memory is what also helps us figure out if the statement is true or false based on what we actually do. If I actually do eat cheese, the statement is descriptive of true action as it applies to me. If I do not eat cheese, the statement does not apply to me. Even still, if I actually avoid eating cheese, then the statement describes an action that is not just un-descriptive, but anti-descriptive to my actual actions. In situations where action statements describe actions which are opposite to those typically engaged in, this can represent a kind of error recognition.

Research has shown that negative error detection generates activity in the caudal region of the anterior cingulate cortex while the conscious awareness of the error shows up in a more anterior cingulate cortex and the posterior cingulate–precuneus (O'Connell, Dockree, Bellgrove, Kelly, Hester, Garavan, Robertson, & Foxe, 2007). In other words, the anterior cingulate cortex might be involved in both preconscious and conscious error detection. Thus, cortical arousal in the anterior cingulate cortex provides a necessary setting condition for error awareness (O'Connell, et al.).

The processing of self-relevant information involves cortical and subcortical areas including the medial prefrontal cortex, posterior cingulate/ precuneus, ventromedial prefrontal cortex, subgenual anterior cingulate, amygdala, and ventral striatum (Rameson, Satpute, & Lieberman, 2010). As noted above, heightened activity in the medial prefrontal cortex is in response to a self-relevant context. The involvement of the amygdala in self-relevant content is telling. It indicates that perception of self-relevant information or a self-relevant context has an affective emotional component. Also, the involvement of the ventral striatum signals dopamine triggered motivation in support of goal-directed actions.

Applying these dynamics to the AHBI statements, it is argued that, depending on the content of each statement, "strongly disagree" or "strongly agree" responses are accompanied by heightened affective and emotional arousal, and heightened motivation with respect to the content of the statement driven by their self-relevance.

Reward and Punishment

Reward and punishment are at the core of goal-directed adaptive behavior. Every living organism executes purposeful actions to maximize reward and minimize punishment in an adaptive fashion. Applying this adaptive framework to individual response to the AHBI items as adults react to each AHBI statement, it can be argued that a "strongly agree" response indicates that the described statement content is associated with a reward producing, pleasant situation; likewise, a "strongly disagree" response is associated with a punishment producing unpleasant situation. This, it is argued, explains the heightened level of affective and motivational arousal to "strongly" responses described above.

Ressler (2004) presented a picture of the emergence of consciousness as a direct outcome of simple neural processes that existed without the need for any higher order system. In this view, pleasurable or disagreeable conscious sensations from diverse stimuli in the environment arise from their higher order connections to innate rewards or punishments (Ressler, 2004). When a conditioned stimulus is related to a reward, it gains pleasant feelings because it is associated in time with the cortical representation of its sensory attributes and those corresponding to innate instinctive processes seeking reward (Ressler, 2004). Likewise, when a stimulus is linked with punishment, it grows to be associated with unpleasant feelings as a result of the correlation of its sensory characteristics with the instinctive visceral inhibition of processes seeking punishment (Ressler, 2004).

Cortical-Subcortical Associations. The associations involve consistent activity between the sensory cortex, the limbic system, the orbital and medial prefrontal cortex, and more lateral prefrontal cortices where stimuli can be incorporated into working memory (Ressler, 2004). As such, a consciously executed action engages responses to either improve the environment or because of the feelings of such environmental or social stimuli. Using fMRI scans of memory while making comparisons of the reward and punishment correlations of the outcomes of previous responses, Ressler (2004) found that they are related to the motivations and attention underlying the conscious selection of a current response.

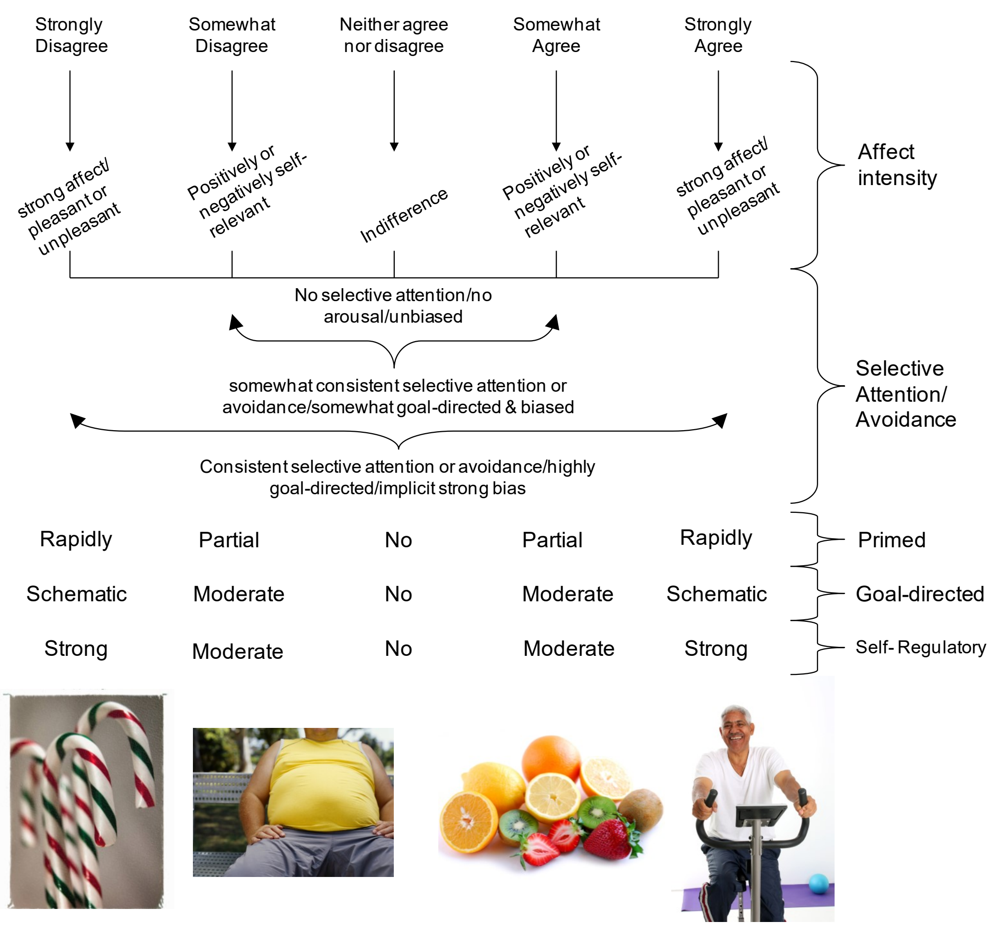
Applying these insights to the AHBI statements, it can be said that when individuals agree or disagree with AHBI statements, they do so based on the reward or punishment, pleasure or displeasure they associate with the statement content and the actions portrayed, and that these associations are the result of sensory, affective/emotional, self-relevant, salient, and robust response linkages developed over time from prior experience. A key switchboard within these response linkages is the basal ganglia.

Habits

Contemporary research has shown that the behavioral changes associated with reward expectation can be supported by two distinct cognitive systems; namely, perceptual sensitivity and habitual response bias (Lauwereyns, 2008). For this discussion only habitual response bias will be considered. According to Lauwereyns (2008), habitual response bias is defined as the pre-existent likelihood of executing a preferred response over another without taking into account the content of incoming perceptual information. The expectation of a reward may produce a response bias

Figure 1

I am always choose actions which keep my weight down.

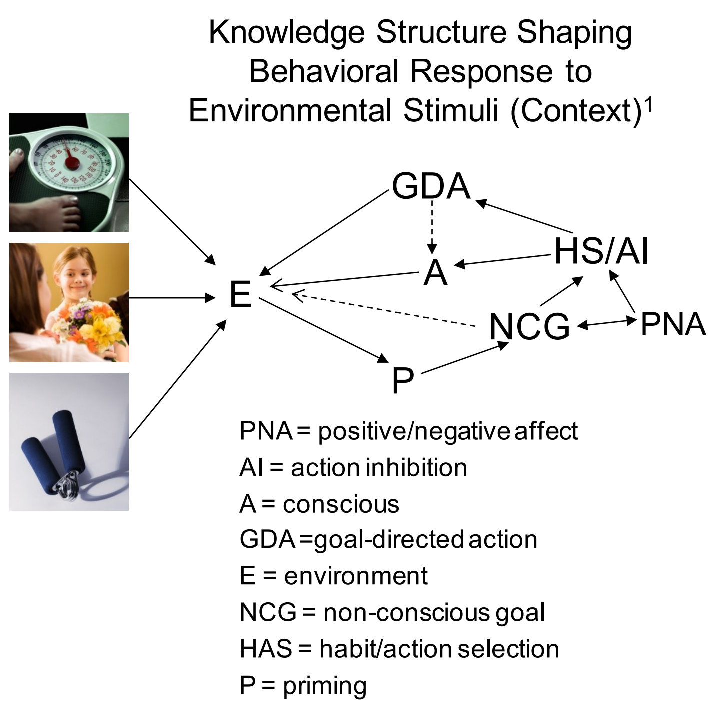


by increasing the chances of executing a response that will return high reward value. This means that the value of a reward can be used to direct actions through the system that shapes response bias.

Cortical-Subcortical Associations. Based on electrophysiological recordings of the brain, a system that influences response bias on the basis of reward are the basal ganglia. The basal ganglia influence the normal level of neuro-activity before sensory information is processed and influences brainstem structures to increase the salience of considered actions based on their reward incentive value via dopamine and specific receptors (Lauwereyns, 2008).

Based on this discussion of reward and punishment, it is suggested that strongly and somewhat responses to the AHBI, whether supporting agree or disagree, reflect different levels of response consistent or inconsistent with the described actions within a AHBI statement based on their association with reward or punishment. Given a statement such as, "I always go to the doctor when I feel ill," a strongly agree response signals a habitual, highly innately rewarding response that has a high likelihood of occurring given the described context; a somewhat agree response signals self-relevant, but less habitual or rewarding response that has some likelihood of occurring given the described context; a neutral response has little or no relationship with habitual behavior or reward given the described context; a somewhat disagree response is also self relevant, but the actions in context described by the state-

Figure 2



Environmental stimuli (context) (E) primes nonconscious goals. Positive or negative affect further activates nonconscious goals, activates habit selection for repeated actions while inhibiting alternative action leading to goal-directed action. Also, nonconscious goals influence attention to environmental factors and determines salience in-line with goals ([1]Aarts, 2007).

ment is somewhat habitually inhibited and somewhat unpleasant and punishment related; finally, a strongly disagree response represents actions in context which are habitually inhibited, very unpleasant, and strongly associated innately with punishment.

Affective/Emotional/Motivational Intensity

Consistent with the hypothesized relationships between strongly or somewhat agree or disagree responses to the AHBI and the dynamics of self relevance, reward and punishment, and selective attention/defense, it is argued that these strongly or somewhat agree or disagree responses to AHBI have a correspondent relationship to different intensities of affective, emotional, and motivational arousal (Figure 1). Strongly agree or disagree responses are associated with the greater arousal of affect, emotion, and motivation, somewhat agree or disagree responses are associated with lesser arousal of affect, emotion, and motivation, and neutral responses are associated with little or no affective, emotional, or motivational arousal. Additionally, it can be argued that strongly or somewhat agree or disagree responses are also associated with differences in affective/emotional/motivational valence such that strongly agree responses are associated with the high positive affect and strongly disagree responses are associated with unpleasant affect. Correspondingly, somewhat agree responses are associated with some positive affect just as strongly disagree responses are associated with some unpleasant affect.

Cortical-Subcortical Associations. The cortical dynamics underlying affective and emotional arousal in response to primed goals (e.g., reward pursuit) include the neural circuit consisting of the ventromedial prefrontal cortex, amygdala, hippocampus (Aarts, Custers, & Veltkamp, 2008). The heightened motivation as a result of primed goals includes the above neuro circuit preceded by the orbitofrontal cortex, moving through the circuit described above before proceeding to the basal ganglia (Grossberg, Bullock, & Dranias, 2008) and then the cerebellum, also implicated in language processing (Highnam et al., 2011).

Nonconscious Goal Pursuit

Nonconscious goal pursuit represents the pursuit of specific goals outside of conscious awareness. This means that latent goals possessed by an individual can be activated without the awareness of the individual holding the goals (Figure 2). According to Aarts et al. (2008), initial priming and resultant affective intensity can prime nonconscious goal pursuit (i.e., actions), especially in association with positive affect (Custers & Aarts, 2005). In other words, non-conscious goal pursuit is only likely to occur when it is associated with primed positive affect.

What this potentially means to agree or disagree responses to the AHBI statements is that the strongly agree responses, and to some extent the somewhat agree responses, because of their greater association with positive affect and greater motivational intensity, are likely to represent goal directed activities not consciously pursued in the associated context.

Goal-Directed Actions, Schema, and Habits

Goal-Directed Actions

Goal-directed actions by definition are purposeful behavior directed towards a goal. Such goals can include the pursuit of dynamics in the environment which contribute to reward, or the avoidance of environmental dynamics associated with punishment. Schema, on the other hand, are cognitive structures built on other cognitive structures which developed at an earlier time (Friedman & Schustack, 2012). Schema activated in different situations communicates expectations based on prior experience, they help us make predictions about what might happen, and they shape actions (Friedman et al., 2012). Schema has relevance to the psychology of personality, cognitive psychology, and social psychology.

The mechanisms of goal directed action are studied in the field of neuropsychology because of the role which goal directed actions play in self-regulation. For example, when a relatively calm dog sees a strange cat, that dog's immediate goal is typically to pursue the cat. As such, the dog is rapidly brought to a state of heightened arousal represented by raised ears, a fixed gaze, a rise of back fur, a more rapid heartbeat, and increase muscular readiness to engage in the goal directed action of going after the cat. The heightened state of arousal associated with the goal of catching the cat is a great example of how goals and goal directed actions impact self-regulation. Earlier I referred to my interest in *Astronomy Magazine*. This interest is tied to a reasonable amount of positive affect which is activated whenever I see the magazine, which then increases my state of alertness and subsequently activates a goal directed routine (i.e., schema) to obtain the magazine. This is how, just as in the example of the dog and cat, that goal directed actions influence self-regulatory processes within the body. Also, as goal directed actions support reward achievement and punishment avoidance they serve an adaptive function. Just as the dog in the example above prepared to pursue the cat, the cat also prepared to run away from the dog, and this preparation to avoid a negative consequence (e.g., death) is adaptive.

The majority of AHBI statements are constructed to represent goal-directed actions. In other words, the statements inherently capture patterns of adaptive action expressed by individuals in response to contextual stimuli or cues based on their reward or punishment value. Consider the statement, "I only go to the doctor when I am very sick or injured." The goal directed action is going to the doctor and the contextual cue is being very sick or injured. From this pairing it can be inferred that the implicit goal is something like "avoid the doctor," and that it takes an extreme injury or illness to override it. If an individual agrees with the statement it is because they recognize this goal directed action schema within them. Likewise, if an individual disagrees with the statement it is because they recognize a goal directed schema which is opposite and one that says something like, "I go to the doctor at the first sign of illness."

Referring to strongly or somewhat responses, it is argued that statements which garner a strongly agree response describe an action in context that is highly rewarding to that individual and, therefore, goal-directed. Likewise, statements which garner a strongly disagree response described an action in context that represents significant punishment to that individual. In this case, the goal-directed action is to avoid. With respect to somewhat responses, a somewhat agree response indicates that the action in context has some reward to the individual and is goal-directed, but not habitually, while a somewhat disagree response indicates that the action in context represent some punishment of the individual and stimulates avoidance.

Cortical-Subcortical Associations. Research has demonstrated that cues associated with reward elicit a strong motivational response in much the same way that Pavlov conditioned the dog to salivate at the sound of the bell because it was paired with feeding. According to Wiltgen, Law, Ostlund, Mayford, and Balleine (2007), such motivational, conditioned response-like motivation depends significantly on the ventral striatum, and the activity of calcium calmodulin-dependent kinase II in the striatum which is essential for the motivational effects of cues associated with reward on goal-directed actions. Further, neuroscience and neuropsychological research has also determined that goal directed actions are handled and controlled by a complex system of brain circuitry within which the ventral striatum is embedded. These brain circuits include the medial prefrontal circuit, orbitofrontal circuit, the dorsolateral prefrontal circuit, and the motor circuit. The medial frontal circuit extends from the anterior cingulate, projects the nucleus accumbens and then ventral striatum and olfactory tubercle; orbitofrontal circuit projections extend to the medial nucleus accumbens, dorsal striatum, ventral portions of the pallidum and back to the medial orbitofrontal circuitry, globus pallidus interior, and rostral medial substantia nigra; dorsolateral prefrontal circuit originates from the prefrontal lobes and extends to the dorsolateral caudate nucleus and the lateral mediodorsal globus pallidus and rostral lateral substantia nigra; and the motor circuits including the motor and premotor cortex, supplementary motor cortex and somatosensory cortex (Gruber, Hussain, & O'Donnell, 2009; Koziol & Budding, 2009). Generally, the medial prefrontal circuit is associated with apathy, the orbitofrontal circuit has a critical role in maintaining motivated motor behavior without reinforcement or influence from the environment, and the dorsolateral prefrontal circuit is responsible for cognitive activity in support of executive function and the generation of adaptive motor function in the absence of external feedback or direction (Koziol et al., 2009).

It should also be noted that all of these neural circuits pass through and depend on regions within the basal ganglia circuitry (e.g., dorsal stratum which includes the caudate, ventral stratum which includes the putamen, nucleus accumbens, septum, olfactory tubercle, globus pallidus, and substantia nigra) (Koziol et al., 2009) to carry out their function. Because all the major cortical areas send input to the stratum, it receives input dealing with perception and regions involved with the analysis of associations, regions controlling affect and motivation, motor function regions, and executive function regions in the prefrontal cortex (Koziol et al., 2009). While all of these inputs are condensed as they move from upper cortical regions to subcortical regions, the basal ganglia still receive a great deal of contextual information about the local environment, as well as internal dynamics relative to goals and the overall purpose of the organism (Koziol et al., 2009). As such, the basal ganglia are capable of determining how one context is similar to another context, the similarity of patterns between one situation in another, and adjusting behavior based on these contingencies. In fact, the basal ganglia are intimately involved in selecting actions and behaviors based upon context and the reward inherent in those actions as a result of prior experience and instrumental learning (Koziol et al., 2009). Finally, research has demonstrated that the globus pallidus and substantia nigra within the basal ganglia are involved in selecting or allowing which actions are to be executed based the value of the behavior relative to goals and context (Koziol et al., 2009).

Schema Theory

Schemas are a complex construct (James, Todd, & Reichelt, 2009). Some see them as memories which remain latent until triggered by salient stimuli (James, Reichelt, Freeston, & Barton, 2007). Others see schema as a kind of template for the way a person perceives him/herself, the environment, and others (Dattilio, 2010). Schemas represent cognitive structures that organize knowledge and information, as well as expectations about a given environment or situation (Friedman et al., 2012).

Self Schemas. Self schemas cognitively organize past experience which subsequently influences future behavior and perception (Chi-Hung, 2005). Self schemas have been implicated in the regulation of behavior, future intentions, choices and decision-making (Chi-Hung, 2005). According to Chi-Hung (2005), self schema act as a cognitive filter which processes congruent self schema information more rapidly and with greater depth, relative to the processing of information which is self schema neutral, or the processing of information which is self schema incongruent. In this latter situation incongruent information or stimuli is actually resisted.

*Information Receptivity***.** Schema and goal-directed actions interact. Individuals who possess firmly engrained schema with a strong affective, motivational, and goal-directed component are referred to as schematics. The dynamic of schema and information relevance is also pertinent to the discussion of selective attention below. It also appears that actions implanted within schema which represent a plan (i.e., plan schema) are more likely to be remembered than an action performed outside the context of a plan schema (Brewer & Dupree, 1983). This suggests that schema influence the recall of actions, and thus play a role in which actions are activated and executed consistent with the organization and meaning of what the schema represents. This further suggests that schemata are embedded action patterns are as well.

Carpenter (1988) found that information that has schema relevance (i.e., addresses content relevant to an individual's schema) is better recalled by schematics relevant to individuals without such strong schema agreement (e.g., aschematics). The authors also found that individuals who possessed defined goals showed better recall of information directly relevant to their goals.

Cortical-Subcortical Associations. Schematic material is processed in a variety of cortical and subcortical regions including familiar frontal-striatum neurocircuitry (dorsolateral prefrontal cortex, orbitolateral prefrontal cortex, dorsal striatum, ventromedial prefrontal cortex) including the amygdala and hippocampus (Rueschemeyer, Pfeiffer, & Bekkering, 2010).

Thus, schematics give greater weight to information that is directly relevant to existing schema when compared against aschematics. In the context of AHBI response dynamics, it is argued that strongly agree or strongly disagree responses to any AHBI statement indicate an individual who is schematic on the context and action described in the statement. Likewise, it is argued that somewhat agree or somewhat disagree responses indicate that the content of the statement approximates a pre-existing schema structure.

Habits and Automaticity.

Habits may qualify as a form of automatic goal-directed actions. Aarts and Dijksterhuis (2000) proposed that goals have the ability to activate habitual action and confirmed that when specific behaviors become habitual they can be activated automatically based on the proximity of an active goal. According to Aarts et al. (2000), this supports the hypothesis that habits are cognitively signified as goal—action associations, and that the creation of strong execution intent can suggest goal-directed automaticity in habits. In addition, habits can be described as form of automatic response to a cue, therefore cues play an important role in the automatic operation of habits (Orbell & Verplanken, 2010). Habits are also a form of instrumental or goal directed conditioning because they work and accomplish a desired task.

Cortical-Subcortical Associations. Distinct behavioral control processes, such as reward guided Pavlovian conditional responses, goal-directed instrumental actions, and stimulus driven habits all involve basal ganglia areas including the putamen and posterior lateral putamen (Yin, 2008). According to Koziol et al. (2009), the neostratum becomes activated as sequential tasks are performed and learned slowly over many trials until they form habits essential to adaptive functioning.

I have played guitar for many years and my fingers are trained to quickly form specific chord structures in sequence based on the needs of the song. The form of each chord represents a habitual structure which I have learned to perform over and over again due to practice. When I was first learning the chords I had to concentrate on holding them in place and pressing them down with enough strength to change the pitch of the string. During this phase of learning my actions were controlled by frontal, striatal, and parietal regions of the brain (Koziol et al., 2009) and learning the muscular formation of the guitar chords depended heavily on attention and cognitive control. Today, however, the formation of the chords is a part of my habit control system where supplementary areas of the frontal cortex, globus pallidus, and putamen all indicate practice related reductions in reaction time associated with reductions in brain activity with acquisition of a motor skill which can be engaged without conscious control (Koziol et al., 2009).

Considering AHBI response options in the context of habitual actions, it is argued that strongly agree or disagree responses indicate a respective statement portrays actions in context which have a habitual, automatic component. Likewise, it is argued that somewhat agree or disagree responses suggest actions in context which are performed less habitually. Finally, neutral responses are argued to have little or no habitual component.

Action Semantics

A key line of research relating a person's response to the AHBI statements and their actual actions is *action semantic* theory. Action semantics are words, phrases, or sentences that describe actions. Research has shown that understanding action words or phrases (e.g., I watch TV at night) requires retrieval of not only those cortical areas involved in autobiographical recognition, but regions linked to actual functional motor activation associated with the physical behavior. In other words, when a person engages in thinking about a familiar action this primes areas of the premotor and motor cortex associated with the action in order to fully understand it (Rueschemeyer, Lindemann, van Rooij, van Dam, & Bekkering, 2010). According to Rueschemeyer, et al. (2010), the performance of motor actions has a selective result on the semantic processing of words such that intentional actions may stimulate precise areas of the neural motor system also activated for lexical-semantic processing of action-related words attesting to the embodiment of language and the dual directional influence between language and the processing of actions.

Cortical-Subcortical Associations. With respect to specific cortical areas, van Dam, Rueschemeyer, and Bekkering (2010) found that a region within the bilateral inferior parietal lobule involved in holding action plans and goals was sensitive to specific motor programs associated with action verbs. Additionally, Lyons, Imattarella-Micke, Cieslak, Nusbaum, Small, and Beilock (2010) found that when a person listens to action-related sentences, neural activation in the left inferior frontal gyrus and left dorsal premotor cortex depends on the person's actual physical experience with the actions described in the sentence. This means that personal experience modulates activity both in regions of the brain associated with the comprehension of language and in those related to motor function and complex action planning.

This insight is critical to understanding how an individual's response to the AHBI can be reflected in actual practiced motor routines. The majority of AHBI statements are framed in the form of goal -directed action which include a situational cue and an action in response to that cue from which can be inferred an implicit goal-relative to the cue. When a person reads the AHBI statements (e.g., I seek health information) the brain is essentially attempting to see if the statements describing different health actions match the actions semantics within that person as a result of personal experience.

To make this judgment, the brain must access the action semantics in the premotor areas of the cortex linked to the person's actual physical behavior. Thus, when a person reads and responds to the AHBI statements the levels of agreement or disagreement with statements is determined by the detection of error depending how well the actions described in the statements fit the action semantics associated with the person's actual behavior. Action semantic theory is what allows the link of AHBI response patterns to innate functional properties of the brain and behavior. But, the relationship goes even further.

Selective Attention

As discussed above, reward expectation can be supported by two distinct cognitive systems: perceptual sensitivity and habitual response bias (Lauwereyns, 2008). Taking perceptual sensitivity as decision-making quality given a ratio of perceptual signal to noise, expectations of reward can improve the signal-to-noise ratio for highly rewarding stimuli (Lauwereyns, 2008). I like *Astronomy* magazine and reading its content is rewarding to me. For this reason, my perceptual sensitivity for this magazine is higher than for other magazines, and I am generally able to detect the *Astronomy* cover over the background noise.

Cortical-Subcortical Associations. Evidence for the system that influences perceptual sensitivity is seen in frontal cortex, with neurons that fire differentially following a reliable prediction of reward (Lauwereyns, 2008). Perceptual sensitivity underlies selective attention. Selective attention is an intrinsic part of how perceptions are prioritized within a visual system that is hierarchically organized (Yantis, 2008). Organizing signals begin in cortical areas that correspond to behavioral goals which drive selective attention; these signals specify which perceptual objects in the environment are to be represented by sensory neurons influenced by changes in contextual stimuli (Yantis, 2008).

With respect to AHBI, it is argued that strongly agree responses to the AHBI statements suggest contextual situations where both perceptual sensitivity and selective attention are higher and stronger. For example, if a person reads or hears the AHBI statement, "I always look for health information so I can know about health care options", and strongly agrees with it, that person will have increased perceptual sensitivity to information sources focused on health care topics and health care treatment options in the paper, on TV, on the radio, or on the internet. This increased perceptual sensitivity will underlie patterns of selective attention for health care treatment related information.

If a person only somewhat agrees with the same PATH statement, the level of perceptual sensitivity for information dealing with healthcare or health care treatment options will not be as strong but still support interest in health care information across the same media which will influence their selective attention. However, if a person gives a neutral response (i.e., neither agrees nor disagrees) to this statement, it is assumed that, relative to the content of the statement, the person has little or no perceptual sensitivity or selective attention to health care or helped retrieve information. Again, these response patterns are shaped by the expectation of reward derived from prior experience.

Selective Defense

People exhibit a defensive reaction to health information they see as contrary to their own self-relevant goals. Kessels, Ruiter, and Jansma (2010) explored whether reduced acceptance of self-relevant health risk information is detectable in early attention mechanisms that show up in attention disengagement processes. Using reaction times and P300 event-related potentials (ERP), the authors showed that reaction time measures where different from ERP data, suggesting that the ERP measure can be extremely useful as a measure of low-level attention biases to health communication, supporting the hypothesis that threatening health information causes more efficient disengagement among individuals who judge the health threat to be self-relevant. This same effect was reported by Falk (2010). Research into the effects of negative priming has shown that even ignored information is engaged to a strong degree in those systems sporting selective attention.

Cortical-Subcortical Associations. Egner and Hirsch (2005) used fMRI to cortically map negative priming contrasted against no priming and found that negative priming triggered increased activation of the right dorsolateral prefrontal cortex, approximating a region closely tied to episodic memory retrieval, as well as activation in the mediodorsal nucleus within the right thalamus, associated with reduced negative priming.

It is argued that the dynamics of negative priming and content disengagement are captured in the strongly or somewhat disagree responses to the AHBI statements. In other words, when an individual disagrees with the content of a PATH statement, they are expressing patterns of selective defense against the action in context expressed due to its association with punishment, displeasure and/or habitual avoidance.

If a person strongly disagrees with the PATH statement, "I always look for health information so I can know about health care options", that person will, based of the discussion of selective defense and negative priming, innately register the health care context fully and then efficiently disengage from it. So, as individual scans the local environment, he or she is innately sensitive to the health care context so they can effectively avoid it.

Beliefs

While this discussion has focused on the potential association between response patterns to the AHBI and the brain-behavior relationships, the discussion must also address the relationship between beliefs and the brain. This is because two AHBI statements address beliefs about the competence of caregivers.

Cortical-Subcortical Associations. The processing of beliefs involves cortical-basal ganglia thalamic circuitry (Samejima & Doya, 2007). The fact that the basal ganglia are engaged in the processing of beliefs also directly ties beliefs to actions and habitual behavior. Because of this relationship, it can be argued that an individual who strongly agrees or disagrees with a statement based on its similarity to his or her existing beliefs is also very likely to act on those beliefs to a greater extent than statements which are only somewhat familiar to existing beliefs and so only somewhat agreed or disagreed with.

Brain-Behavior and AHBI Constructs

The AHBI assesses behavioral tendencies through motivated goal-directed actions in context which captures eleven different constructs repeatedly confirmed by factor analysis (Navarro, 2012) which address issues such as health care seeking/avoiding, health decision locus of control, medical professional competence/incompetence, involvement in family health, and participation in physical activity.

This section will briefly discuss the relationship between AHBI constructs and research linking them to brain behavior and specific cortical regions beyond their relationships to goal-directed actions. The constructs to be reviewed include trust/distrust, physical activity, family involvement in health, and care seeking/avoiding.

Trust/Distrust

According to Dimoka (2010), trust and distrust are associated with different patterns of cortical and subcortical activation and affective arousal such that trust is accompanied by lower activation in the orbitofrontal cortex and with higher activation in the anterior paracingulate cortex. As noted above, the orbitofrontal cortex is associated with maintaining motivated behavior while the paracingulate cortex is involved in our ability to predict future intentional social interactions resulting from the actions of an individual (Walter, Adenzato, Ciaramidaro, Enrici, Pia, & Bara, 2004).

In contrast, distrust is associated with strong activation in the bilateral amygdala and insular cortex (Dimoka, 2010). The involvement in the amygdala with distrust indicates that distrust versus trust is associated with affective arousal. Therefore, it is reasonable to argue that strongly agree response to the AHBI statements addressing distrust should have greater affective response while strongly disagree responses should be associated with motivation.

Physical Activity

The hippocampus, generally associated with the encoding of episodic memory, has been linked with higher levels of motion and physical activity. Increased activation in the hippocampus has been linked to stance and locomotion (Jahn, Wagner, Deutschländer, Kalla, Hüfner, Stephan et al. (2009) while exercise rats (i.e., rats which spontaneously and regularly run in a tread wheel) have also been found to display higher hippocampus activity (Filipovic, Gavrilovic, Dronjak, & Radojcic, 2007) leading some to suspect that individuals with a natural propensity to engage in regular physical activity have a hippocampus which is especially active. Based on this research it is reasonably to suspect that respondents who strongly agree with the statements describing regular physical activity would show heightened hippocampus activity relative to respondents who strongly disagree. Additionally, exercise patterns are supported by schema (Kendzierski, 1988; Sheeran & Orbell, 2000; Yin & Boyd, 2000).

Family Involvement

According to Kim, Leckman, Mayes, Feldman, Wang, and Swain (2010), increasing levels of family centeredness are associated with areas of brain plasticity including increases in gray matter volume of the prefrontal cortex, parietal lobes, and midbrain areas, and increased gray matter volume in the midbrain including the hypothalamus, substantia nigra, and amygdala. The involvement of the substantia nigra within the basal ganglia in family centeredness suggests heightened levels of motivation due to dopamine while the amygdala certainly suggests greater affective arousal with increased family centeredness. Applying this research to respondent levels of family centeredness with respect to health issues, it can reasonably be assumed that they possess like patterns of brain behavior, cortical, and subcortical involvement relative to respondents who do not express family centeredness.

Summary

This paper has attempted to ground AHBI response patterns to theory addressing language and semantic processing, priming and nonconscious processes including habit automaticity and selective attention triggered by contextual cues, and the framing of AHBI response patterns within goal directed action theory and schema theory. Particular note was given to action semantic theory as it is the theoretical basis that ties disagree responses to the AHBI to the meaning a respondent applies to actual health-related behavior.

Additionally, considerable effort has been made to link AHBI response patterns to cortical and subcortical areas of the brain in order to ground it in embodied phenomena.

Of particular note were the medial frontal cortex and other proximate areas for their role in determining autobiographical meaning captured in the AHBI statements, and, together with the basal ganglia, in processing self relevant environmental or social cues. The basal ganglia alone was of particular note due to its involvement signaling reward, determining the salience of an action, influencing conditioned response like motivations, goal-directed actions including action gating, inhibition, and stimulus driven habits all central to the interpretation of AHBI responses. It is speculated that the basal ganglia, because of its role in "releasing" actions, plays a role in determining the pattern of their expression in response to the environment.

The review of the associations between actual AHBI themes and brain behavior further serve to strengthen the argument that the system of patterns identified by the AHBI encompass a broad psychodynamic framework, are associated with brain-behavior dynamics, and emulate a self-regulatory system of patterns which balance the innate needs of the evolving biological dynamic system with the adaptive demands of the social and physical environment.

References

Aarts, H., Custers, R., & Veltkamp, M. (2008). Goal priming and the affective-motivational route to nonconscious goal pursuit. *Social Cognition*, 26(5), 555-577. Retrieved from EBSCOhost.

Aarts, H., & Dijksterhuis, A. (2000). Habits as knowledge structures: Automaticity in goal-directed behavior. *Journal of Personality and Social Psychology*, 78(1), 53-63. doi:10.1037/0022-3514.78.1.53

Alonzo, A. A. (1985). Health as situational adaption: A social psychological perspective. *Social Science & Medicine*, 21(12), 1341-1344. doi:10.1016/0277-9536(85)90440-X

Brewer, W. F., & Dupree, D. A. (1983). Use of plan schemata in the recall and recognition of goal -directed actions. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 9 (1), 117-129. doi:10.1037/0278-7393.9.1.117

Burianova, H., & Grady, C. L. (2007). Common and Unique Neural Activations in Autobiographical, Episodic, and Semantic Retrieval. *Journal of Cognitive Neuroscience*, 19(9), 1520-1534. Retrieved from EBSCOhost.

Canessa, N., Borgo, F., Cappa, S. F., Perani, D., Falini, A., Buccino, G., & ... Shallice, T. (2008). The different neural correlates of action and functional knowledge in semantic memory: An fMRI study. *Cerebral Cortex*, 18(4), 740-751. doi:10.1093/cercor/bhm110

Carpenter, S. L. (1988). Self-relevance and goal-directed processing in the recall and weighting of information about others. *Journal of Experimental Social Psychology*, 24(4), 310-332. doi:10.1016/0022-1031(88)90023-6

Cesario, J., Plaks, J. E., Hagiwara, N., Navarrete, C., & Higgins, E. (2010). The ecology of automaticity: How situational contingencies shape action semantics and social behavior. *Psychological Science*, 21(9), 1311-1317. doi:10.1177/0956797610378685

Chi-Hung, N. (2005, September). Academic self-schemas and their self-congruent learning patterns: Findings verified with culturally different samples. *Social Psychology of Education*, 8(3), 303-328. Retrieved May 19, 2009, doi:10.1007/s11218-005-4015-5

Custers, R., & Aarts, H. (2005). Positive Affect as Implicit Motivator: On the Nonconscious Operation of Behavioral Goals. *Journal of Personality and Social Psychology*, 89(2), 129-142.

doi:10.1037/0022-3514.89.2.129

Dattilio, F. M. (2010). Examining the Scope and Concept of Schema: Should We Look Beyond Cognitive Structures?. *Psihologijske Teme / Psychological Topics*, *19*(2), 221-234.

David, N., Bewernick, B., Cohen, M., Newen, A., Lux, S., Fink, G., et al. (2006, June). Neural Representations of Self versus Other: Visual -Spatial Perspective Taking and Agency in a Virtual Ball-tossing Game. *Journal of Cognitive Neuroscience*, 18(6), 889-910. Retrieved July 24, 2009, from Academic Search Premier database.

Daw, N. D., & Shohamy, D. (2008). The cognitive neuroscience of motivation and learning. *Social Cognition*, 26(5), 593-620. Retrieved from EBSCOhost.

Dimoka, A. (2010). What does the brain tell us about trust and distrust? Evidence from functional a neuroimaging study. *MIS Quarterly*, 34(2), 373-A7. Retrieved from EBSCOhost.

Falk, E. B., (2010). Communication neuroscience as a tool for health psychologists. Health Psychology, 29(4):346-54. PMID: 20658821

Filipovic, D., Gavrilovic, L., Dronjak, S. & Radojcic, M. B. (2007). The Effect of Repeated Physical Exercise on Hippocampus and Brain Cortex in Stressed Rats. *Annals Of The New York Academy Of Sciences*, 1096207-219. doi:10.1196/annals.1397.087

Friedman, H. S. & Schustack, M. W. (2012). *Personality: Classic theories and modern research* (5th ed.). MA: Allyn & Bacon ISBN: 0-205-05017-4

Egner, T., & Hirsch, J. (2005, November). Where Memory Meets Attention: Neural Substrates of Negative Priming. (Czech). *Journal of Cognitive Neuroscience*, *17*(11), 1774-1784. Retrieved September 12, 2009, doi:10.1162/089892905774589226

Estes, Z., & Jones, L. (2009, February). Integrative priming occurs rapidly and uncontrollably during lexical processing. *Journal of Experimental Psychology*: General, 138(1), 112-130. Retrieved April 21, 2009, doi:10.1037/a0014677

Gennari, S. P., MacDonald, M. C., Postle, B. R., & Seidenberg, M. S. (2007). Context-dependent interpretation of words: Evidence for interactive neural processes. *NeuroImage*, 35(3), 1278-1286. doi:10.1016/j.neuroimage.2007.01.015

Grossberg, S., Bullock, D., & Dranias, M. R. (2008). Neural dynamics underlying impaired autonomic and conditioned responses following amygdala and orbitofrontal lesions. *Behavioral Neuroscience*, 122(5), 1100-1125. doi:10.1037/a0012808

Gruber, A. J., Hussain, R. J., & O'Donnell, P. (2009). The Nucleus Accumbens: A Switchboard for Goal- Directed Behaviors. *PLoS ONE*, 4(4), 1-10. doi:10.1371/journal.pone.0005062

Highnam, C. L., & Bleile, K. M. (2011). Language in the Cerebellum. *American Journal Of Speech-Language Pathology*, 20(4), 337-347. doi:10.1044/1058-0360(2011/10-0096)

Kiefer, M., & Brendel, D. (2006, February). Attentional Modulation of Unconscious Automatic Processes: Evidence from Event-related Potentials in a Masked Priming Paradigm. *Journal of Cognitive Neuroscience*, 18(2), 184-198. Retrieved January 5, 2009, doi:10.1162/089892906775783688

Kendzierski, D. (1988, March). Self-Schemata and Exercise. *Basic & Applied Social Psychology*, *9*

(1), 45-59. Retrieved September 13, 2009, from Business Source Premier database.

Jahn, K., Wagner, J., Deutschländer, A., Kalla, R., Hüfner, K., Stephan, T., & ... Brandt, T. (2009). Human Hippocampal Activation during Stance and Locomotion. *Annals Of The New York Academy Of Sciences*, 1164229-235. doi:10.1111/j.1749-6632.2009.03770.x

James, I. A., Reichelt, F. K., Freeston, M. H., & Barton, S. B. (2007). Schemas as Memories: Implications for Treatment. *Journal of Cognitive Psychotherapy*, 21(1), 51-57. Retrieved November 6, 2008, from ProQuest Health and Medical Complete database. (Document ID: 1255570611).

James, I., Todd, H., & Reichelt, F. (2009). Schemas defined. *Cognitive Behaviour Therapist*, 2(1), 1-9. doi:10.1017/S1754470X08000135.

Kessels, L. E., Ruiter, R. C., & Jansma, B. M. (2010). Increased attention but more efficient disengagement: Neuroscientific evidence for defensive processing of threatening health information. *Health Psychology*, 29(4), 346-354. doi:10.1037/a0019372

Kim, P., Leckman, J., Mayes, L., Feldman, R., Wang, X., & Swain, J. (2010). The plasticity of human maternal brain: Longitudinal changes in brain anatomy during the early postpartum period. *Behavioral Neuroscience*, 124(5), 695-700. doi:10.1037/a0020884.

Koziol, L. F. & Budding, D. E. (2009). Subcortical structures and cognition. New York, NY: Springer.

Lau, H., & Passingham, R. (2007, May 23). Unconscious Activation of the Cognitive Control System in the Human Prefrontal Cortex. *Journal of Neuroscience*, 27(21), 5805-5811. Retrieved July 27, 2008, doi:10.1523/JNEUROSCI.4335-06.2007

Lauwereyns, J. (2008). The Contribution of Dopamine to the Implementation of Reward Value During the Control of Action. *Central Nervous System Agents in Medicinal Chemistry*, 8(2), 72-84. Retrieved from EBSCOhost.

Levy, D., Stark, C., & Squire, L. (2004, October). Intact Conceptual Priming in the Absence of Declarative Memory. *Psychological Science*, 15 (10), 680-686. Retrieved January 19, 2009, doi:10.1111/j.0956-7976.2004.00740.x

Lyons, I. M., Mattarella-Micke, A., Cieslak, M., Nusbaum, H. C., Small, S. L., & Beilock, S. L. (2010). The Role of Personal Experience in the Neural Processing of Action-Related Language. *Brain and Language,* 112(3), 214-222. Retrieved from EBSCOhost.

Navarro, F. H. (2008). *AHBI Users Manual*. Fontana, California: Neubehaviors Corporation.

Navarro, F. H. (2012). *AHBI: Content and psychometrics*. Nasville, TN: Neubehaviors Corporation.

Norman, G. (2010). Likert scales, levels of measurement and the "laws" of statistics. *Advances In Health Sciences Education*, 15(5), 625-632. doi:10.1007/s10459-010-9222-y.

O'Connell, R.G., P. M. Dockree, M. A. Bellgrove, S. P., Kelly, R. Hester, H. Garavan, I. H. Robertson, and J. J. Foxe (2007). The role of cingulate cortex in the detection of errors with and without awareness: a high-density electrical mapping study. *European Journal of Neuroscience*, 25, 2571–2579.

Ortigue, S., Bianchi-Demicheli, F., de C. Hamilton, A., & Grafton, S. (2007, July). The Neural Basis of Love as a Subliminal Prime: An Event-related Functional Magnetic Resonance Imaging Study. *Journal of Cognitive Neuroscience*, 19(7), 1218-1230. Retrieved January 5, 2009, from Academic Search Premier database.

Ode, S., Winters, P. L., & Robinson, M. D. (2012). Approach motivation as incentive salience: Perceptual sources of evidence in relation to positive word primes. *Emotion*, *12*(1), 91-101. doi:10.1037/a0025186

Orbell, S., & Verplanken, B. (2010). The automatic component of habit in health behavior: Habit as cue-contingent automaticity. *Health Psychology*, 29(4), 374-383. doi:10.1037/a0019596

Rameson, L. T., Satpute, A. B., & Lieberman, M. D. (2010). The neural correlates of implicit and explicit self-relevant processing. *NeuroImage*, 50(2), 701-708. doi:10.1016/j.neuroimage.2009.12.098

Ressler, N. (2004). Rewards and punishments, goal-directed behavior and consciousness. *Neuroscience & Biobehavioral Reviews*, 28 (1), 27. doi:10.1016/j.neubiorev.2003.10.003

Rose, M., Haider, H., & Büchel, C. (2005, June). Unconscious Detection of Implicit Expectancies. *Journal of Cognitive Neuroscience*, 17 (6), 918-927.

Rueschemeyer, S., Lindemann, O., van Rooij, D., van Dam, W., & Bekkering, H. (2010). Effects of intentional motor actions on embodied language processing. *Experimental Psychology*, 57(4), 260-266. doi:10.1027/1618-3169/a000031

Rueschemeyer, S., Pfeiffer, C., & Bekkering, H. (2010). Body schematics: On the role of the body schema in embodied lexical-semantic representations. *Neuropsychologia*, 48(3), 774-781. doi:10.1016/j.neuropsychologia.2009.09.019

Samejima, & Doya, K. (2007). Multiple Representations of Belief States and Action Values in Corticobasal Ganglia Loops. Annals of the New York Academy of Sciences, 1104213-228. doi:10.1196/annals.1390.024

Sternberg, R.J., & Sternberg, K. (2012). *Cognitive Psychology*, 6th Ed. Wadsworth Cengage Learning

Sheeran, P., & Orbell, S. (2000, July). Self-schemas and the theory of planned behaviour. *European Journal of Social Psychology*, *30*(4), 533-550. Retrieved September 13, 2009, from Academic Search Premier database.

van Dam, W. O., Rueschemeyer, S., & Bekkering, H. (2010). How specifically are action verbs represented in the neural motor system: An fMRI study. *NeuroImage*, 53(4), 1318-1325. doi:10.1016/j.neuroimage.2010.06.071

Unkelbach, C., Fiedler, K., Bayer, M., Stegmüller, M., & Danner, D. (2008). Why positive information is processed faster: The density hypothesis. *Journal Of Personality And Social Psychology*, 95(1), 36-49. doi:10.1037/0022-3514.95.1.36

Walter, H., Adenzato, M., Ciaramidaro, A., Enrici, I., Pia, L., & Bara, B. G. (2004). Understanding Intentions in Social Interaction: The Role of the Anterior Paracingulate Cortex. *Journal Of Cognitive Neuroscience*, 16(10), 1854-1863. doi:10.1162/0898929042947838

Wiltgen, B. J., Law, M., Ostlund, S., Mayford, M., & Balleine, B. W. (2007). The influence of Pavlovian cues on instrumental performance is mediated by CaMKII activity in the striatum. *European Journal Of Neuroscience*, 25(8), 2491-2497. doi:10.1111/j.1460-9568.2007.05487.x

Vogeley, K., & Fink, G. (2003, January). Neural correlates of the first-person-perspective. *Trends* *in Cognitive Sciences*, 7(1), 38-42. Retrieved June 8, 2009, doi:10.1016/S1364-6613(02) 00003-7

Yantis, S. (2008). The Neural Basis of Selective Attention: Cortical Sources and Targets of Attentional Modulation. *Current Directions In Psychological Science* (Wiley-Blackwell), 17(2), 86-90. doi:10.1111/j.1467-8721.2008.00554.x

Yin, H. H. (2008). From Actions to Habits. *Alcohol Research & Health*, 31(4), 340-344.

Yin, Z., & Boyd, M. (2000, May). Behavioral and Cognitive Correlates of Exercise Self-Schemata. *Journal of Psychology*, *134*(3), 269. Retrieved September 13, 2009, from Academic Search Premier database.

Yokoyama, S., Miyamoto, T., Riera, J., Jungho, K., Akitsuki, Y., Iwata, K., & ... Kawashima, R. (2006). Cortical Mechanisms Involved in the Processing of Verbs: An fMRI Study. *Journal Of Cognitive Neuroscience*, 18(8), 1304-1313.