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The Mental Simulation of Motor Incapacity in Depression

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In depression, negative beliefs are coupled with profound physical weakness. Specifically, the belief that one is incapable of altering events in order to prevent expected negative outcomes or bring about positive outcomes leads to bodily symptoms characterized by low energy, slow motor movement, and delays in the initiation of movement. The purpose of this article is to present a theoretical model describing the causal mechanisms that link these cognitive and somatic elements of depression. We propose that (a) the inability to alter events is conceptualized metaphorically as motor incapacity; (b) as part of this conceptualization, the experience of motor incapacity is mentally simulated; and (c) this simulation leads to both subjective feelings of lethargy and peripheral physiological changes consistent with motor incapacity.

Keywords: depression; embodied cognition; conceptual metaphor; hopelessness; psychomotor retardation; motor imagery

According to cognitive theories of depression, depression is prompted by negative cognitive evaluations of life events (Abramson, Alloy, & Metalsky, 1989, 2002; Beck, 1967, 1987; Clark, Beck, & Alford, 1999). These negative evaluations involve "the expectation that highly desired outcomes will not occur or that highly aversive outcomes will occur and that one cannot change this situation" (Abramson et al., 2002, p. 269). Specifically, depression arises when a negative life event of personal importance is evaluated as stable (likely to persist over time) and global (likely to affect many other areas of life), expected to lead to other negative consequences, and taken as evidence that one is unworthy or deficient. Thus, a proximal, sufficient cause of depression is hopelessness, where, in the face of negative events believed to be pervasive and enduring, people believe that they are powerless.

Hopelessness leads to a cluster of bodily symptoms that include low energy, retarded initiation of voluntary responses, and psychomotor retardation (Abramson et al., 1989; Joiner et al., 2001). Psychomotor retardation is characterized by immobility or slowed motor movement, delays in motor activity, postural slumping, attenuated facial expression, and slowed speech (Parker & Brotchie, 1992; Widlöcher, 1983). Psychomotor retardation is positively correlated with the degree and onset of depression (Nelson & Charney, 1981; Parker, 1990; Parker et al., 1994; Rush & Weissenburger, 1994) and Global Assessment of Function (GAF) but not with psychotic symptoms (Hickie, Mason, & Parker, 1996). Psychomotor retardation also clusters together with sadness on the Hamilton Depression Rating Scale (items 1 and 8) in people with major depression, according to a factor analysis (Cleary & Guy, 1975). Psychomotor retardation severity is

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correlated with the success of therapeutic interventions (Widlöcher & Daniel, 1983), predicts fluoxetine nonresponse (Taylor, 2004), and mediates the negative effects of maternal depression on emotional development in children (Beeber & Leeman, 2002).

How does hopelessness, or the belief that one is incapable of avoiding negative events or reaching a goal, lead to slowed motor movements and lethargy? Although cognitive theories of depression (e.g., Abramson et al., 2002; Beck, 1987) assert that deficits in response initiation follow naturally from expectations of powerlessness and hopelessness, we suggest that explanations for this link should and can be elaborated. It seems intuitive that the promise of failure should dampen efforts to succeed. However, why should hopelessness with respect to an abstract goal, like building a positive reputation, lead to impaired response initiation with respect to concrete motor goals, like reaching for a cup of tea? In other words, why should a perceived inability to alter abstract aspects of life foster an inability to alter one's immediate physical surroundings? Recent research on embodied cognition, conceptual metaphor, and mental imagery offers some clues. Mental concepts appear to involve the mental simulation of sensory perceptions and motor actions. For concepts regarding intangibles, such as honor, obligation, or freedom, these sensorimotor simulations are often metaphorical (Gallese & Lakoff, 2005). For example, on this basis, the concept of freedom from political oppression might involve simulating the ability to freely move one's body. These simulations are the bodily experiences that were initially associated with the concept in early development. Finally, research on mental imagery demonstrates that sensorimotor simulations produce corresponding physiological effects, as if one were reliving the experience (see Cuthbert, Vrana, & Bradley, 1991, for a review).

The purpose of this article is to propose a theoretical model describing the causal pathways linking certain cognitive and somatic elements of depression. We hypothesize that (a) hopelessness and powerlessness are conceptualized metaphorically as motor incapacity (Lakoff & Johnson, 1980, 1999), (b) the sensorimotor experience of motor incapacity is mentally simulated or reenacted, and (c) this simulation produces corresponding peripheral physiological effects. We conclude that the metaphorical mental simulation of motor incapacity is largely responsible for the low energy and psychomotor retardation seen in depression. Of note, these symptoms do not characterize all forms of major depression, and other processes may give rise to psychomotor retardation. This model specifically addresses the causal mechanisms that link hopelessness to low energy and psychomotor retardation for cases in which both of these symptoms do arise.

Background

The proposed model is rooted in three areas of research: embodied cognition, conceptual metaphor, and mental imagery. This section briefly reviews evidence supporting the general notions that concepts produce mental simulations of sensorimotor experience, and these simulations should have peripheral physiological effects.

The Nature of Concepts

In the embodiment paradigm, concepts, rather than consisting of arbitrary symbols for things in the world, involve mental simulations of perceptions and actions using many of the same neurons as actual perception and action (Barsalou, 1999; Gallese & Lakoff, 2005; Lakoff & Johnson, 1980, 1999). Barsalou (1999) proposed that partial simulations of perceptual memories comprise thought. Similarly, James, Reichelt, Freeston, and Barton (2007) proposed that cognitive schemas activated during episodes of depression are multisensory memories of past events stored as a unitary concept. In particular, concepts for motor actions appear to involve mentally simulating the execution of that action. Reading or listening to action words, such as "kick," for example, activates areas of the motor cortices involved in those actions (e.g., kicking objects with the foot; Hauk, Johnsrude, & Pulvermüller,

2004; Tettamanti et al., 2005). Individual multimodal neurons known as "mirror neurons" have been found in the sensorimotor cortices that are active during both the performance of specific actions as well as the perception of another person performing those same actions or when hearing a sound associated with that action (Gallese, Fadiga, Fogassi, & Rizzolatti, 1996; Kohler et al., 2002; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996). Garbarini and Adenzato (2004) note that mirror neurons, by coupling action observation and action execution, demonstrate that the premotor area is involved in both the planning of motor actions and in representing their underlying abstract purpose. This suggests that mental simulation of motor actions participates in the conceptualization of actions. Other neurons known as canonical neurons are active during both a specific action, such as a pincer grasp, and the perception of an object that can be acted on in that way, such as a cup with a small handle (Gallese, 2003; Rizzolatti, Fogassi, & Gallese, 2000). As a result of these findings, Gallese and Lakoff (2005) argue that "the same neural substrate used in imagining is used in understanding" (p. 456). For example, the concept of grasping would involve the simulation of reaching out for an object, taking hold of it, and feeling the object in one's palm.

Conceptual Metaphor

Gallese and Lakoff (2005) argue that abstract concepts also involve sensorimotor simulations and that these simulations are often metaphorical. For example, the sensorimotor simulations involved in the concept of grasping would also arise in the concept of understanding or comprehending, as in "she has a good grasp of math," "he is grappling with quantum theory," or "I cannot wrap my mind around that idea." Thus, the idea of grasping, whether it be grasping a mug or grasping the meaning of a joke, is instantiated by mentally simulating the motor action of grasping physical objects. Gallese and Lakoff predict that when a person conceptualizes the act of comprehension metaphorically as grasping, the sensorimotor areas of the brain responsible for the motor performance of grasping (as well as the perception of another person grasping) will be active. Preliminary evidence supports this prediction (Rohrer, 2001). In addition, Glenberg et al. (in press) demonstrated that the concept of delegating responsibilities or communicating information, as in "she gave him an idea," involves the mental simulation of transferring physical objects by hand from one person to another. They also found that this simulation is accompanied by weak motor impulses to the hands.

Metaphor is traditionally defined as figurative language. Tied to this is the sense that calling something metaphorical demotes it to the status of something merely intended as analogy. However, according to conceptual metaphor theory (Gibbs, 1992; Gibbs, Bogdanovich, Sykes, & Barr, 1997; Gibbs & O'Brien, 1990; Lakoff & Johnson, 1980, 1999), metaphorical expressions in language, art, and gesture are simply manifestations of underlying metaphorical concepts that comprise people's understanding of the world. Conceptual metaphors involve understanding an abstract domain of experience (e.g., knowledge, time, affection) in terms of a sensorimotor experience (e.g., sight, traversing a landscape, warmth) due to an early, learned association of the two. For example, knowing is often conceptualized as seeing (Johnson, 1997; Lakoff & Johnson, 1980). To indicate that a person understands something, that person might say, "I see what you mean." Of people who do not understand or do not know what they are doing, one might say they are "blind" or "in the dark." This metaphor ostensibly arises in early development, because originally seeing and knowing are associated with the same experience (Johnson, 1997). In other words, the two are conflated. One knows something because one sees it, and one visually inspects something in order to know it. Later, one conceptualizes knowing in terms of seeing even when vision is not involved. Analysis by Johnson (1997) of early verbal utterances associated with seeing and knowing demonstrate that, initially, seeing is only used to indicate visual perception but is later used to indicate knowing in the absence of seeing.

Thus, according to this developmental theory of conceptual metaphor, primary metaphorical concepts are formed early in development when certain sensorimotor experiences (e.g., trying

to move an object that is too heavy) are conflated with a subjective or introspective observation (e.g., failing to accomplish a goal). Later, the same subjective or introspective observation triggers the simulation of the sensorimotor experience, and the simulation facilitates conception of the more sensory-impoverished subjective observation. Conceptual metaphors may also be formed through the integration or blending of these primary metaphors, which are grounded directly in experience (Grady, 1997; Lakoff & Johnson, 1999). The kinds of experiences that lead to basic metaphorical concepts, according to Lakoff and Johnson (1980), are common to most human beings around the world. As a result, many basic conceptual metaphors appear across different cultures.

According to Lakoff and Johnson (1999), the cognitive processes responsible for conjuring up metaphorical concepts and linking abstract ideas with sensorimotor experience need not be conscious or voluntary. Rather, abstract ideas automatically invoke the sensorimotor imagery with which they were initially conflated.

Sensorimotor Imagery

Based on research on mental imagery, the sensorimotor simulations in embodied cognition should have peripheral physiological effects. Lakoff and Johnson (1999) explain that conceptual metaphor utilizes sensorimotor imagery for domains of subjective experience. Extensive research during the past 30 years has demonstrated that mental imagery in various sensory modalities (i.e., visual, auditory, tactile, gustatory, spatial) (a) shares neural substrates with actual perception and action (Kosslyn, 1994), (b) operates under many of the same constraints as actual perception and action (Cooper & Shepard, 1973), and (c) produces corresponding physiological effects (Cuthbert et al., 1991). For example, imagining one's hand in a bucket of hot or cold water produces changes in the skin temperature of the hand consistent with the mental image (Kojo, 1985, 1990). Cuthbert et al. conclude that mental imagery reproduces the same somatic responses as the original situation, and these responses are integral components of imagery.

Imagining physical movement activates the same areas of the brain as motor planning and execution (Decety, 1996; Decety & Ingvar, 1990; Decety & Jeannerod, 1995; see Jeannerod & Frak, 1999, for a review). Motor imagery also increases the excitability of the spinal reflex pathways (Li, Kamper, Stevens, & Rymer, 2004) and produces attenuated motor signals to the body that resemble the imagined action (Bird, 1984; Hale, 1982; Jacobson, 1931; Lang, 1979, 1984). Imagining physical exertion increases muscle strength (Yue & Cole, 1992) as well as heart rate and breathing frequency (Decety, Jeannerod, Durozard, & Baverel, 1993) and results in EEG recordings that correspond to moments of imagined exertion (e.g., jumps and turns in imagined skiing; Suinn, 1980). As a result of these physiological and neural activations, motor imagery leads to the impulse to perform the imagined movement (Ulich, 1967).

Similarly, negative motor imagery in which a person imagines suppressing movement has been shown to suppress corticospinal excitability and attenuate twitching of the thumb induced by transcranial magnetic stimulation (Sohn, Dang, & Hallett, 2003). Consequently, imagining a lack of movement or an inability to move may create a subjective experience of motor incapacity and dramatically reduce actual physical movement.

Motor imagery need not be conscious or voluntary (Jeannerod & Frak, 1999). Jeannerod and Frak (1999) note that, while motor imagery traditionally refers to conscious imagery, it may also include unconscious elements involved in motor planning. To be precise, a person may automatically engage in motor imagery to solve a visuospatial problem but not be aware that they are doing it.

Theoretical Model

Taken together, research on embodied cognition, conceptual metaphor, and imagery suggests that abstract concepts are accompanied by central and peripheral physiological activity that resemble

certain basic, sensorimotor experiences. The implications for cognitive theories of emotion are profound. According to cognitive theories of emotion, some sort of conceptual evaluation of the abstract, personal significance of life events (i.e., appraisal) often mediates emotional responses to those events (Scherer, Schorr, & Johnstone, 2001). Thus, the broader theoretical model presented here asserts that some emotions are mental simulations or reenactments of bodily experiences (e.g., falling, smothering, carrying a heavy weight) that result when one conceptualizes the abstract, personal meaning of a situation or event (e.g., financial loss, a restrictive relationship, social pressures) metaphorically in terms of that experience. Further, based on research on somatic imagery, this model holds that some of the peripheral physiological concomitants of some emotions (e.g., muscle tension, changes in body temperature and breathing patterns) derive from these simulated sensorimotor experiences. Importantly, any innate responses that would occur in the sensorimotor experience are expected to occur during its simulation.

With respect to the mediating role of cognition, although concepts in appraisal may moderate emotional responses, the relationship can be one of mediation rather than moderation in that an emotional response could not occur to many types of events (particularly those characterizing modern, everyday human life) without some sort of conceptual evaluation. For instance, how one evaluates the loss of a job may determine the emotional response, not the event itself, and the event would not necessarily evoke any emotion without some sort of cognitive evaluation. Siemer, Mauss, and Gross (2007) found that appraisal is both a necessary and sufficient cause of emotional responses to certain types of situations with ambiguous meaning. The metaphor simulation model applies especially to these kinds of situations. Nevertheless, when particular cognitive inferences become habitual thinking styles, these styles can act as overall moderators of the emotional effects of life events.

Metaphor Simulation in Depression

When applied to depression, the metaphor simulation model suggests that hopelessness leads to low energy and psychomotor retardation through the metaphorical simulation of motor incapacity. First, an inability to alter or prevent negative events or bring about positive events (i.e., hopelessness, futility, personal deficiency, and psychological powerlessness) is conceptualized metaphorically as motor incapacity. Motor incapacity, as it is used here, refers to (a) a lack of physical energy and momentum, (b) an inability to exert physical force, or, more specifically, (c) an inability to exert physical force that is capable of reaching or altering a physical scene in a way envisioned. Examples of motor incapacity include being unable to walk through thick snow, lift a heavy box, or catch a ball. In the latter case, one may be capable of running towards the ball with outstretched hands but not of running fast enough or reaching out accurately enough to catch the ball.

Second, motor incapacity is mentally simulated. This simulation is an integral component of the concept of hopelessness and leads to subjective feelings of immobility and lethargy as well as corresponding peripheral physiological changes, namely, low energy and psychomotor retardation.

In the motor incapacity metaphor, the abstract cause of one's inability to alter events is the physical cause of one's motor incapacity, which could be a physical burden, obstacle or barrier, thick medium, trap or restraint, or nontraversable distance. This metaphor is prevalent in common verbal expressions, such as:

> *I am* stuck *on this math problem. I can't* get through *the homework. The crisis is* insurmountable. *I can't* get past *this problem. There's* no way out *of this dilemma. My efforts have* made no dent *in his attitudes. I cannot* lift *my grade. All my hard work is* getting me nowhere. *My dreams are* out of reach. *My goal is* too far away. *My hands are* tied.

Despite these illustrations using language, this is not a language-based theory. Importantly, one need not say or think these words (e.g., as internal verbal dialogue) in order to conceptualize a hopeless situation as one in which motor movement is impaired (Johnson, 1997; Lakoff & Johnson, 1980, 1999). Rather, one need only simulate the experience of motor incapacity in understanding the personal significance of the situation. This process is likely to occur automatically, involuntarily, and mostly outside of conscious awareness (though not inaccessible to consciousness).

The metaphor simulation model suggests that feeling down, trapped, or paralyzed in depression simultaneously reflects both subjective bodily sensations and conceptual beliefs about the abstract personal significance of life events. This conflation of feeling and perception is the consequence of recruiting the bodily experience of motor incapacity in forming the concept of oneself as powerless.

This model is in accord with the kinds of events that trigger episodes of depression. Typically, depression is thought to arise in response to loss, in a broad sense. However, research has shown that the key feature of depressogenic events is not simply loss but, more precisely, entrapment (e.g., blocked escape) or defeat (e.g., a putdown), and depressogenic losses without these features are uncommon (Brown, Harris, & Hepworth, 1995). Brown (2000) states, "In the context of the loss, experiencing an inability to move forward, being stuck, or being defeated or humiliated appears to be more salient" (p. 83).

Metaphorical Entailments

In the hopelessness/motor incapacity metaphor, one believes that the obstacles to effective movement are insurmountable. However, if there is the slightest possibility or expectation of removing the obstacle, escaping the trap, or lifting the burden and restoring capacity—in other words, if there is some small hope—then the logical result would be anxiety or frustration (i.e., psychomotor agitation and rumination). This prediction is based on the logical entailments of the metaphor. A small chance of escaping a trap or reaching a desired object would likely evoke a sense of urgency and pressure to take advantage of the opportunity. This metaphorical entailment is consistent with the model of depression and anxiety proposed by Alloy, Kelly, Mineka, and Clements (1990) in which uncertainty about one's inability to change circumstances leads to anxiety or psychomotor agitation, while depression and psychomotor retardation are more likely to occur when one is completely certain that circumstances are immutable.

Another entailment of the motor incapacity metaphor is that one cannot reach preferred locations or acquire desired objects. Metaphorically, these locations or objects, representing goals or aspirations, would involve sensory rewards or physical pleasures (e.g., sunshine, fruit hanging from a tree, a drink of water). As a result, individuals should fail to simulate sensory pleasure. This entailment is consistent with another characteristic symptom of depression, anhedonia, which represents an inability to experience anticipatory pleasure (Klein, 1984). Also consistent with this account, Gilbert, Allan, Brough, Melley, and Miles (2002) found that anhedonia in depression can be attributed to perceptions of defeat and entrapment.

Abstract Action and Motor Activity

One might argue that some degree of motor activity is always necessary to alter negative events or bring about positive events. However, acting in a psychological or abstract sense does not necessarily require any motor movement at all. For example, one can make a decision without moving, yet this might be described as "taking action." Some examples of psychological or abstract actions include getting a job (as opposed to getting a cup of coffee), passing a test, winning an award, committing to a relationship, or acquiring knowledge. Although these tasks may require some motor activity, the actual motor demands may be minimal, and success at the task is not

necessarily contingent upon success at the motor components of the task. For example, a person may be capable of performing the necessary motor actions to take an exam yet be incapable of passing the test.

The metaphor of mental or abstract activities as physical actions is listed by Grady (1997) as a primary metaphor, or one directly grounded in early experience. Voluntary physical actions, like reaching for a cup or pouring juice, are coupled with certain mental activities like motor planning or mental imagery of a series or pattern of actions and their intended outcome. Consequently, the inability to accomplish a motor task is conflated with the failure to accomplish a psychological goal, which is to instantiate an envisioned state of affairs. An inability to pour a cup of juice is conflated with the subjective or introspective experience of failing to satisfy the goal of pouring juice. This creates a conceptual metaphor in which psychological goals are thought of (and felt) as motor tasks. This is manifested in common verbal expressions about goals, such as "taking steps towards a degree," "a dream taking shape," "the pursuit of happiness," "nailing the exam," or "taking the reins" on a project. As a result, one can conceive of a psychological or abstract state of helplessness that does not impair motor activity and move towards a goal, psychologically speaking, without actual locomotion.

The conflation of abstract failure and motor incapacity is an experience that is likely shared by people of all cultures and socioeconomic backgrounds. Consequently, the proposed model should apply equally to people of different backgrounds. However, culture and socioeconomic status and other individual experiences could influence the extent to which the metaphor is utilized to represent life events and precisely how it feels to be physically incapacitated.

The metaphor of psychological or abstract action as physical movement is elaborated by Lakoff and Johnson (1999), where the "manner of action is [the] manner of movement," "speed of action is speed of movement," "suspension of action is the stopping of movement," and "difficulties are impediments to movement" (p. 188). With respect to difficulties, they write:

> *If you are physically stuck in a bog, then it is very hard to move forward at all, and it is uncertain as to whether you will be able to reach your destination. So, if you are bogged down on a project, then it is very hard to make progress at all, and it uncertain* [sic] *as to whether you will reach your goal, that is, succeed with the project . . . the language and the logic of physical impediments to motion are mapped onto the language and logic of difficulties in achieving purposes. (p. 189)*

Feeling Down

Depression and sadness are often described as feeling down or low. People speak of being downtrodden, downcast, down in the dumps, in a slump, or in a rut. Moreover, to be down low is another, separate meaning of the word *depressed* (Webster's, 2001). These expressions are consistent with the somatic symptoms of depression, particularly low energy, postural slumping, sleepiness, and the slowing of motor movements. On the one hand, they may reflect self-observation of the depressed state or what it subjectively feels like to experience lethargy and sluggishness. On the other hand, the metaphor simulation model suggests that hopelessness causes somatic symptoms consistent with being low through the simulation of a common feature of motor incapacity, namely, an inability to rise in vertical space.

Powerlessness, or a lack of control, is often conceptualized metaphorically as being down (Lakoff, 1987; Lakoff & Johnson, 1980; Schubert, 2005). Schubert (2005) presented pairs of group labels associated with power and powerlessness, such as "parents-child," "employer-employee," and "master-servant," together on a screen with one label above the other. The relative positions of the labels varied. When asked to determine which group was the more powerless, response times were significantly faster when the powerless group was presented on the bottom and slower when presented on top. In contrast, response times were significantly faster for identifying the more powerful group when that group was presented on the top. In another study described in the same

paper, Schubert found that judgments of groups, such as "worker," "aide," "child," "pupil," and "menial," as powerless were faster when the response necessary to make the judgment involved pressing the down cursor key on the keyboard and slower when participants had to press the up key. Schubert also found that groups were judged more quickly as powerless and pictures of animals judged as more powerless when presented in the lower half of the screen.

If powerlessness is also conceptualized more broadly as motor incapacity and entails the mental simulation of inhibited motor movement, the tasks involving powerlessness should exhibit slower response times overall, because making a response requires motor movement. This is what Schubert found and was a significant main effect in each of the previously mentioned studies.

Consistent with the hypothesis that depression involves the mental simulation of being down or low, Riskind and Gotay (1982) found that participants asked to adopt a slumped posture were significantly less persistent on a subsequent learned helplessness task. In addition, states of sadness lead to a downward shift in visual attention (Fisher, 1963; Rosenblatt, 1956). In a study by Wapner, Werner, and Krus (1957), participants were asked to bisect a square by adjusting a horizontal rod up or down. After receiving an F on a midterm exam, participants showed signs of sadness and placed the rod lower in the square than they did before receiving their grade, while participants who received an A showed signs of happiness and placed the rod higher in the square. A sense of being down also surfaced in graphic depictions of depression in a study by Lundholm (1921). When asked to draw lines depicting the emotional tone of adjectives related to depression (*sad, melancholy, mournful, doleful,* and *sorrowful*), 84% of the lines drawn by participants exhibited a downward directional tendency. In contrast, 58% of the lines for opposite words (*merry, cheerful, gay, jolly,* and *joyous*) had an upward directional tendency.

The metaphor of powerlessness as down has numerous plausible bases in experience. Physical powerlessness resulting from low physical energy or being overwhelmed by a physical force (e.g., a multitude of objects, ocean waves, physical burdens, or opponents in a fight) typically causes the body to occupy a low position in space in a painful or uncomfortable manner. Thus, one component in metaphorically simulating physical powerlessness can be the experience of being physically down.

Negative Views of the Self

Views of the self as deficient or unworthy play a role in triggering depression (Abramson et al., 2002). Similarly, personal defeat and humiliation are common features of events that elicit depression (Brown, 2000). According to the proposed model, negative views of the self involve the mental simulation of being down, which leads one to feel down (and therefore depressed). Like powerlessness, negative evaluations of the self are associated metaphorically with a lower position of the body in vertical space (Lakoff & Johnson, 1980). Being humiliated by negative social judgments, for instance, can be conceptualized as being put down or cut down, reduced in size, or taken down a level. People *look down on* those who are of *low* status. In contrast, positive social evaluations can be conceptualized as elevation, as when one is *built up* by compliments, held in *high* regard, or given an ego *boost* with praise. Consistent with this metaphor, people with high status or top executive positions are commonly given higher positions in physical space (e.g., thrones and pulpits). Worthlessness and rejection, on the other hand, are associated with being low (e.g., low self-esteem, low regard, lowly servant).

One plausible experiential basis for this metaphor is the observation that worthless objects (e.g., trash, rotten food) are often physically rejected by hand or mouth, causing them to fall to the ground. Also, in early childhood, being put down on the ground or not picked up by a parent is conflated with social or psychological rejection, as is being shoved to the ground by other children.[1] Later, social rejection is conceptualized as being cast down (e.g., being "dumped" by

a romantic partner, "declined" by an admissions committee, or "turned down" by an employer). In addition, being physically low to the ground is associated with filth and decay. Both are often used to conceptualize worthlessness as well as immorality and sin. This metaphor is evident in Christian beliefs, where the final destination of sinners is down in Hell, and devils are "fallen" angels. As a result, social rejection and the belief that one is worthless may cause a person to feel subjectively low.

In addition to negative self-imagery causing one to feel down, feeling low and incapacitated for exogenous reasons may encourage negative self-imagery because of the association between motor deficiency and a deficient or worthless self and between low physical position and negative social evaluations. Independent of one's initial self-image, the belief that a goal is unachievable may encourage people in a depressed state, upon feeling lethargic and low, to infer their own unworthiness and experience guilt or even a sense that they are being punished. In other words, even if their personal attributes are not accountable for the hopelessness of the situation, they may infer that they are worthless or deficient, because they *feel* low.

A Motivation-Motor System

The hypothesis that psychomotor retardation is evoked by the metaphorical simulation of motor incapacity is consistent with neurological studies of depression. Both depression and psychomotor retardation have some overlapping neural substrates with a motivation-motor system (Depue & Iacono, 1989). The Behavioral Approach System (BAS) regulates motor behavior associated with the initiation of locomotion and movement toward desired objects (e.g., searching for food; Gray, 1994). The BAS involves links between (a) limbic regions of the brain associated with basic drives and innate motivational tendencies and (b) motor regions of the brain associated with planning and executing motor movements (Depue & Iacono, 1989). Depression appears to involve hypoactivation of the BAS, or a disruption of the neurological system involving the frontal lobes and limbic regions (Mayberg, 1997; Videbech et al., 2002), leading to the hypothesis that depression represents a deficit in approach motivation (Davidson, 1999; Depue & Iacono, 1989; Depue, Krauss, & Spoont, 1987; Fowles, 1988, 1993; Gotlib et al., 1998; Henriques & Davidson, 2000; Kasch, Rottenberg, Arnow, & Gotlib, 2002). The hopelessness/motor incapacity metaphor suggests that approach motivation is literally the motivation to move physically towards things but that the approach motivation system can be co-opted to regulate goal-oriented behavior that has little to do with actual physical movement.

Depression is associated with decreased activity in the left prefrontal cortex, evinced by reductions of electrical activity (Gotlib, Ranganath, & Rosenfeld, 1998; Henriques & Davidson, 1990, 1991), glucose metabolism (Baxter et al., 1989; Kato et al., 1995), and cerebral blood flow (Bench et al., 1992; Passero, Nardini, & Battistini, 1995). Activity in the left prefrontal cortex is also associated with activation of the motivation-motor system (Davidson, Jackson, & Kalin, 2000; Harmon-Jones & Allen, 1997; Sutton & Davidson, 1997).

Similarly, motor planning and positive motor imagery also appear to be dominated by the left hemisphere. Stroke damage to the left hemisphere is associated with a decrease in the velocity of both real and imagined hand movements for both hands, while decreases due to damage in the right hemisphere are restricted to the left hand (Sabaté, González, & Rodríguez, 2004). Listening to sentences describing simple motor actions activates a left-lateralized fronto-parieto-temporal system involved in action execution and observation (Tettamanti et al., 2005). Kable, Lease-Spellmeyer, and Chatterjee (2002) found that the presentation of verbs associated with bodily actions activates areas of the brain involved in action execution primarily in the left hemisphere (the left posterior aspect of the middle and superior temporal gyri). In contrast, response inhibition or negative motor imagery (imagining the suppression of movement), like that associated with self-restraint or avoidance, is dominated by the right hemisphere (Garavan, Ross, & Stein, 1999).

Psychomotor retardation is associated with reduced regional cerebral blood flow (rCBF) in the left dorsolateral prefrontal cortex (DLPFC; Bench, Friston, Brown, Frackowiak, & Dolan, 1993; Dolan, Bench, Brown, Scott, & Frackowiak, 1994; Dolan et al., 1993; Narita, Odawara, Iseki, Kosaka, & Hirayasu, 2004; Videbech, 2000; Videbech et al., 2002). Reduced rCBF in the left DLPFC is also found in induced states of sadness (Liotti et al., 2000; Mayberg et al., 1999). Blood flow to this region increases upon clinical recovery in individuals with major depression (Bench et al., 1993). The left DLPFC is also active during the mental simulation of motor actions (Decety et al., 1994; Grafton, Hazeltine, & Ivry, 1995; Leonardo et al., 1995; Malouin, Richards, Jackson, Dumas, & Doyon, 2003; Seitz et al., 1997; Stephan et al., 1995) and the motor planning and initiation of voluntary or willed actions (Frith, Friston, Liddle, & Frackowiak, 1991). Further, there is some evidence that repetitive transcranial magnetic stimulation (TMS) of the left DLPFC alleviates depression (Loo, Mitchell, McFarquhar, Malhi, & Sachdev, 2007; Mitchell & Loo, 2006; Stern, Tormos, Press, Pearlman, & Pascual-Leone, 2007).

Consistent with this, individuals with unipolar major depression exhibit slower performance in mentally rotating objects (Rogers et al., 2002) and decreased activation in the left premotor area in a motor task involving the right hand (Guenther et al., 1986). These findings suggest impaired motor imagery and planning in depression, which is consistent with the mental simulation of motor incapacity. Of note, a wide body of research suggests that motor planning is facilitated by or largely composed of the mental simulation of prospective motor action (Johnson, 2000; Klatzky, McCloskey, Doherty, Pelligrino, & Smith, 1987; Klatzky, Pelligrino, McCloskey, & Lederman, 1993; Rosenbaum, 1991; Rosenbaum & Jorgenson, 1990; Rosenbaum, Vaughan, Barnes, & Jorgensen, 1992).

Depressed individuals also show weaker index finger force in response to TMS of the motor cortex (Oathes & Ray, 2006). When considered in context with research by Sohn, Dang, and Hallett (2003) showing that imagining the suppression of movement attenuates TMS-induced thumb twitching, this raises the possibility that depressed individuals are mentally simulating a lack of movement, and this metaphorical simulation hinders the simulations necessary for planning actual movements.

These studies linking depression, psychomotor retardation, motor simulation, and the BAS in the brain suggest that the slowing of movement and retarded initiation of voluntary responses seen in depressed individuals is caused by the mental simulation of motor incapacity or a reduction in the mental simulation of motor movement, and that the negative cognitive evaluations that prompt depression lead to psychomotor retardation by metaphorically accessing the motivation-motor system. Basic motivations and drives that evolved to regulate motor behavior and locomotion (e.g., giving up the physical struggle to break free of a trap or reach a distant object) are thus recruited through the mechanisms of conceptual metaphor and imagery to regulate abstract behaviors (e.g., giving up the struggle to reach a distant goal, such as winning an award). The result is that *hopelessness is manifested as a motor deficit.*

Implications for Clinical Practice

A primary goal of psychotherapy for depression is to change how events are evaluated in order to change the resulting emotions (Beck, Rush, Shaw, & Emery, 1979). The metaphor simulation model of emotion, applied here to depression, has several implications for therapy: (a) it points to new ways of identifying cognitions; (b) it opens up the possibility of curbing the somatic symptoms or feelings of depression regardless of how events are evaluated; and (c) it suggests that real or imagined bodily experiences of motor capacity will alleviate both the cognitive and somatic elements of depression.

Identifying Cognitions

A first step in cognitive psychotherapy is to identify how events are being evaluated (Beck et al., 1979). One implication of the metaphor simulation model is that, in addition to identifying cognitions based on internal verbal monologues and reported visual imagery, cognitions might be identified based on metaphorical, conceptual simulations manifested in both central and peripheral activity. These simulations are evident in metaphorical expressions, imagery, gestures, and bodily states. For instance, if a person slouches, hangs his head, and complains of fatigue upon discussing an "enormous" obligation, this suggests that he is evaluating the obligation as a heavy burden that he finds difficult to carry. On the other hand, difficulties can also be conceptualized as physical obstacles (Lakoff & Johnson, 1999). Whether a situation is a burden or an obstacle has implications for what behavioral solution seems most appropriate. If a person throws his hands in the air, as if to toss aside or brush off an object, this suggests that he has given up or dropped the burden and thus believes the task to be impossible. Thus, when viewed as manifestations of metaphorical concepts, reported sensory experiences, bodily movements, and physical complaints offer a window into a person's cognitive evaluations, and indeed largely constitute those cognitive evaluations. More than just figures of speech or expressive body language, they reveal the subjective qualities of the person's emotional state and what sensorimotor experiences the person is utilizing to understand the abstract meaning of his or her situation.

The Difficulty in Countering Beliefs

The metaphor simulation model suggests that when a person begins a statement with "I feel," as in "I feel weighed down by work," "I feel drained by the demands of parenthood," or "I feel pressured by my friends," these statements simultaneously refer to both a sensorimotor experience in the body and a cognitive evaluation of an abstract event. In other words, they are not casual misuses of the term "feel" but reflect both an emotional reaction and cognitions in relation to an event, because the cognitive evaluation, carried out through conceptual metaphor, involves the simulation of a bodily experience. For this reason, emotions themselves may provide a person with evidence that the world is indeed as they believe it to be. If the person *feels* weighed down, then she is effectively weighed down and the task at hand is indeed too much to handle, it would seem, because she has essentially created from within the effects of the event as she sees it. The sensations generated by her metaphorical schema thus confirm and validate her assessment of the situation. This may explain the difficulty in countering cognitive evaluations. Therefore, reality testing and the correction of distorted conceptualizations may be furthered by drawing a clear distinction between the actual impact of events and their emotional consequences (reflecting the metaphorical impact). A heavy course load, for instance, may feel like a burden thereby generating fatigue, but if one can consider the course load as separate from this experience of fatigue, it may be easier to evaluate the true challenges imposed by the curriculum and recognize opportunities for meeting those challenges.

Disrupting the Causal Chain

The proposed model suggests that emotions might be altered without first altering how events are evaluated. In the causal chain linking life events to depression, the model inserts new elements, that is, metaphor and sensorimotor simulation, as the proximal causes of low energy and psychomotor retardation. In so doing, it offers new access points for disrupting the link and averting emotional suffering. Specifically, if depression results from mentally simulating the experience of motor incapacity, interfering with this simulation either through contradictory physical experience or somatic imagery should alleviate depression. The power of this approach

lies in the fact that emotions could be altered and the somatic symptoms of depression could be alleviated even if cognitive evaluations are relatively accurate and events are immutable.

Experiencing Motor Capacity

The physical experience of motor capacity, or exercise, represents a therapeutic application of the proposed model. Actual sensorimotor experiences can hinder the comprehension of concepts that require simulating opposing or contradictory sensorimotor information. For example, Zwaan and Yaxley (2003) found that it takes longer to verify that two words representing parts of objects are related if the words are visually presented in a vertical order that contradicts the vertical spatial positions of the parts (e.g., *root* above *branch*). With respect to motor movements, it takes longer to process words and sentences involving implied movements (e.g., toward the body, as in "open the drawer") or spatial orientations (e.g., up, as in the roof of a car) when one must simultaneously move one's hand in the opposite direction (i.e., away from the body or down; Borghi, Glenberg, & Kaschak, 2004; Glenberg & Kaschak, 2002). These findings lend support to the notion that physical response generation plays an essential role in thought and imagery (Cuthbert, Vrana, & Bradley, 1991). Thus, physical exercise, which involves the actual bodily experience of motor capacity, should hinder the mental simulation of motor incapacity in concepts of hopelessness and powerlessness and in this way reduce depression.

Both aerobic and nonaerobic exercise are effective treatments for depression comparable to pharmacological therapy or cognitive-behavior therapy (Ahmadi, Samavat, Sayyad, & Ghanizadeh, 2002; Dunn, Trivedi, Kampert, Clark, & Chambliss, 2005; Lawlor & Hopker, 2001). One mechanism for the positive effects of exercise, other than an increase in mood-elevating endorphins, is an increase in perceived self-efficacy (Craft, 2005), or the belief that one is capable of performing the necessary tasks to exercise influence over events (Bandura, 1995). The construct of self-efficacy is similar to hope and power, and the effects of stressful life events on symptoms of depression are mediated by low perceived self-efficacy (Bandura, 1994; Maciejewski, Prigerson, & Mazure, 2000). Like hope and power, self-efficacy, or psychological control over events, is conceptualized metaphorically as physical control (Lakoff & Johnson, 1980, 1999). Research on exercise and depression suggests that, in engaging in physical exercise, the bodily experience of motor control encourages a sense of psychological or abstract control over life.

Exercise has also been found to reduce hopelessness (Hembree, 2001) and the negative cognitions associated with depression (Lash, 2000). For instance, Reynolds (1996) describes a case study of a depressed client who described herself as helpless, inadequate, weak, heavy, "pulled by events," and psychologically stuck. After embarking on a physical exercise program that involved biking on a local trail, she described herself as light, free, strong, and in control. This suggests that the sensorimotor experience of motor capacity might counteract concepts of oneself as psychologically incapable, which, according to the model presented in this proposal, rely on simulating physical incapacity. Like overriding pain signals by rubbing a bruised elbow, experiencing motor capacity might override the simulation of incapacity and consequently make it more difficult to conceptualize a situation as hopeless or oneself as powerless.

While any physical activity is likely to benefit mental well-being over being sedentary, activity that is high in the experience of motor efficacy should be more effective for depression than exercise that involves low levels of perceived motor efficacy. Bodin and Martinsen (2004) found that one 45-minute session of martial arts exercises significantly increased positive affect and self-efficacy, but riding on a stationary bike had no significant effect. From a metaphorical perspective, riding on a stationary bike is truly "an exercise in futility" in which, despite all efforts, one is literally "going nowhere." Martial arts, in contrast, is effectively a demonstration (actual or pantomime) of motor capacity. Hence, the findings of Bodin and Martinsen suggest that the experience of motor capacity is partially responsible for the antidepressant effects of exercise.

Other physical activities that appear to confer high motor efficacy include dance, sculpture, gardening, and most sports.

Of note, just as physical activity can increase hope, physical inactivity or incapacity should predispose individuals to believe that a situation is hopeless. Consequently, a prediction of the metaphor simulation model of depression is that the experience of physical incapacity will make it difficult to mentally simulate the experience of capacity and thereby facilitate or strengthen thoughts of hopelessness. Further, the model suggests that this is one of the many possible ways in which certain physical conditions associated with chronic motor incapacity, such as obesity, advanced age, and pregnancy, might cause depression.

Motor Imagery

Despite the antidepressant effects of physical exercise, exercise is a huge challenge for people feeling utterly depleted and sluggish. This creates a catch-22, whereby an individual becomes depressed, because they believe themselves metaphorically incapacitated, but cannot generate the experience of physical capacity, because they are depressed. Given that an increase in self-efficacy (feeling more in control psychologically) accounts for some of the antidepressant effects of exercise (the experience of physical control), mental imagery of physical activity may reduce depression via the same mechanism. In the domain of exercise and sports research, imagining motor movements and physical energy has been found to motivate physical activity, raise energy levels, reduce stress and anxiety, and improve physical performance (Hall, 1995; Hausenblas, Hall, Rodgers, & Munroe, 1999; Martin, Moritz, & Hall, 1999; Rodgers, Hall, Blanchard, & Munroe, 2001; Vadocz, Hall, & Moritz, 1997). A prediction of the model is that the mental simulation of motor capacity will interfere with hopelessness and elevate mood and, as a result, will facilitate or speed long-term cognitive change in cognitive behavioral therapy for depression.

Being Up

With respect to feeling down and low, another prediction of the model is that actual physical elevation or verticality or the mental simulation of being up will reduce depression by making it more difficult to mentally simulate being down. For instance, one could sit in a high position looking out over other objects or walk along an elevated trail for a short period each day. In addition, mental imagery of being up or "standing tall" should interfere with feelings of powerlessness and hopelessness. However, caution is warranted. Inconsistency or incompatibility between evaluations of a situation and artificially adopted bodily states may exacerbate rather than alleviate negative mood, especially if one is reluctantly obligated to adopt the incongruous state. Riskind (1984) asked participants to adopt either a slumped or upright posture following success or failure at a task. Mismatches between the situation and the posture led to lower motivation, a more external locus of control, and higher depression.

Inciting Simulations

It may be difficult for depressed individuals to imagine effective motor movement, because, according to the model, they essentially believe themselves to be physically incapacitated. Any imagery might be hindered by sensorimotor feedback that confirms their belief in their own incapacity or by their metaphorical worldview, which places them squarely in an impossible situation. This possibility is supported by research showing that depressed individuals are slower at mentally rotating objects (Rogers et al., 2002), and individuals with actual motor incapacity (due to cortical degeneration or Parkinson's) also perform motor tasks more slowly in their imaginations commensurate with the extent to which their actual motor movements have slowed (Dominey, Decety, Broussolle, Chazot, & Jeannerod, 1995; Sirigu et al., 1995).

Consequently, in the absence of actual physical experience, more effective interventions might be those involving the delivery of strong cues indicating motor capacity. For instance, a video game or virtual reality device could produce a perceptual illusion of motor capacity. Dance music, with its rapid rhythm and frequent verbal allusions to physical activity, may also evoke strong simulations of rapid, effective bodily movement. Indeed, many musical parameters are metaphorically indicative of bodily motion, creating somatic imagery that follows the contours of pitch (Eitan & Granot, 2006). Hypnotic suggestions of motor capacity may succeed in overcoming simulations of powerlessness (see Santarpia, Blanchet, Lambert, Venturini, & Cavallo, 2006). Nevertheless, while these interventions might provide quick relief, voluntarily initiated, active mental imagery of motor capacity, perhaps honed through practice, may prove most powerful in the long term, because it would ostensibly activate areas of the brain involved in voluntary, willed motor acts (characteristically compromised in depression; Abramson et al., 1989; Joiner et al., 2001; Parker & Brotchie, 1992).

If the metaphorical simulations composing hopelessness are essentially sensory memories, consistent with Barsalou (1999) and the perspective on schemas by James et al. (2007), one possible way of effectively conjuring up new simulations might be to frame the process as the recall of sensory memories rather than mental imagery, which primarily connotes imagery in the visual modality. Therefore, instead of asking a depressed person to imagine or "see themselves" performing a successful motor act, one might ask the person to remember "what it feels like" to succeed at a motor act or experience physical energy.

Simulation and Reappraisal

Linking simulations of motor capacity to conceptual evaluations of specific life events should be particularly successful in alleviating depression. As with physical exercise, the simulation of motor capacity should make it easier for people to have hope, essentially because they *feel* capable of reaching their goals. For example, contemplating or discussing a seemingly hopeless situation while hiking to energetic music (in contrast to reclining on a couch) should facilitate reappraisal processes by interfering with the simulated perception of physical powerlessness necessary to feel that the situation is truly hopeless. In other words, current motor experiences should inhibit feelings of hopelessness, and if one cannot *feel* hopeless about a situation, one should find it exceedingly difficult to *believe* that the situation is hopeless. Further, if thoughts about a situation are accompanied by bodily sensations of power, this might encourage beliefs that the situation is somehow amenable to change. These predictions are based on research in embodied cognition showing that concurrent sensorimotor experiences influence conceptual processing that requires contrasting or overlapping sensorimotor simulations (Borghi et al., 2004; Glenberg & Kaschak, 2002; Kaschak et al., 2005; Stanfield & Zwaan, 2001; Zwaan & Yaxley, 2003).

One might also generate the experience of motor capacity when developing new goals or aspirations, coming up with solutions and strategies to tough problems, or replacing impossible wishes with more feasible ones. In effect, when a given situation is truly immutable, the experience of motor capacity should make it easier to find hope in new places. Storytelling or hypnosis in a style similar to that employed by Milton Erickson (Rosen, 1991; Santarpia et al., 2006) and therapeutic techniques involving body work in relation to thought, such as the Alexander technique (Jones, 1997), might be useful for promoting these mental processes in an individual seeking therapy.

Discussion

Limitations

The proposed model addresses only a subset of the cognitive and somatic features of depression, namely, the link between thoughts of hopelessness and low energy and psychomotor

retardation. Among the remaining features, for example, are the effects of depression on attention and memory, the involvement of stress hormones, and the role of light in seasonal depression.

These features are not inconsistent with the model but may lie outside its scope. On the other hand, some aspects of depression may be related through metaphor to the psychological intricacies of motor behavior. This article presents a somewhat superficial picture of motor capacity given the complexity of motor behavior and motor drives. Nevertheless, simulating the experience of motor incapacity should involve the same sophisticated neurobiological systems as actual motor incapacity. This includes any evolved patterns of response, basic negative affect (e.g., the pain of unsatisfied desires or thwarted plans of action), and nonmetaphorical abstractions concomitant with the perception that one has failed at a motor task, such as the simple recognition that the current state of affairs does not conform to the desired state envisioned. For example, if one cannot run fast enough to catch a ball, this creates a sense of motor incapacity simply by virtue of being unable to move fast, but even after successfully carrying out the adequate motor actions, the ball may be blown off course by a gust of wind. A sense of powerlessness and lack of control would be expected in this circumstance as well. Thus, one important element of the experience of motor capacity appears to be that one's motor actions be followed by the expected sensory feedback. The perception of motor incapacity in this circumstance may therefore require the perception of a discrepancy between the current and desired sensory input. In this case, the desired input would be the sensation of the ball in one's hand.

Other metaphorical concepts may also play a role in depression. For example, a negative social evaluation, such as an insult, criticism, or snub, can be conceptualized metaphorically as a physical injury. This metaphor may drive expressions such as "stinging criticism," "verbal aggression," "bruised ego," "wounded pride," "taking a jab at someone," and "getting stepped on." The result of simulating the sensorimotor experience of injury would be physical pain. Indeed, research on social pain has demonstrated that areas of the brain involved in the experience of physical pain (the dorsal anterior cingulate cortex and anterior insula) are active in response to social rejection or exclusion (Eisenberger, Lieberman, & Williams, 2003; MacDonald & Leary, 2005). Words, it turns out, can hurt just like sticks and stones.

Finally, the model does not preclude alternative causal mechanisms for the creation of low energy and psychomotor retardation in depression. Moreover, the model suggests that the causal arrow can go both ways, with low energy and motor retardation of endogenous origin influencing conceptual evaluations and enabling thoughts of hopelessness.

Conclusion

The metaphor simulation model of depression explores the implications of theory and research on embodied cognition, metaphor, and mental imagery for the hopelessness theory of depression (Abramson et al., 1989, 2002). This synthesis of findings from clinical and cognitive psychology offers one possible explanation for the link between certain cognitive and somatic elements of depression. According to the proposed model, the belief in a psychological or abstract inability to alter negative life events or bring about positive circumstances is conceptualized metaphorically as motor incapacity. In forming this concept, the experience of motor incapacity is partially recreated both mentally and physically in the central and peripheral nervous systems. This mental simulation is therefore deemed responsible for the low energy and psychomotor retardation arising in hopelessness depression. The sluggishness and lethargy of depression thus arise automatically and involuntarily from the belief that one is trapped, stuck, sapped, burdened, paralyzed, obstructed, or otherwise incapacitated by abstract circumstances in life.

Note

1. Some of the consequences of not being picked up by a parent include, in addition to being down, continued motor incapacity (e.g., being unable to reach an object or too tired to walk home from the park) and the persistence of pain from hunger or gas, particularly for infants. Thus, mentally simulating social rejection may include not only the simulation of being down and incapacitated but pain and hunger as well.

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