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Two Motivational Systems That Shape Development: Epistemic and Self-Organizing

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Two Motivational Systems That Shape Development: Epistemic and Self-Organizing

Kurt W. Fischer and Michael W. Connell

Cognitive science with its narrow focus on the structure of the mind has largely lost sight of motivation. In this essay we propose that understanding the structure of the mind requires understanding the forces and biases that shape the mind – which are generally called “motivation”. Development is not the execution of a program, the implementation of a blueprint, or the unfolding of a pre-determined sequence. It is a dynamically equilibrated, self-organizing process that is both driven internally toward higher levels of complexity and simultaneously supported and shaped powerfully by the contexts to which it has adapted over evolutionary time and to which it is constantly adapting in real time (Baldwin, 1894; Fischer & Bidell, 1998; Heckhausen, 2000; Piaget, 1967/1971; van Geert, 1998; Vygotsky, 1978; Wiener, 1965). Understanding development requires identifying and characterizing the processes that allow a person to bootstrap him/herself into acquiring the fundamental representations needed to build ever more complex knowledge. These processes provide the impetus to move toward higher levels of complexity, and they are shaped by internal and external constraints and influences, resulting in the diverse yet characteristic shapes that development and learning assume.

In this article we argue that two kinds of motivation are key mechanisms that together drive and shape cognitive and emotional development: epistemic motivation, and self-organizing motivation. A concrete developmental phenomenon exemplifies each type of motivation: circular reactions for epistemic motivation and positive self-attribution bias for self-organizing motivation. Epistemic motivation promotes development of skills and knowledge of the world. Self-organization promotes construction and regulation of stable patterns of activities based on long-term goals and representations, especially those involving self and others.

These two motivational processes work through similar processes although they act to shape distinct content. Both of them constitute broad developmental forces that have strong sensorimotor origins in early development and are realized in terms of specific goals and concerns of each developing individual. They function through particular emotional organizations that comprise similar processes of appraisal, feedback, and adaptation. The concrete phenomena of circular reactions and positive self-attribution facilitate building specific dynamic models of the two kinds of motivation, which specify both common processes and differences in content. Based in emotion processes and neural networks, these models outline how the two related types of motivation participate in developmental processes operating across diverse time scales (seconds to years).

Epistemic Motivation: Circular Reactions in Children & Adults

In a classic portrait of infancy, a baby experiences an interesting event, such as seeing a mobile jiggle over her crib, and she works hard to make it happen again and again. This is the essence of the mechanism of epistemic motivation – a drive to repeat and master interesting events in the world, and thus to create knowledge. With Piaget's (1936/1952) classic observations, he tied a string from his baby's hand or foot to the mobile, and she moved her limb over and over to make the mobile move. For example, a baby girl in a crib with a low-hanging mobile moves her arms and legs around in apparently random motions, happening to jerk the string or kick the mobile and thus making the object spin and emit a sound like a musical chime. The motion and sound attract her attention, and she focuses on the mobile and kicks her legs more enthusiastically at the same time. These activities make it more likely that she will jiggle the mobile again, and over time she repeats and varies her activities until she learns an effective way to kick her foot to create the interesting actions of the mobile.

Circular Reactions in Children

The relation between action and event is the key to circular reactions, and the phenomenon has been described extensively by not only Piaget but also J. M. Baldwin (1894), Henri Wallon (1970), and Carolyn Rovee-Collier (Rovee-Collier & Sullivan, 1980). Response-contingent activity promotes positive emotions and leads directly to growth of knowledge and skills (Fischer, Shaver, & Carnochan, 1990; Krapp, this volume; Locke, 1993). "Interesting" events create circular reactions, which lead people to persist until they master a skill or understand an event.

In Piaget's words, "...[W]hat Baldwin called the *circular reaction* [is] the first step toward all other accommodations. The child does something at random, and when he gets an interesting result, he repeats the action indefinitely. In this way, he learns to suck his thumb, to seize objects, to make noises by knocking hard things together, and so on. The circular reaction is therefore the utilization of chance." (Piaget, 1927, *The First Year of Life in the Child*, as cited in (Gruber & Vonèche, 1977, p. 202). Piaget describes the circular reaction as a mechanism for explaining how infants develop initial sensorimotor knowledge that will serve as the foundation for all later knowledge.

Complex Circular Reactions in Adults

Although most of the research literature attributes circular reactions primarily to the early years, research suggests that it is an important mechanism in development and learning throughout the human life span (Csikszentmihalyi, 1997; Fischer & Yan, 2002; Krapp, this volume; Yan & Fischer, 2002). The process seems to be more protracted in early development and therefore more obvious, but older children, adolescents, and adults can all be captured in circular reactions by captivating contingencies. For example, creators of electronic games recognize the power of this mechanism of epistemic motivation when they create circular

structures to their games to keep people playing, sometimes to the point of exhaustion. Computer programming can have the same qualities: How often have the two of us been caught by a programming effort, as time passes unnoticed, until we end up disoriented and feeling strange from exhaustion as we finally break out of the programming activity? The difference between infant, child, and adult circular reactions seems to be the complexity of the capturing activity. Infants can be captured more easily by ordinary events in the world, while adults are captured by complicated tasks and games that are usually socially constructed. The capturing comes not from the complexity of the action but from the motivational process that appraises it as interesting and worth repeating or varying. Studies of microdevelopment illustrate some such circular activities, as we will describe later. Developmental and educational scholars have appreciated neither the role of epistemic motivation in producing the circular reaction in the first place nor its role in driving and shaping development.

Research on microdevelopment in learning situations shows the pervasiveness of circular reactions in adult learning and problem-solving (Yan & Fischer, 2002). When adults encounter a novel, interesting task or situation, they commonly pursue it energetically until they reach some understanding or skill, or until they become tired or are obliged to pursue another goal. For example, when Granott (1994; 2002) placed adult teachers and graduate students in a room with Lego robots, which they had never seen before, they began exploring the robots energetically. Their explorations demonstrated a recurring, circular learning process, as shown in Figure 1 for one dyad, named Ann and Donald. (The scale labeled Skill Level is based on hierarchical complexity level as specified in skill theory, which is strongly grounded in empirical research demarcating distinct developmental levels: Dawson, 2002; Dawson & Gabrielian, 2003, in press; Fischer, 1980; Fischer & Rose, 1994; <http://gseacademic.harvard.edu/~hcs/base/index.shtml>). They began with primitive, confused activities with one of the robots

and gradually built up some understanding of the gadget over a few minutes of exploration, as shown in the Start panel. Soon, however, they encountered a change in the situation – a wire falling out and being put back inadvertently in a different place. Their “skill” collapsed, falling down again to a primitive, confused level, and then gradually they built it up again over a few minutes, as shown in the panel Redo Gadget. Next, someone walked up and asked them to explain what they had done: Their explanation again collapsed immediately to a very low level, as shown in the panel Explain, and then relatively quickly they built up a more complex explanation. Finally, in the fourth panel Redo, they purposely removed a wire and put it back in a different place, and once again their skill fell down to a low level, and they gradually built it up until the session ended.

Insert Figure 1 about here.

This example shows the dynamics of a circular reaction. Not only did the adults spontaneously stay with the task and repeatedly work with understanding and controlling the robot, even though they were free to do other activities at any time. They also evidenced a recurring process of short-term learning and collapse of skill, thus showing a kind of repetition or circularity similar to the infant trying over and over to make a mobile jiggle and occasionally succeeding. The activity and skill are more complex than the infant’s, and consequently the circularity is less obvious to an observer; but it is clearly present. We hypothesize that older children and adults regularly show circular reactions of this kind in their daily learning and problem-solving.

Even Charles Darwin demonstrated complex circular reactions as he struggled to understand variations in species and fossils. His notebooks clearly demonstrate both short-term circular reactions, such as trying to understand a particular species, fossil, or formation (a kind of finch, a dinosaur bone, a coral reef) and longer-term ones, such as groping with the

nature of evolution (Fischer & Yan, 2002; Gruber, 1981; Keegan, 1989). Indeed, his notebooks show that he worked for years to understand the nature of species variation and evolution, building a series of different explanatory principles, several of which were abandoned while others were maintained and revised. Eventually, he constructed the successful principle of evolution by natural selection, which emerged from his earlier principles and also required repeated reconstruction. He “discovered” it several times and then lost it, similar to the way that Ann and Donald lost their understanding of the Lego robot several times. Eventually in 1838 and 1839 he consolidated the principle into a skill that he could consistently formulate, generalize, and use to explain many of his observations.

In general, circular reactions in both infants and adults depend on at least three components: (1) a process that spontaneously *generates* behaviors, (2) a mechanism for *detecting and appraising* interesting response-contingent configurations of the world (some set of criteria for what constitutes an interesting event), and (3) an intrinsic motivation to attend to and try to repeat an interesting behavior once it has been observed. (4) In older children and adults, a fourth component is required – a mechanism for appraising whether something is interesting based on the person’s long-term goals and knowledge. For example, Darwin appraised observations and ideas in terms of his goal of explaining the variations of species and his extensive knowledge of biology and geology.

Taken together, these last three components constitute what we call *epistemic motivation* – the intrinsic human ability to identify interesting events and the motivation to attend to them and to try to make them repeat. These components are essential to fundamental emotional/motivational processes in development and learning and provide clues about the nature of the motivational processes underlying regulation of behavior and learning.

Model for Epistemic Motivation

Emotion and motivation organize a feedback process that controls immediate behavior and shapes learning and development (Bickhard, this volume; Fischer et al., 1990; Frijda, 1986; Heckhausen & Schulz, 1995; Higgins, Roney, Crowe, & Hymes, 1994; Lazarus, 1991; Scherer, 1984). This process of behavior regulation forms the core of the models of epistemic motivation and self-organizing motivation. Figure 2 shows the general model as applied to epistemic motivation: A person acting in a specific context notices something important based on his or her concerns and goals (notable change) and appraises that change. Based on the appraisal, s/he selects (unconsciously) a pattern of behavior (action tendency), which is a script, not merely a single action. For example, the script for anger includes a focus on the problematic situation, a bias toward attributing blame, a pattern of facial expression and posture, and a tendency to act aggressively. In epistemic motivation, the appraisal is that the change is interesting, and the action tendency is to attempt to repeat the event or activity. The action tendency thus leads to circular reactions.

As infants grow, they develop the capacity to monitor their action tendency and often adjust them before they carry out an overt act, as shown in the bottom of the figure (monitoring of action tendency). For example, a child can become anxious in reaction to feeling angry at Mom. For epistemic motivation, if a notable change is interesting but socially inappropriate, such as bumping into someone on the sidewalk, most people will not try to recreate it (except in slapstick comedies).

Mathematical models of neural networks capture an essential part of this model: In a context a person processes input through the nervous system and acts, and the results of the action feed back to alter the values of elements in the neural network (Elman, Bates, Johnson, Karmiloff-Smith, Parisi, & Plunkett, 1996; Grossberg, 1987). This feedback shapes the neural

network and thereby influences future action tendencies, which is key to learning and development. The network component of the model is represented in Figure 2 by the multi-node diagram under Appraisal. We will describe the properties of neural networks below.

This model represents the type of feedback mechanism that we hypothesize to be common to both types of motivation, epistemic and self-organizing. Dealing with the full range of motivational phenomena requires an elaboration of the circuit, explicitly differentiating two kinds of knowledge stored in neural networks. On the one hand, people have knowledge about *how the world is*, which involves primarily epistemic motivation. On the other hand, they have knowledge about *how I and other people generally act or should act* in the world, which relates centrally to self- (and other-) organizing motivation.

Insert Figure 2 about here.

The basic idea of the motivational model is that a person senses and appraises the world around her, and the appraisal informs possible actions. For example, jumping is not an option when crawling on hands and knees through a narrow tunnel. This context also provides information about the relative value of selecting any given action, which (in this model) translates into a probability of selecting that action given the current state of the world: The probability of jumping while crawling in a tunnel (or while standing in a room with a very low ceiling) is small since jumping will likely crack your skull. Because people sometimes forget themselves or miscalculate, the conditional probability of selecting such an action will typically still be nonzero. Conditional probabilities form an action tendency repertoire, such as a probability of jumping of .01, waving .21, kicking .23, doing nothing .35, etc.

From this repertoire of possible actions, one action is selected based on the conditional probabilities, which are determined by personal history, motivational state, context, and appraisal. Between the time a person selects an action and the time s/he executes it, s/he

generates internal expectations about what should happen when the action is carried out – some effect on the state of the world, which will be experienced via the senses. The *notable change* arises from a comparison of the *expected* outcome with the *experienced* outcome resulting from the action. If the actual effects match expected effects, then there is no notable change, representations about the world do not change, and no surprise, interest, or other behavior-organizing affective states are induced. If, on the other hand, the expectations do not match the experience, then this difference serves as a feedback signal to drive learning, moving the expectations closer to the current experience.

For older children and adults, another component must be added to the model to expand epistemic motivation beyond the immediate interest of an event to include its relation to a person's long-term goals and knowledge. Emotion theorists often place these long-term representations in the same box with all the appraisals of the proximate aspects of the event. We suspect that a realistic model of motivational/emotional processes requires separate loops for short-term appraisal of current experience and long-term appraisal of expected outcomes and implications (represented in Figure 6 later in this article). Many of the circular reactions of older children and adults depend on the interest sparked by long-term appraisal. Being caught in a circular computer game is mediated mainly by the short-term appraisal loop, but being caught in a search to explain an anomaly in a computer program or a pattern of variation in species is mediated mainly by the long-term loop. We will elaborate properties of this loop in the discussion of self-organizing motivation, which depends more obviously on the long-term loop than epistemic motivation.

Over time, the process of epistemic motivation outlined in Figure 2 refines knowledge and skill to make them more accurate and more adaptive. In simulated neural networks,

mechanisms of this kind have produced effective adaptive learning, without need for any kind of explicit teacher (Elman et al., 1996; Grossberg, 1987; Tesauro, 1995).

Neural Networks

Artificial neural network models are computer simulations of neural processes based on data from neurobiology and neurochemistry. They are powerful tools for exploring how constraints and processes at the neural level might percolate up to constrain and shape mental/psychological and behavioral phenomena (Elman et al., 1996; Grossberg, 1987; Quartz & Sejnowski, 1998). They avoid many of the flaws of classical cognitive science, which are based on the assumption of a language of thought, an encoding or copying of the world in the brain or mind (Bickhard & Terveen, 1995; Bickhard, this volume; Fischer & Bidell, 1998; Piaget, 1967/1971). Instead of a language of thought, cognition is based in action, and it can be illuminated by analysis of the neural bases of learning and action. In this paper, we use artificial neural networks as a source of concepts and constraints for analyzing the mechanisms that underlie motivation and for scaffolding interpretations of the concrete scenarios that exemplify each type of motivation – circular reactions and self-organizing bias. The neuroscientific foundations of the networks complement the cognitive and behavioral foundations of most research on motivation and development.

Virtually all of the many different types of artificial neural network models share two assumptions: (1) the neuron doctrine – the neuron is the atomic processing unit in biological neural systems, and (2) the network doctrine – that learning processes act upon synapses that connect neurons to one another, thereby producing the changes in neural circuitry for memory formation, skill acquisition or refinement, and other alterations in mental processing or overt behavior. Every neural network model works with the properties of three components: nodes (simulated neurons), connections (type and strength), and learning rules that specify how

synaptic properties change under what conditions (typically from some kind of experience).

Figure 3 diagrams these elements for a generic neural network model.

Insert Figure 3 about here.

The construction of these models is informed and constrained by principles of neuroscience, so that they are grounded in a way that purely cognitive or behavioral models are not. The use of neural network models to analyze motivation has been rare, and we hope to catalyze work on modeling motivation through this analysis. Neural network models can suggest novel hypotheses and provide data on the feasibility of a hypothesis concerning the mechanism(s) underlying, for example, development of epistemic motivation and self-organizing motivation. They have proved extremely fruitful in analyzing other change phenomena, such as habituation, learning, and cognitive and language development (Elman et al., 1996; Grossberg, 1987; Mareschal & Johnson, 2002).

Indeed, neural networks have properties that seem to have direct analogues in human motivation. First, they show something akin to circular reactions. To adapt, learn, or develop, they act, adjust, and act again – over and over and over, just like people caught in a circular reaction, as indicated by the bottom arrow in Figure 3. This property is central to what is called “self-organization” in neural networks and other dynamic systems (Thelen & Smith, 1994; van Geert, 1991): Through processing biases and bootstrapping mechanisms, they sustain persistent patterns, and over time different kinds of patterns often emerge as a function of experience. In a similar way the human being (with central contributions from the brain, of course) produces persistent and changing patterns of activity over time and experience. We propose that motivational processes, such as both epistemic and self-organizing motivation, specify key biases and organizing principles that create these properties and that are similar in neural networks.

Second, neural networks provide mechanisms for coordination of information across diverse contents, such as vision and movement (Bullock & Grossberg, 1988; Mareschal & Johnson, 2002) or emotion and cognition. An essential question for understanding human action and thought is how affect and behavior organize each other. Neural network models are a valuable tool that facilitates understanding how affective information (such as positive and negative evaluations of events and activities) shapes learning and knowledge. The circular reactions of epistemic motivation are one example of how motivation and emotion can drive and shape learning.

Appraisal and Emotion

Feedback to modify the value of taking a particular action can take several forms. At one extreme, information can have a relatively innate, automatic effect, such as touching a hot stove and experiencing painful burning, which will sharply change the probabilities of action tendencies. For most of human experience, including epistemic and self-organizing motivation, the notable change derives from the comparison of expectation with experience, and it is proportional to the discrepancy between expectation and experience (Hebb, 1949; Heckhausen & Schulz, 1995; Kagan, 1970; McCall, Kennedy, & Appelbaum, 1977). Epistemic motivation functions not only in human beings but in many animals (Hebb & Thompson, 1968), which show responses to moderate novelty such as interest and exploration. The ultimate result of epistemic motivation then is an increase in the probability of an action tendency that has produced an interesting outcome.

These examples highlight the role of emotion in the model in Figure 2. The experience of a notable change or discrepancy between expectation and experience leads to an affective appraisal of the significance of the change for the person (Fischer et al., 1990; Lazarus, 1991): Is it good for me or bad for me (evaluation)? How can I cope with it (coping potential)? One

example is an appraisal that something is interesting, as in epistemic motivation. Another is that it is dangerous, as with the hot stove. The appraisal creates a signal that focuses and organizes attention and behavior in a particular pattern – for epistemic motivation, interest in and exploration of the activities and events leading up to the interesting effect.

This kind of learning based on feedback of an evaluation (reinforcement/ punishment) signal has been shown to be surprisingly powerful in artificial neural network models learning to do complex but useful tasks. For example, neural network programs have learned to play backgammon at the level of a master based only on the program's experience playing the game against itself (with two players both operated by the computer program). The only feedback was a simple evaluation signal – winning or losing the game (Tesauro, 1995).

Some commercial products have integrated motivation and neural networks into their programs to create more complex, human-like agents. For example, computer games such as The Sims simulate characters that have personalities and act independently, seemingly showing “free will”. The program even allows the human player to turn free will on or off for Sims characters. Each character has a set of motivational characteristics (like weight patterns in a neural network) that interact with properties of objects (also like patterns of weights) to produce goal-directed activities and learning. In this way, characters start with motivational patterns or “personalities”, and objects start with what J. J. Gibson (1979) called “affordances”. Each character's appraisals of particular experiences affect the neural networks, so that the character's actions change based on its interactions with particular objects and other characters. We know of no efforts yet to program game characters to have epistemic motivation, although some robots have been programmed with partial epistemic motivation, trying to learn how to function in their particular environments – for example, how to move

around effectively in a laboratory, office, or home (Fischer, Yan, McGonigle, & Warnett, 2000; McGonigle, 2001; Nehmzow & McGonigle, 1994).

In epistemic motivation, the process in Figure 2 eventually leads to change in the person's representations and skills and gradual decay of the orienting and perseveration of the circular reaction as he or she successfully assimilates the new information. As the person gains more experience with the contingency between his or her actions and their outcomes, expectations are refined so that eventually s/he expects that when s/he kicks a leg (for example) in a certain manner, the mobile will swing and chime. Since expectation is aligned with experience at this point, the affective reaction diminishes right along with the "error" or mismatch signal. As mastery is achieved, the person loses interest in the task and moves on to some other activity. This kind of model strikes us as a plausible, straightforward, and elegant mechanism that the neural system can use to optimize learning – one that explains the emergence, maintenance, and extinction of circular reactions.

Epistemic motivation serves to modify attention and behavior to exploit surprising events and thus extract interesting information about the world. The feedback signal of notable change is adaptive for learning and development because unexpected activities and events produce a mismatch between the state of activities in the world and the person's representation of those events and activities in the nervous system. The feedback from that mismatch leads to repetition of the activity until the person's representation approximates the results of the activity. The function of this kind of motivational mechanism is to improve *knowledge and skill* (understanding how the world works).

Self-Organizing Motivation: Positive Self-attribution Bias

A second powerful pattern of behavior captures the essence of self-organizing motivation, just as circular reactions capture the essence of epistemic motivation. When a

person detects a notable change, s/he immediately appraises it as good or bad for the self (to be approached or avoided) – a part of the motivation process in Figure 2 (Fischer et al., 1990; Frijda, 1986; Higgins et al., 1994; Lazarus, 1991). Generally, people are biased toward the positive, seeking events and activities that are good for the self and avoiding those that are bad. This positive bias goes far beyond immediate reactions, however, pervading the ways that people represent themselves and others. Self-organizing motivation involves constant appraisal of ongoing activity in terms of its significance for representing oneself and important others, especially evaluating positive and negative aspects of self and others. In essence, self-organizing motivation creates a bias toward enduring appraisal of oneself in positive terms, although the process does also lead to negative biases, both transient and enduring.

People are typically biased to promote or positively represent themselves, including their family and ethnic or religious group, taking personal responsibility for what is good and valued in their lives. Early attachments to caregivers provide a basis for this positive bias in representation of the self as lovable, good, and secure (Ainsworth, Blehar, Waters, & Wall, 1978; Ayoub, Fischer, & O'Connor, 2003; Bowlby, 1969). In contrast, people are biased to see others as responsible for what is bad, mean, or to be avoided and to project negative attributions onto outgroups. This prejudice develops early in infancy, when toddlers in their first pretend play typically show what is called “affective splitting”, representing themselves as good and nice and other people as bad and mean (Fischer & Ayoub, 1994). Harry Stack Sullivan (1953) and Daniel Stern (Stern, 1985) described early versions of this affective splitting in young infants, who seem to organize their world in terms of good and bad activities from the start – good breast, bad breast (won't give milk), good Mom, bad Mom (witch), good me, bad me. This self-organizing bias toward the positive and its complement – the other/outgroup-organizing bias toward the negative – are remarkably pervasive and powerful. Indeed, the

general pattern of bias is often called the fundamental attribution error or the totalitarian ego (Greenwald, 1980; Unger & Crawford, 1992).

Positive and Negative Biases in Representing Self-in-Relationships

Research with the Self-in-Relationships Interview illustrates the self-organizing bias in representations of self and others by children, adolescents, and adults (Fischer, Ayoub, Noam, Singh, Maraganore, & Raya, 1997; Fischer, Wang, Kennedy, & Cheng, 1998; Harter & Monsour, 1992). For example, in a study in Suzhou, China, a 17-year-old girl named Jin described herself in her important relationships (with mother, father, best friend, teachers, etc.), listing several characteristics for each relationship (Wang, 1997). Then she created the diagram in Figure 4a, organizing the characteristics with the most important in the center of the concentric rectangles and the least important in the outer rectangle. She grouped the characteristics that she saw as belonging together by drawing a line around them, and she indicated important relations between characteristics or groups by drawing a line between them. The relations were designated as showing similarity, opposition, or conflict, as shown in Figure 4a by numbers, letters, and arrow heads, respectively. Most children and teenagers produced sophisticated, complex self-descriptions analogous to Jin's. Children and teenagers in the U.S., South Korea, Taiwan, and China all showed the same sophistication, despite claims in the literature that Asian adolescents do not show sophisticated self-descriptions (Kitayama, Markus, & Matsumoto, 1995).

Insert Figures 4a and 4b about here.

The diagrams show dramatically the self-organizing evaluative bias, as illustrated in Figure 4b. The person rated each of his or her self-descriptions as positive (+), negative (-), or neither/ambivalent (+/-). Consistently across studies using this interview, people indicate that most of their characteristics are positive, and the relatively few negative responses are mostly

marginalized as not important. Figure 4b highlights this pattern by stripping away everything from the diagram except the pluses and minuses. Jin created 18 positive descriptions, 5 negative, and 1 neither/ambivalent, and she made the central rectangle (most important) overwhelmingly positive, with negatives relegated to the less important and least important rectangles. Younger children usually show an even stronger positive bias, leaving out all negative characteristics unless they are specifically asked to include them and hardly ever placing any negative or ambivalent characteristics in the central rectangle as most important. Older children and adults often place one or a few ambivalent or negative characteristics in the center as most important, while at the same time placing mostly positive characteristics there, maintaining a general positive bias in importance.

In many situations the self-organizing bias fits this strongly positive pattern, but different meanings and contexts can change the bias dramatically. For example, in pretend play many 2- and 3-year-children prefer and enjoy taking the role of a mean, aggressive character, who often has more power and controls the action in a story or game. They also tend to understand these vivid negative roles (being mean) better than positive roles (being nice) (Fischer & Ayoub, 1994; Fischer et al., 1997; Hand, 1982; Hencke, 1996). These young children seem to trade power and vividness for goodness. Even for adults, negative events and creatures can be vivid and attractive: Satan in Milton's Paradise Lost or Darth Vader in Star Wars is more vivid and perhaps more interesting than God or Obi-Wan Kenobe.

People can sometimes switch between positive and negative states. Sullivan (1953) describes babies as organizing all their current experience around either a positive or negative state, whichever they were experiencing at the moment. Harter (Harter, 1982) describes young children as feeling "all good" or "all smart" at one moment and "all bad" or "all dumb" at another. In a pattern called hidden family violence, children and parents act as victims and

tyrants in their abusive homes but as “perfect” good students and citizens in their public personas (Fischer & Ayoub, 1994). In dissociative identity disorder (multiple personality), people seem to organize each identity (personality) around a predominant emotional state, usually with a one-sided valence of mostly negative or positive; different identities are organized around different emotional states (Bower, 1981; Fischer & Ayoub, 1994; Osgood, Jeans, Luria, & Smith, 1976). However, in pretend play and in most other situations, children generally stop choosing negative roles for self by 4 or 5 years of age, although they still flock to stories about evil characters (usually vanquished eventually by good characters). As the model of self-organizing motivation is developed, it will need to predict these sorts of variations in choices about positive and negative self and other.

The vast majority of children show a positive self-organizing bias similar to that of 17-year-old Jin in Figure 4, and this pattern seems to hold even in cultures that emphasize modesty, such as China, Taiwan, and Korea (Fischer et al., 1998). However, there is one circumstance that leads to a striking reversal of the bias – extreme child abuse, especially sexual abuse (Calverley, 1995; Fischer & Ayoub, 1994; Raya, 1996; Westen, 1994). In one study, for instance, adolescents who had been severely abused showed a dramatic reversal of the pattern in Figure 4b (Calverley, Fischer, & Ayoub, 1994; Fischer et al., 1997): They produced predominantly negative characteristics and placed them in the central core of the self-in-relationships diagram, as shown in Figures 5a and 5b for Alison. In this study, the effect of abuse was to shift the affective organization to a negativity bias, while maintaining the same level of developmental complexity as other girls of the same age. (Note: Some studies using the Self in Relationships Interview have used circular diagrams, as in Figures 5a and 5b, and others have used rectangles, as in Figures 4a and 4b.)

Insert Figures 5a and 5b about here.

Allison was a 17-year-old American girl who had been sexually and physically abused repeatedly by her father and several other men starting at the age of 4. She saw herself as empty, sad, used, unlovable, bad, different, lonely, desperate, and scared, all of which she categorized as very important characteristics. In general, she described herself in preponderantly negative terms, with 20 negative categorizations, only 4 positive ones, and no neither/ambivalent ones. What a sad, woeful representation of self! The only ray of hope in Figure 5 is that Allison sees her positive characteristics as important (all with her friends, none with her parents or the real me). Like Allison, many of the sexually abused adolescent girls in this study categorized placed their negative self-descriptions as most important, but unlike her many did not see their positive characteristics as important, relegating most or all of them to the less important and least important circles. This negative affective bias seems to stem from the experience of extreme abuse, especially the kind of personal violation that comes with sexual abuse (Waller, Putnam, & Carlson, 1996; Waller & Ross, 1997; Westen, 1994). Self-organizing motivation may be biased toward positive self-attributions in most people, but in extreme cases it can be reset to a predominantly negative bias.

Model of Self-Organizing Motivation

A model of self-organizing motivation must explain the normative positive bias that pervades not only self-in-relationships but also many other self-evaluations, but the consistency of the positive bias makes it obvious and easy to model. The more interesting and challenging scientific task is explaining the variations in affective bias – the shift to a negative bias with abuse, the affective splitting and other variations in positive and negative bias across situations in abused and non-abused children, and the common attribution of negative characteristics to people different from the self, especially people from outgroups.

Self-organizing motivation involves an evaluative bias toward a positive or negative valence of representation of self and others. Such a bias generally fits with the centrality of evaluation in the appraisal process that forms the core of the model for motivation and emotion in Figure 2. As children develop, they move beyond that simple model to include an additional loop (at least one) that appraises how the event or activity relates to long-term goals and knowledge, shown in Figure 6. The second loop is important for advanced forms of epistemic motivation, such as Darwin's search for a principle to explain evolution, and it is essential for self-organizing motivation. The baby's initial division of experience and action into good versus bad develops by the end of the second year to include representations of self and others as independent agents. By 2 or 3 years of age, most children constantly appraise events not only in terms of evaluation for proximate aspects but also in terms of long-term relevance to these representations of self and others.

The general model of self-organizing motivation in Figure 6 specifies how this more complex process occurs. The person detects a notable change, as in emotion processes in general (Figure 2) and quickly appraises this change in terms of both short-term implications of current experience and long-term implications of the expected outcome over time. These two appraisals are coordinated to produce an action tendency that combines short-term and long-term appraisals. Consider a new college student attending the beginning of her freshman year at a highly competitive college, such as Harvard, Cambridge, or Oxford University. Attending the first meeting of her physics class, she appraises the immediate situation – I understand what the instructor says, I am treated respectfully – resulting in a short-term appraisal that all goes well. At the same time, she appraises the situation in terms of long-term expectations – everybody here is so smart, which is different from my old school; there I worked hard in school and did not always understand the material, especially physics – resulting in a long-

term appraisal that maybe people are going to discover that I am not really so smart. The co-existence of the two kinds of appraisals leads to complexly motivated actions. Perhaps she says as little as possible to avoid disturbing the immediately positive situation and being found out as not really smart. Perhaps she assertively criticizes another student's mistaken answer to a question to show how smart she is.

In the self-in-relationships studies, Jin's long-term representation of herself as honored, respected, contented, and lovable (Figure 4a) biases her toward positive emotions in many situations and toward action tendencies based in her confidence and security. Researchers on attachment describe this pattern as a secure internal working model for attachment that provides a strong basis for effective action in the world (Ainsworth et al., 1978; Ayoub et al., 2003; Bowlby, 1969). Across diverse situations, Jin carries with her this positive self-representation as a core component of her long-term appraisal process, resulting in action tendencies of approach and exploration: She often acts confidently to learn in school, to interact happily with friends, and to share her inner feelings with her mother and best friend. Her immediate appraisal of a situation as safe and supportive typically fits with her long-term appraisal of herself as honored and lovable.

In some situations, of course, she experiences negative long-term appraisals, knowing that she has sometimes acted shamefully and lost face with a teacher or felt tense and awkward in school. Situations that evoke these long-term representations lead to action tendencies of avoidance, escape, or anger: She spends little time with the teacher with whom she lost face, stays away from the classmates with whom she feels tense, and minimizes her interactions with these people whenever possible. On the other hand, in the tradition of restitution that is prominent in Chinese culture, she may seek out the teacher to restore a

respectful relationship by undoing her shame and restoring her face (Mascolo, Fischer, & Li, 2003).

Self-organizing motivation works differently for Alison (Figure 5a). Her long-term representation of herself as unlovable, bad, empty, sad, used, lonely, scared, insecure, dirty, and a failure all lead her to expect the worst. Her short-term appraisal of her interactions with a teacher can indicate that the situation is safe and positive, but her long-term representations lead to appraisal that in the long term the teacher will dislike her and take advantage of her – the way adults generally do, according to her working model of relationships (Ayoub et al., 2003). Her action tendency to trust a teacher based on short-term appraisal mixes with her action tendency to expect dislike and abuse based on long-term appraisal, and the result is ambivalence or hostility.

Self-organizing motivation thus coordinates short-term appraisal of the immediate situation with long-term appraisal based on representations of self and others. Positive and negative evaluation form the primary dimension of both kinds of appraisal. Processes that combine the two kinds of appraisal lead to the varied array of motivational-emotional patterns of action that we have described. As scientists, we face the challenge of building models that can capture and explain these remarkable variations in human behavior.

Conclusion: The Roles of Motivation in Development

The two types of motivation – epistemic and self-organizing – as well as the phenomena that illustrate them (circular reactions and positive attribution bias) involve common mechanisms while simultaneously differing in the ways that they shape behavior. Both involve appraisal that coordinates experience with expectation, and both use the discrepancy as an information signal that shapes action, learning, and long-term development. Both depend on a process of extraction of regularities from experience that is modeled

effectively by artificial neural networks. From a developmental perspective, the two mechanisms of motivation *coordinate* cognitive and affective facets of experience (action, attention, knowledge, social relationships, environmental affordances) into hierarchically organized adaptive activities, representations, and strategies, working together to shape activity and development.

Epistemic and self-organizing motivation differ in the systems being coordinated, especially the dimension of expectation appraised – novelty and interest in the first case and relevance to self-representation in the second. In epistemic motivation and circular reactions, the motivation is to repeat interesting phenomena and gain control of them, which drives the process of knowledge acquisition. In self-organizing motivation and self-attribution bias, the motivation is to match and sustain long-term values and representations of self, usually as positive.

An important component of the process for both types of motivation is short-term appraisal of proximate aspects of an event or activity in contrast to long-term appraisal of implications of an event for broad goals and representations. Epistemic motivation in infancy and early childhood depends primarily on short-term appraisal of proximate aspects (at time scales of seconds), but with development it comes to be driven also by long-term appraisal, such as career or family goals (at times scales of days and months). Self-organizing motivation emerges with the capacity to represent self and others, although it has an early sensorimotor precursor in the affective organization of behavior in terms of positive and negative evaluation (good for me versus bad for me). The dimension of affective evaluation remains central at all times, usually with a positive bias involving self; but some circumstances evoke negative biases. Extreme sexual abuse in childhood seems to shift the general self-organizing bias from positive to negative.

In general, epistemic motivation begins with discrepancies between experience and expectation that drive changes to representations about the nature of the world, exploiting surprising events to extract interesting information about the world. Its function is to improve knowledge, to create more effective representations of how one can act effectively in the world. On the other hand, self-organizing motivation begins with discrepancies that appraise the match between experience and evaluative representations of self and others. With experience and development these representations become relatively stable, reflecting the expected evaluations of different courses of action in terms of characteristics of oneself and other people. Its function seems to be to predict and stabilize how the person will interact with the world, especially other people. The normative pattern centers on a positive bias for self and attribution of negative characteristics as less important or as belonging to other people. These two kinds of motivational systems pervade human activity, where they work together to shape long-term development. We have presented a framework that researchers can use to begin to articulate the two systems and specify how they shape development and how they contribute to the wide variations among human beings in knowledge of the world and evaluation of self and others (Fischer & Bidell, 1998; Heckhausen, this volume; Mascolo et al., 2003).

List of Figures

Figure 1. A Circular Reaction in an Adult Dyad Exploring a Lego Robot

Data from Granott (1994, 2002)

Figure 2. Model of Motivational System

Caption. This general model of motivational/emotional feedback applies to a wide range of actions and contexts, including the circular reactions of epistemic motivation, as shown in the italicized examples. (Reference: Fischer, Shaver, & Carnochan, 1990)

Key: Notable Change: Something happens that the person notices. Appraisal: Person evaluates the notable change with respect to its valence (positive or negative) and coping potential for the self. For epistemic motivation, it is evaluated as interesting. Action Tendency: Person has various probabilities for specific actions, such as for a baby kicking, hitting with hands, or lying still. Monitoring: Person can notice their own activity and appraise it, which becomes common later in development.

Figure 3. Generic Artificial Neural Network Model

Caption. Nine nodes (circles) are organized in three layers (input, hidden, output) and connected from left to right. Lines between nodes indicate connections, each with a specific synaptic weight (connection strength.) The network changes its activity patterns as a result of learning rules that systemically modify synaptic weights based on experience. The network repeats its activity, as in a circular reaction, in order to learn appropriate activity patterns.

Figure 4a. Diagram of Self-in-Relationships by 17-Year-Old Jin

Figure 4b. Positive Bias in Jin's Self-in-Relationships Diagram

Figure 5a. Diagram of Self-in-Relationships by 17-Year-Old Alison, Who Had Been Severely Abused.

Figure 5b. Negative Bias in Alison's Self-in-Relationships Diagram

Figure 6. Model of Self-Organizing Motivation

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