Metacognition

Chris Mathe, PhD

Introduction

For those who are reading this with some trepidation about what sounds like a technical and difficult subject, please relax. I have found that metacognition is a 50 cent word for something all of us do every day to one extent or another. Consider how you might have gone about preparing and writing at article or essay for school. You might have considered how simple or difficult your subject was going to be to learn. You probably considered many different strategies to learn the topic how much study-time was needed. As you progressed, you probably gained more confidence in your abilities to recall accurately the new material you were studying. All of these activities would be considered aspects of metacognition. Very simply put, metacognition is thinking about thinking.

While the concept is very simple, the subject is rich in theory, research, and philosophy. Being a broad, general area of psychological inquiry, metacognition has been defined in many different ways by many different people over the last two decades. Consider just a small sample of these definitions:

- “Knowledge and cognition about cognitive phenomenon” (Flavell, 1979).
- “A process by which one jumps out of the system to observe the system” (Hofstadter, 1980).
- “An active, reflective process that is explicitly and exclusively directed at one’s own cognitive activity. It involves the self-monitoring, self-evaluating, and self-regulating of ongoing tasks” (Kluwe, 1982, as cited in Berardi-Coletta et al., 1995)
- “Knowledge and control one has over one’s thinking and learning” (Swanson, 1990).
- “Cognition about one’s own cognitions” (Nelson, 1992).
- “A part of self-consciousness that deals with knowledge of one’s mental states… and includes an ongoing perception of one’s inner reality” (Nelson, 1992).
- “The ability to monitor, control, and organize mental activity” (Shimamura, 1996).

- "[Metacognition]… refers to monitoring and management of one's thinking, including making plans before a thinking episode, regulating during the episode, and reflecting back afterwards to revise and plan future practices. Metacognition reorganizes thinking by providing on-line monitoring and redirection" (Perkins & Grotzer, 1997).
- "Cognitive operations on cognitive products" (Sheppard & Teasdale, 2000).
- "What we know about what we know" (Simon & Bjork, 2001).

In addition to the simple definition of "thinking about thinking," several other explicit and implicit themes run though most of these definitions of metacognition: Monitoring, self-consciousness, and awareness all assume processes consciously available for observation. Organizing, controlling, managing, and planning imply a dynamic modeling of one's inner and outer experiences to devise and implement action strategies. With these ideas in mind, let's examine some basic concept.

Basic Concepts

Metacognition is related to self-awareness and consciousness and these three terms are used somewhat interchangeably in the literature. Referring to consciousness, Dennett (1978) explained, "That of which I am conscious is that to which I have ***access***, or (to put the emphasis where it belongs), that to which ***I*** have access." Self-awareness, according to Nelson (1992), refers to knowledge about one's physical and mental states, and therefore includes an ongoing perception of one's inner reality. Consciousness, then, refers to access to knowledge, and self-awareness refers to access to knowledge about one's self. Metacognition, according to the definitions above, would subsume these definitions, but also include modeling, controlling, and organizing aspects.

Metacognitive models have developed, in part, as a reaction to the sub-personal theories that show cognition as an organization of subsystems whose interactions somehow explain the behavior of the whole person. The problem with these models, according to Dennett (1978), is that there is no structure or mechanism proposed to direct cognitive processes – there's no one in charge. In attempting to further develop the "box and flow" models of the cognitive folks into a model that included consideration of the monitoring and control aspects of metacognition, Dennett (1978), suggested adding a Control component (another box) that joined and mediated the functions of perception, memory, and resulting actions (physical or mental).

We might compare metacognition to an on-line executive that can observe, check, and alter problem-solving strategies before, during, and after cognitive tasks. It is more than knowledge about one's self (self-awareness) as a problem solver. It is also more than knowledge about problem-solving strategies and tactics which represent metacognitive knowledge but *not* metacognitive processing (Berardi-Coletta et al., 1995). Information acquired through metacognitive processing would be, according to Flavell (1979), knowledge about oneself, the task (problem-domain knowledge), and the strategy (procedural knowledge).

With this groundwork laid, we move on to the most influential theoretician and researcher in the field of metacognition, Thomas O. Nelson.

Nelson's Metacognitive Model

Nelson has been at the forefront of metacognitive theory and research for many years. His Metacognitive Model, updated and modified over the last several years, has provided a structure for him and many others to debate, test, and expand upon. His model, in general, is a conceptual explanation of how humans are able to deal with everyday objects and actions (the "Object-Level") and also think about and control those objects and actions in a self-reflective way (the "Meta-Level").

Nelson and Narens (1990) postulated three principles of metacognition

1. Cognition is split up into two or more interrelated levels. Nelson and Narens worked with two levels: the object-level and the meta-level but saw no reason why other levels of abstraction could not also be present.
2. The meta-level contains a dynamic model of the object-level.
3. The flow of information between the two levels can be characterized by the words "control" and "monitoring", depending on the direction of information flow.

Figure 1 illustrates Nelson's Metacognition Model. It postulates that humans think in at least two levels of abstraction. The Meta-Level watches and adjusts our actions based on various inputs, including its own model of the Object-Level.

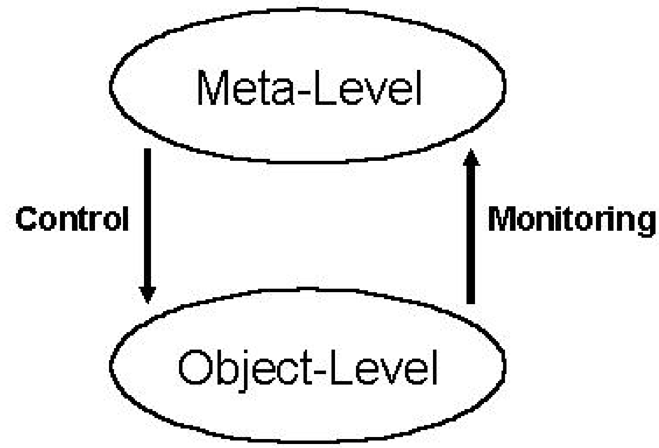

Figure 1. Metacognitive Model
Adapted from Nelson and Narens (1990)

A model that has the human thinking processes both *do* the observing, and *be* the thing observed, might have drawn significant criticism from 19th century methodologists. This paradox was described by Comte, "The thinker cannot divide himself into two. Of whom one reasons whilst the other observes him reason. The organ observed and the organ observing being, in this case, identical, how could such observation take place?" (cited in James, 1890, p. 188). Wilhelm Wundt reportedly talked about this same paradox as being like a baron who attempts to pull himself out of a bog by his own pigtail (Nelson, 1996).

Wundt proposed solving the paradox by concurrently and passively observing one's behavior while Titchener and James suggested that such introspection should occur after a self-observed activity takes place (Fancher, 1990). Nelson (1996) was not satisfied with either of these two approaches to resolving what he described as "Comte's Paradox." For help, Nelson turned to the work of Alfred Tarski that sought to resolve the entire category of self-referencing paradoxes.

A classic example of another self-referencing paradox is the sentence: "This statement is false." If the statement is false, then the statement is true. But, if the statement is true, then the statement is false… and round and round we go. Tarski (1985) approached paradoxes of self-reference in a new way. He used the idea of a *meta* concept. The basic idea behind the meta concept is that there is at least one level of abstraction above and separate from the object-level to which it refers.

Nelson (1996) offered an excellent example of resolving a self-referencing paradox by using Tarski's two level approach. Try to determine the validity of the following sentence:

THISS SENTENCE CONTAINS THREEE ERRORS.

At the most basic level, the "object-level," the sentence contains two errors – the spelling of "this" and "three" – and therefore could be evaluated as false. At the next level of abstraction, the sentence is in error by claiming there are three, rather than two, errors. So, at this meta-level, there are a total of three errors and the sentence could be evaluated as true. This is a good example of how a given sentence can be operating at two different levels at the same time. Tarski (1985) sought to resolve such paradoxes by distinguishing between different levels of abstraction. "At the lowest level, the object-level, there are only sentences about things other than sentences. At the next level up, the meta-level, there are only sentences about object-level sentences" (Nelson, 1996).

Nelson used a Tarski-like solution to create the Metacognitive Model. By using object- and meta-level distinctions, he is able to breakdown what Comte's Paradox sees as one process into at least two simultaneous processes. "At the object-level are cognitions concerning external objects. In theory, at the second meta-level would be cognitions concerning the first-level cognitions" (Nelson, 1996). According to Nelson, by understanding that any lower-level cognition can itself become the subject of a higher-level cognition and that these processes can occur simultaneously, the Metacognitive Model resolves Comte's Paradox.

That there can be several levels in addition to the simple two-level model presented here is easily shown. Right this second aren't you thinking about metacognition? Isn't the act of modeling metacognition an act of meta-meta-cognition? This potentially endless progression of higher and higher levels of abstraction led Newberg et al. (Newberg et al., 1997) to question Nelson's model. In their search for consciousness, they conjectured whether there might exist some ultimate meta-level. Such a level would be the final arbiter regarding all our thoughts, feelings, and behaviors. But, because of Godel's (Hofstadter, 1980) incompleteness theorem (a model can never fully describe that which it models), this ultimate meta-level would still be subject to Comte's

Paradox. Arguing against the hierarchical structure of the Metacognitive Model, they suggested that Dennett's (1993) more complex model of consciousness might be a way around having to consider an ultimate meta-level. Dennett's model uses multiple drafts of reality competing against each other in the brain in order to create a "primary pattern of consciousness" (Newberg et al., 1997).

These philosophical and rather esoteric arguments aside, the Metacognitive Model attempts to explain how humans might use many levels of thinking, each level modeling those lower down, to monitor and control cognitive processes. Whether there is an ultimate meta level probably will never be answered. As defined by Nelson (1997), the levels are relative and imperfect, and as such, not subject to Godel's theorem – models of lower levels are not expected to fully and perfectly describe "reality" or the "truth." The point is that one of the major functions of metacognition is to model one's own behavior and the inner and outer worlds within which it occurs.

Metacognitive Research

In an effort to categorize the prodigious research on various aspects of metacognition, Nelson created the conceptual diagram shown in Figure 2. Originally created to show metacognition in relation to memory activities, this diagram still provides an excellent take-off point for systematically examining the nuts and bolts of metacognition in general. The top of the diagram shows various monitoring activities while the bottom shows various control activities. The activities to the left presumably effect all the subsequent activities to their right (e.g. ease of learning judgments effect judgments of learning and feelings of knowing etc.). Similarly, the monitoring activities on the top presumably effect the control activities on the bottom (e.g. ease of learning judgments

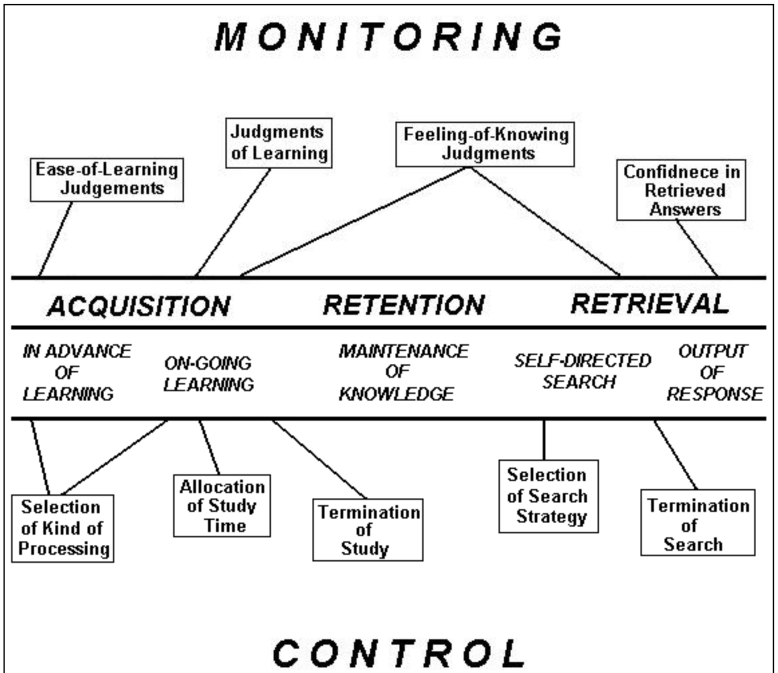

Figure 2. Metacognition and Fields of Research
Adapted from Nelson (1996)

effect selection of kind of processing). Therefore, the model predicts that if there are inaccuracies or other problems at a particular stage (moving left to right), the causes of the inaccuracies or problems will be discovered amidst the complex interactions of the monitoring and controlling tasks that came before it.

There have been hundreds of papers written on several of these activities and they effect each other, metacognition in general, learning, intelligence, development, and pathology. Below I review a small sample of the research.

Ease of Learning Judgments – These are predictions of how easy learning will be either in terms of which items will be easiest or in terms of which strategies will make learning easiest (EOL). Underwood (1966) and Nelson & Leonesio (1988), to name just two of many, generally found that EOL's were highly correlated with Allocation of Study Time in that subjects allocated more time to those items judged to be difficult. Much more will be discussed about this subject below. These judgments presumably form the basis of our strategies to learn as yet unlearned materials.

Judgments of Learning – These judgments (JOL's) are made during or at the end of learning and refer to the subject's estimates of his or her propensity to subsequently remember the studied items. Most of the research on judgments of learning have concentrated on verbal abilities and have demonstrated that, while such predictions are frequently less than accurate, sometimes very wrong, and often overconfident, JOL's generally have been shown to predict subsequent memory performance with above-chance accuracy (Arbuckle & Cuddy, 1969; Gardiner & Klee, 1976; Groninger, 1979; King et al., 1980; Lovelace, 1984). Simon and Bjork (2001) showed similar results with JOL's in relation to motor learning tasks. Some independent variables have no effect on learning but do have an effect on the accuracy of the metacognitive monitoring of that acquisition (Mazzoni & Nelson, 1995; Waver & Burns, 1990, as cited in Nelson, 1996). Nelson (1996) concludes that these findings help to constrain theories of metacognition and confirm the idea that metacognitive processing is in some sense separate than other aspects of cognitive processing.

Feeling of Knowing Judgments – One of the first metacognitive aspects to be evaluated was the feeling of knowing (FOK). These are predictions of subsequent memory performance on currently non-recallable items. While it has been long known that people often have feelings of knowing something they cannot recall and feel the answer is on the tip of their tongue, the accuracy of these feelings was not empirically assessed until the pioneering work by Hart (1965; 1967). He compared what people thought they knew (metacognitive monitoring) with what they actually knew (performance on a forced-choice test). He found that individual's FOK accuracy was greater than chance, but less than perfect. With this work, Hart laid the foundation subsequent work (Nelson et al., 1986; Nelson et al., 1984) that developed a meaningful measure of the degree of metacognitive monitoring accuracy and predictability. These studies suggested that people have partial, but imperfect privileged access to their own idiosyncratic knowledge when it comes to FOK judgments and that individuals' metacognitive judgments are more accurate than the normative recall probabilities for predicting their own memory performance.

Confidence in Retrieved Answers – This refers to how sure the person is that the answer that was retrieved is the correct answer. Koriat, Lichtenstein, & Fischoff (1980) found that asking subjects to explicitly list reasons for and against each possible answer (meta-level cognition) significantly improved the appropriateness of their subsequent confidence in their answers. The subjects who did not perform this analysis tended to have over-inflated confidence in their answers compared to their results. The implications of these results are that when metacognitive processes are engaged, more realistic predictions of performance takes place that could have a significant effect on subsequent strategies to improve or otherwise change performance.

Allocation of Study Time – How do people use metacognitive judgments to control their study-time allocation and hence to determine what it is that they will learn? Many different studies with different populations have indicated that, in general, people seem to devote more study time to the difficult items: Of the 46 studies conducted before 2000 on time allocation, 35 found that people study difficult items preferentially, and 11 studies were indeterminate (Son & Metcalfe, 2000). Recently however, a careful study by Son & Metcalfe (2000) found that people do not always allocate their study time to items that are judged as difficult; they sometimes devote their time to the items judged to be easy. Further, the study disconfirms the well-accepted discrepancy-reduction models (Dunlosky & Hertzog, 1998; Thiede & Dunlosky, 1999) which state that people will preferentially study what they find most difficult or most unlearned. Instead, they found that people seem to use the discrepancy-reduction mechanism only under particular specific conditions and that people use their meta-knowledge perhaps in a more strategic way than past research suggested. Time pressure seems to be a deciding factor in choosing which items to study: under high time pressure, people allocated more time to judged-easy items; under low time pressure, they devoted more time to judged-difficult items. Son and Metcalf also found that time allocation was influenced by learning goals: more time was allocated to judged-difficult items when they were studying for a test and more time was allocated to judged-easier items when free reading. Finally, the researchers found that people tended to allocate more time to and perform better on materials judged as interesting. Their results indicate that past theories about the way people allocate their study time are too simple and that people may use their metacognitions in a much more strategic and situation-sensitive manner than was previously known.

Developmental Issues

Robert Kegan (1994), in his book, *In Over Our Heads*, presents a model of cognitive development from infancy to adulthood that closely parallels the multiple levels of abstraction in the Metacognitive Model. Kegan describes a process whereby children at first think only in terms of the object level and gradually progress in their thinking to what he calls 3rd or 4th Order Consciousness (see Table 1 for detailed explanations of each level). Apropos of the Metacognitive Model, each of the successive levels of consciousness requires a higher level of abstraction and a meta-view of the preceding level.

Level of Consciousness	Description
1st Order of Consciousness: Independent Elements	Young children (2 – 6 years old). Characterized by attachment to immediate, momentary, and the atomistic making their thinking fantastic and illogical, their feelings impulsive and fluid, and their social relationships egocentric.

2nd Order of Consciousness: Durable Categories	Adolescence (ages 7 – 10). Develop the capacity to organized things, others, and the self as possessors of elements or properties enables their thinking to become concrete and logical, their feelings to be made up of time-enduring needs and dispositions rather than momentary impulses, and their social-relating to grant to themselves and ot others a separate mind and a distinct point of view.
3rd Order of Consciousness: Cross-Categorical Meaning Making	Teens to Adults. The capacity to subordinate durable categories to the interaction between them makes their thinking abstract, their feelings a matter of inner states and self-reflexive emotion ("self-confident," "guilty," "depressed"), and their social-relating capable of loyalty and devotion to a community of people or ideas larger than the self.
4th Order Consciousness: Multiple Roles Interrelatedness	Adult. Seeing self as the creator and manipulator of multiple roles in multiple systems makes their thinking flexible and expansive, their feelings as self generated and related to internal states, and their social-relating interdependent, flexible, and highly conscious.

Table 1. Kegan's Four Orders of Consciousness

The first order of consciousness is involved with thinking about objects as separate elements. The second level is about organizing those elements into categories. The third level is about relationships between categories. Finally, the fourth level is about organizing these relationships. Each successive level subsumes or encompasses the prior level. "That which was subject becomes object to the next level" (Kegan, 1994). In this way, Kegan's model is almost a complete restatement of the Metacognitive Model in developmental terms using four levels instead of two. Kegan's work is significant for parents and teachers in that he stresses the importance of evaluating accurately children's order of consciousness and creating "bridging strategies" to help them move to the next level. These bridging strategies are almost identical to the interventions studied by Swanson (1990), Perkins and Grotzer (1997), and Berardi-Coletta et al. (1995).

In an effort to determine whether subjects of relatively low aptitude can compensate their performance with high levels of metacognition, Swanson (1990), indeed found that, regardless of aptitude, higher metacognitive children performed better than the lower metacognitive children.

If higher metacognitive abilities can compensate for lower aptitude, people would benefit from improving their metacognitive capabilities. In as much as standard IQ scores might only measure aptitude, increased use of metacognitive skills might not even show up in resulting IQ scores. The usual estimates of intelligence are based on content (knowledge based) whereas focus on metacognitive skills (process/strategy based) can, according to Perkins and Grotzer (1997), significantly improve problem-solving capabilities. Their research involved using interventions to reorganize learners' thinking with metacognitive strategies, not just "practice-up" skills. While these interventions sometimes only modestly increased standard IQ scores, they argue that interventions designed to improve thinking processes and strategic thinking do, indeed, improve true intelligence in that they provide people with cognitive resources to think better across a range of contexts.

Berardi-Coletta et al. (1995) studied strategies that might help shift subjects from object-level problem solving to meta-level thinking. While subjects performed tasks, the researchers examined the differences in performance between subjects required to make simple "think-aloud" verbalizations and those required to make "state-your-reasons" verbalizations. In asking subjects for explanations of their thinking and solution process while doing tasks, they sought to shift subject's thinking from ongoing cognitive processes to metacognitive thinking directed at *examining* ongoing cognitive processes. In a series of experiments, the metacognitive problem-solvers performed significantly better than non-process oriented control groups performance on both training and information transfer tasks. The metacognitive group also consistently formed more sophisticated problem representations and developed more complex strategies.

Neurophysiology

Luria proposed more than 30 years ago that frontal-lobe processing is involved in the activity of planning and the ongoing implementation of the plan (Nelson, 1996). In order to study how the frontal lobes migtht effect metacognitive processes, subsequent research was conducted with Korsakoff patients (Shimamura et al., 1988; Shimamura & Squire, 1986) and with high altitude climbers (Nelson et al., 1990). Both populations suffer neurological deficits in the frontal lobes - Korsakoff patients have large amounts of frontal lobe damage and high altitude climbers experience temporary frontal lobe deficits resulting from oxygen deprivation. All three of these studies examined accuracy of feeling of knowing judgments and the accuracy of the retrospective confidence in retrieved answers. For both the Korsakoff patients and the climbers, their feeling of knowing accuracy was significantly lower than normal people, and their retrospective confidence judgments were no different than normal people. Similarly, Janowsky, Shimamura, and Squire (1989) found that people with only frontal lobe damage, the feeling of knowing accuracy was below normal and their recall and recognition were normal. These findings suggest that there might be distinct areas of the brain associated with different metacognitive tasks and that the frontal lobes are an essential structure in prospective monitoring judgments and for efficient allocation of self-paced study time during learning.

Even newer research on the prefrontal cortex shows that this area is a crucial nexus of neurons coming from the sensory systems and of the neurons returning to the sensory and movement systems (LeDoux, 2002). The Metacognitive Model is very similar to the Executive function postulated by LeDoux (2002). He conjectures that a controlling, monitoring, and management function resides in working memory in the prefrontal cortex. The Executive function presumably organizes the bottom-up input from the sensory system and then issues top-down management commands to the sensory and movement systems.

It is worth noting that the neurobiological research to date gives physiological support to at least some of the conceptual aspects of the Metacognitive Model.

Putting it all together

A person's metacognitive monitoring does not have to be perfect to be useful. Although frequently inaccurate, metacognitive monitoring plays a key role as the "input device" for the individual's control system. When such monitoring is distorted, we would expect to see effects on their cognitions and behaviors. Support for this view is offered by a Sheppard and Teasdale (2000) study that examined depressed and non-depressed subjects' responses to neutral statements and statements from the Dysfunctional Attitude Scale (developed by Weissman and Beck). Their research suggests that depressed subjects showed little or no ability to use metacognitive monitoring of potentially dysfunctional responses compared to the non-depressed controls. They hypothesized that some people may be depressed as a result of their decreased ability to monitor and subsequently deselect potentially depressing thoughts and behaviors.

In an attempt to move our sometimes esoteric and sometimes tedious discussion into the real world, I wish to present an excellent example of metacognitive concepts in action. Like Kegan's (1994) developmental model discussed above, Prochaska and his colleagues have created a model of change that implicitly utilizes the Metacognitive model (Prochaska et al., 1995). In their book, *Changing for Good*, the authors lay out a model of psychological change based on their years of empirical research with smokers, alcoholics, and the chronically depressed. They stress the importance, like Kegan, of accurately assessing the cognitive skills of the person who wishes to change.

Briefly, the model is composed of six phases and is viewed as cyclical in that at any stage in the cycle, people can (and do) backtrack into some earlier stage (see Figure 3). The six stages are:

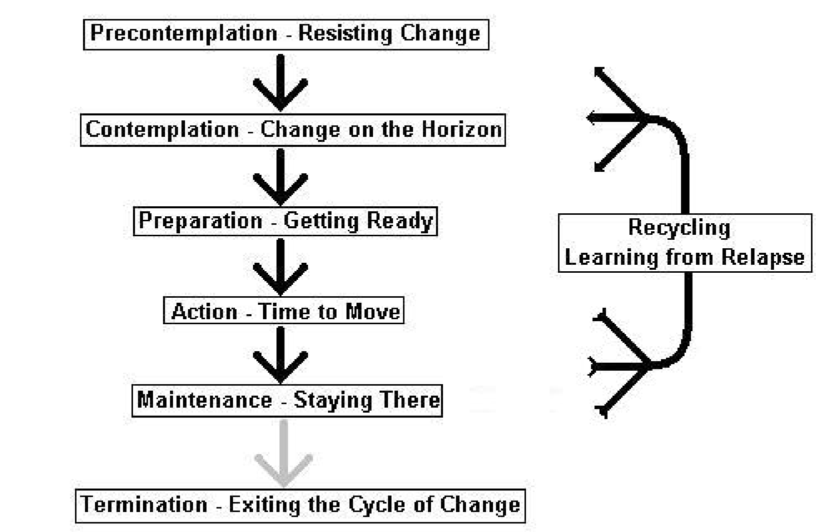

Figure 3. Prochask's Model of Change
Adapted from *Changing for Good* (Prochaska et al., 1995)

Precontemplation – This stage is typified by denial and resistance. The person usually has little accurate knowledge of their problem, does not monitor nor control their activities around the problem, and actively rejects any attempt to develop strategies of change.

Contemplation – In this stage, a person has the general feeling that they might have a problem (greater self-awareness and more knowledge about the problem). However, they have only a small glimpse of how their problem is effecting their life and those around them, and very little idea of how they might change and how their lives might be different if they changed. So both their knowledge and their self-awareness have improved, but they still lack an accurate picture of their problem and its effect and still do not have any strategies for change.

Preparation – This stage is typified by strategic planning. The person has come a long way in their self-awareness, knowledge of their problem, and how it is effecting their lives. They now turn towards developing a vision of the future without their problem, developing strategies to achieve the vision, and gathering the resources to implement those strategies.

Action – This is the stage that is most visible to the outside world – the person takes action to change their behaviors. Many relatives and clinicians make the mistake of pushing their loved ones and clients into this stage without consideration of the person's cognitive and metacognitive skills. At this point, a successful changer is much more aware of themselves in relation to those around them, has accurate and comprehensive knowledge about their problem and its effects, can effectively develop and implement strategies and adjust those strategies based on accurate observation and reflection, and has a vision for what their lives will be like after they change.

Maintenance – The changer at this stage has successfully implemented a plan of change. The task now is to mold the short-term strategies used to get to this stage into long-term changes in self-image and world-model. In other words, using the success of doing their lives differently to change their underlying metacognitive models used in monitoring and controlling their behaviors.

Termination – Prochaska et al. (1995) suggest that the maintenance stage might be a life-long destination for some successful changes – that termination of the problem is not possible: problems like drug use, alcoholism, major depression – might require the constant monitoring and controlling present in the maintenance stage. For other problems, they suggest that at some point, the self and world models have changed sufficiently to consider the problem terminated.

Of course, I have only touched on the major assumptions of their model and there is much I have not covered. However, I view this model as a practical and very useful application of metacognitive concepts. At each step in the cycle, specific interventions and activities are suggested based on the person's ability to accurately see themselves and their challenges, develop learning strategies, and implement and adjust those strategies. An important message of their research is that that people cannot move on to the next stage of change until they develop the necessary cognitive and metacognitive skills required of that level. For instance, when a person is in the Precontemplative stage, it is neither practical nor useful to offer interventions designed to move them into action. The authors suggest that precontemplators do not yet have adequate self-awareness, understanding of what their challenges are, a vision of how they could change, or what it might be like to change. Instead, the authors suggest information gathering, journaling, feedback by others around the person – all interventions designed to increase the knowledge of the problem and of self and of how the problem effects them and others around them.

The Metacognitive model serves as an excellent tool for accessing and making sense of our client's deficits in planning, strategizing, and controlling their cognitive behaviors. As clinicians, many of us are in the business of helping our clients develop their metacognitive abilities, whether we know it or not. Most therapeutic approaches foster an increased awareness of self and a willingness to consider new ways of thinking and behaving. The research clearly suggests that increased use of and improvements in metacognitive processes can have beneficial effects on subsequent cognitive tasks.

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