Psychological Review
1999, Vol. 106, No. 1, 3–19

0033-295X/99/$3.00

A Hot/Cool-System Analysis of Delay of Gratification: Dynamics of Willpower

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A 2-system framework is proposed for understanding the processes that enable—and undermine—self-control or "willpower" as exemplified in the delay of gratification paradigm. A cool, cognitive "know" system and a hot, emotional "go" system are postulated. The cool system is cognitive, emotionally neutral, contemplative, flexible, integrated, coherent, spatiotemporal, slow, episodic, and strategic. It is the seat of self-regulation and self-control. The hot system is the basis of emotionality, fears as well as passions—impulsive and reflexive—initially controlled by innate releasing stimuli (and, thus, literally under "stimulus control"); it is fundamental for emotional (classical) conditioning and undermines efforts at self-control. The balance between the hot and cool systems is determined by stress, developmental level, and the individual's self-regulatory dynamics. The interactions between these systems allow explanation of findings on willpower from 3 decades of research.

The question that we address here is, if humans initially are driven by impulses pressing for immediate release, ruled by a pleasure principle, and largely indifferent to reason—as has long been assumed—we need to understand how they become able to control their actions and feelings, overcoming the power of stimuli to elicit automatic reactions, and exerting the self-control strategies or "willpower" essential for the execution of their difficult-to-achieve intentions. In recent years, there has been a virtual explosion of research and theorizing about self-regulatory processes that have illuminated many aspects of self-regulation relevant to willpower (Baumeister & Heatherton, 1996; Cervone, 1996; Cervone, Jiwani, & Wood, 1991; Cervone & Wood, 1995; Dodge, 1986, 1993; Loewenstein & Prelec, 1993; Marlatt, 1996a, 1996b, Marlatt, Baer, Donovan, & Kivlahan, 1988; Mischel, Cantor, & Feldman, 1996; Mischel & Patterson, 1976, 1978; Mischel, Shoda, & Rodriguez, 1989; Rodriguez, Mischel, & Shoda, 1989).

Nevertheless, the nature of willpower, as assessed in situations like the delay of gratification paradigm (Mischel & Ebbesen, 1970), remains debatable. For example, Baumeister and Heatherton (1996) discussed the underregulation that occurs when willpower fails as "a matter of inadequacy in one's strength to override the unwanted thought, feeling or impulse" (p. 3) and described many of the conditions that may enhance or undermine such strength. They also made clear the costs of failures of self-regulatory strength evident from crime and teen pregnancy to alcoholism and drug addiction, to domestic violence and educational underachievement. Yet, the nature of that strength, and the processes that underlie it, still await a unifying theoretical account. The hot-system/cool-system framework we propose here yields specific theory-based predictions that address this theoretical challenge.

Willpower: Overcoming Stimulus Control

In this article, the aspect of willpower that is our concern is the ability to inhibit an impulsive response that undoes one's commitment (e.g., to bypass dessert, to forgo tobacco or alcohol or cocaine, etc.). We illustrate how the interaction of the hypothesized two systems—one "hot" and the other "cool"—can enable individuals to overcome the power of stimulus control (documented and extolled in 5 decades of behaviorism) and, thus, purposefully prevent powerful stimuli from eliciting their impulsive immediate responses that quickly undo their best intentions.

We focus our analysis and predictions on the delay of gratification paradigm because it is a prototype for the study of willpower in the pursuit of difficult goals that has been researched extensively empirically, both experimentally and longitudinally (reviewed in Mischel, Ebbesen, & Zeiss, 1972; Mischel et al., 1989). In addition, it is proving to be remarkably diagnostic of individual differences in self-regulatory competencies that appear to have important long-term implications for social and cognitive adaptation. For example, in certain conditions of this paradigm, the number of seconds a preschooler is willing to wait for two marshmallows, rather than settling for one available immediately, is predictive of cognitive and social outcomes decades later, including Scholastic Aptitude Test (SAT) scores (Mischel, 1996; Mischel et al., 1989; Shoda, Mischel, & Peake, 1990).

The Delay of Gratification Paradigm

In the delay of gratification paradigm, the participant, often a young child, is presented with some consumable item that he or

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Preparation of this article was supported by National Institute of Mental Health Grants MH39349 and MH48066.

We would like to thank Todd Heatherton for constructive comments on an earlier version. We would also like to thank Alessandra Testa and Lisa Schwartz.

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she desires, for example a food treat. A dilemma is posed for the child: Wait until the experimenter returns and get two of the desired treats, or hit a bell and the experimenter will return immediately, but in this case only one will be given. Although the child clearly prefers the larger outcome and chooses to wait for it, soon the delay becomes very trying as the child tries to persist in pursuit of the chosen goal in the face of the conflict and temptation experienced. While simple in its structure, this paradigm has proved to be not only empirically informative but also theoretically provocative, apparently tapping the types of skills and self-regulatory strategies crucial for impulse control and for sustaining willpower or "strength" in the face of strong temptation.

Psychological discussions of how people manage to persist and exert self-control in this type of situation traditionally have invoked the notion of character traits such as ego control (Block & Block, 1980) or conscientiousness (e.g., Bem & Allen, 1974). Although such constructs may help to characterize individual differences in self-control predispositions and behavior, they do not address certain questions: When a conscientious or ego-controlled person resists the temptation of immediate gratification for the sake of longer term goals, what does he or she do cognitively, emotionally, and behaviorally? What mental mechanisms underlie such activities and enable or undo them? The search for a theory, or a metaphor, within which to ask and try to answer such questions guides the present effort.

Theory-Based Predictions

The hot-system/cool-system framework we propose yields a coherent set of theory-based predictions that we examine in relation to the major findings from the delay of gratification research paradigm obtained in diverse studies over several decades. These applications of the framework are presented in some detail to show how the hot/cool system is assumed to operate and to illustrate its utility and relevance for clarifying the interaction of cognition and emotion in this context. Although the "predictions" here are made years after the empirical findings from these experiments became available, they provide a set of clear expectations and explanations for the diverse phenomena and seeming paradoxes identified in those studies that have long awaited a unifying theoretical interpretation. In these illustrations, the heuristic value of the framework for generating additional hypotheses for future studies of willpower and self-control, and for analyses of cognition–emotion interactions in related research contexts, are delineated.

Self-regulation plays a role in so many diverse aspects of human behavior that it has become a topic in danger of losing its boundaries, as recent reviews have suggested (Mischel et al., 1996). Therefore, having stated what our focus in this article is—the mechanisms that underlie willpower or strength as exemplified in the delay of gratification paradigm concretely, and as manifested in diverse everyday contexts requiring resistance to temptation in the course of goal pursuit—we also want to be clear about what it is not. We recognize, of course, that a host of variables influence the ability to persist in the pursuit of difficult goals and commitments and in the face of obstacles and temptations, variables that include (among many others) the person's perceptions of control and self-efficacy, optimistic orientation, and self-monitoring routines (e.g., Carver & Scheier, 1981; Karoly, 1993; see review in Mischel et al., 1996). Those analyses highlight some of the important individual differences on variables that may be basic prerequisites for willpower such as goals (e.g., Dweck & Leggett, 1988; Grant & Dweck, in press) and a focus on promotion or prevention strategies (e.g., Higgins, 1997). However, self-control tasks that entail extended periods of resisting temptations that strain the will (or the self-regulatory system) also demand strategic mobilization of thought, feeling, and action, coordinated over time and place to "take control" and to sustain it (Cantor, 1990; Gollwitzer, 1996; Higgins, 1998; Kuhl, 1985; Norem, 1989). The underlying mechanisms that allow that are the concern of the proposed framework.

Outline of the Hot/Cool Framework

We propose that there are two types of processing—hot and cool—involving distinct interacting systems (see also Metcalfe & Jacobs, 1996, 1998). The *cool cognitive system* is specialized for complex spatiotemporal and episodic representation and thought. We call it the "know" system. The *hot emotional system* is specialized for quick emotional processing and responding on the basis of unconditional or conditional trigger features. We call it the "go" system. A summary of the main characteristics of the two systems is given in Table 1. Of critical importance to self-regulation and to goal-directed volition is the interaction of these two systems.

We illustrate some aspects of the hot/cool framework with a neural network model—the language at which our metaphor is cast—at a broad level of generality. However, we have deliberately eschewed most references to the abundant relevant findings from brain research that tempt speculations about differences in the brain structures within which the hot and cool systems may have their primary locations, if and when they prove to be more than metaphors. But while we are sensitive to the need to avoid premature connections to the neural level, we nevertheless chose to structure our metaphor as a neural network not only because we believe it provides a useful interdisciplinary heuristic at this time but also because it has at least a hope of ultimately connecting to a cognitive neuroscience level of analysis in which metaphors could evolve into more tangible forms. We apply this metaphor here to a series of experiments focused on goal-directed self-control or willpower within the delay of gratification paradigm—a paradigm at the core of our understanding of human impulse control and volition in the service of future consequences (e.g., Mischel, 1996; Mischel et al., 1989). The network incorporates central characteristics of each of the two systems and elaborates

Table 1
Characteristics of the Two Systems

Hot system	Cool system
Emotional	Cognitive
"Go"	"Know"
Simple	Complex
Reflexive	Reflective
Fast	Slow
Develops early	Develops late
Accentuated by stress	Attenuated by stress
Stimulus control	Self-control

their interaction in the specific case of resistance to temptation in this context.

Precursors to the Hot System/Cool System: Metaphors in the Analysis of Volition

When psychology separated from philosophy at the end of the last century, theorists tried to leave behind the concept of willpower, but it repeatedly returns, cloaked in varying metaphors. Freud (1911/1959) attempted to abandon it completely, making the issue of human volition moot by putting all the psychic determinants into unconscious motives; what we do, think, and feel is determined by the vicissitudes of biological impulses struggling for release from the id in its confrontations with the barriers and counterforces from the rest of the psyche. The intrapsychic wars were waged mostly beyond the individual's awareness, in the continuous battles among an essentially hot id and cool ego and frigid superego. In his understandably pessimistic view of human nature and of the possibility—or impossibility—of volition that followed, Freud saw the only hope in efforts to replace the dark impulsiveness of the id with the reason and insights of the ego.

From Freud to Skinner to Kelly

Unmoved by this metaphor (except perhaps to reaction formation), the alternative theory that emerged, *radical behaviorism,* argued that behavior is under the control of external stimulus conditions, governed by the cues, contingencies, and consequences provided by the environment and the organism's reinforcement history (Skinner, 1938). Although they held opposite views of the locus of behavioral control, Freud and Skinner shared the conviction that willpower (or "personal agency" in current terminology) was just another fiction through which we try to delude ourselves.

Protesting against the unconscious motivational determinism of classic psychoanalytic theory and the environmental determinism of Skinner's behaviorism, and anticipating the cognitive revolution that was soon to come, George Kelly (1955) proposed that people do not simply act as motivated or "driven" organisms: They also are perceivers and construers of behavior and of themselves. We may not be able to change events, he argued, but we can always construe or conceptualize them differently, viewing them in a new way that can enhance the possibility of freedom and volition.

The Cognition–Emotion Connection

Kelly's prescient recognition of the importance of cognition (and the mental activities of the cool system, in our terms) provided a route for reinstating human volition into psychology. But even to his most appreciative critics the exclusive focus on alternative construals slighted the power of what the behaviorists called "stimulus control" (or the force of the hot system, in our terms). It was Zajonc (1980) who reminded the field that people both think and feel, arguing elegantly (and even with evidence) that preferences—affective judgments—can occur without extensive inferences and can precede them: Affect and cognition are controlled by separate systems, and affect is primary in his view.

Zajonc's (1980) claim came at a time when psychology considered affect to come last, that is, to be postcognitive. A century earlier, James (1884; 1890) and Lange (1967) had suggested that people monitor their reactions and only then feel the emotion. Presumably, prior to the monitoring, the emotion does not exist as such but comes into being only after the expression is processed cognitively. There is the implicit suggestion of two systems, one incorporating emotion, and the other devoid of it. Similarly, Schachter and Singer (1962) proposed that emotional arousal provided a diffuse state open to radically different cognitive interpretations that guide the behavior. That, under some circumstances, the emotional behavior may precede knowledge of the reasons for it is in keeping with the hypothesized differences in speed of the hot- and cool-system responses. Although the ordering of events given by James and Lange may be debatable, the interactive aspect of the James–Lange and the Schachter–Singer positions foreshadows the complicated interplay between the two systems presented here.

Hot/Cool Analysis of Traumatic Memory

The proposed framework builds on these and other contributions from diverse areas of the field. Its most direct precursor is a recent hot-system/cool-system analysis of human traumatic memory, focusing on the differential sensitivity of the hippocampi and amygdala in response to stress (Metcalfe & Jacobs, 1996, 1998). In their analysis, much more closely tied to physiology than the psychological framework we propose here, Metcalfe and Jacobs argued that human memory may be thought of as consisting of two interacting systems—one that is hot and amygdala-based and another that is cool and hippocampally centered. Although they focused primarily on the hippocampus, they recognized that the cool system also includes frontal and other cortical areas implicated in comprehension, semantic processing, working memory, metacognition, planning, and control functions as well as problem solving and high-level thinking. Their hot system is tuned to respond preferentially to biologically significant triggers. Although Metcalfe and Jacobs acknowledged that these may be appetitive and attractive as well as threatening and fear provoking, it is the latter that is their focus as it bears on traumatic memory. In contrast, here we focus on the appetitive nature of the hot system and its role in self-control.

The Present Framework

The framework proposed here for the analysis of delay of gratification and willpower is deliberately cast at a molar psychological level, with no commitment to the anatomical structures in the physiological substrate. The guiding, monitoring, and working memory functions of the cool system allow the person to keep the goals in mind while pursuing them and monitoring progress along the route. We consider most implicit memory and perceptual processing needed for comprehension to be part of the cool system. What we here call the cool system consists of a variety of subsystems with particular functions, which researchers have been delineating with increasing precision. Without undermining these subtler subsystem distinctions, in the present framework we group these together as cool functions within a single cognitive system to highlight their commonality and to note the overall contrast to the more impulsive and direct functions that underlie the noncognitive emotional hot system.

The idea that there are two types of representation, one fundamentally emotional and reactive and the other essentially cognitive, also has a long history of both research and explanatory metaphors. It is seen, for example, in the suggestion by both Berlyne (1960) and Estes (1972) that any stimulus may have two functions: informative–cognitive and motivating–arousing. Likewise, the type of distinctive cool cognitive system proposed is consistent with the findings and conclusions that other researchers have provided in cognitive psychology for declarative, locale memory (e.g., Bjork, 1988; Bjork & Bjork, 1992; O'Keefe & Nadel, 1978; Squire et al., 1990), episodic and semantic memory (Tulving, 1985), metacognitive processes (e.g., Bjork, 1994; Koriat & Goldsmith, 1996; Metcalfe, 1993, 1996), and also with much of the work on nonemotional implicit memory processes (e.g., Graf & Schacter, 1985; Schacter, 1987, though some of the work on implicit memory with emotional conditioning, we would consider to be hot-system specific), as well as knowledge structures (Gentner & Holyoak, 1997) and problem solving. In contrast, the hot system deals with the kinds of automatic responses to both appetitive and fear-producing unconditional stimuli, and their learned associates, that were the focus of behaviorism and animal learning and that have been relatively neglected in studies of human cognition.

In its specific instantiation, the proposed framework depends on the contextualized social–personality interaction analysis given in Mischel and Shoda's (1995) cognitive–affective personality system (CAPS). Unlike most cognitive dynamical network models, CAPS specifically included affective nodes in their network, opening up the possibility for the interaction of emotion and cognition (e.g., Cervone, Kopp, Schaumann, & Scott, 1994; Kruglanski, Clement, & Jost, 1997; Wright & Mischel, 1982). As Kunda and Thagard (1996) noted, however, although Mischel and Shoda's model introduces needed affective units into social–cognitive processing, these affective units are given the same status as other kinds of nodes, including informational content nodes.

Thus, as Kunda and Thagard (1996) suggested, although the CAPS model may account for much data, including, for example, the role that affect plays in impression and stereotype formation, it may be limited insofar as emotions entail different mental processes than do cognitions. Here, we propose that there are indeed important functional differences between emotional and cognitive representations and processes. Such differences are substantiated by compelling cognitive neuroscience data (reviewed by Metcalfe & Jacobs, 1996, 1998) that make it worthwhile to conceptualize two separate but interacting systems: hot and cool. The utility of this interacting-systems approach is illustrated in the more parsimonious account it allows of the phenomena of willpower found in the delay of gratification experiments analyzed from this perspective in subsequent sections.

Dynamics of Hot/Cool Interactions

The cool system is narrative, weaving knowledge about sensations and emotions, thoughts, actions, and context into an ongoing narrative that is coherent, goal sensitive, and strategic. Cognitive rumination is a hallmark of this system, although, of course, nonimpulsive actions may stem from this system. This system, in and of itself, though, is devoid of emotion and vitality.

The hot system contributes the feeling components to the phenomenology. The hot system is largely under "stimulus control," characterized by rapid automatic triggering, conditioned responding, inflexibility, stereotyping, and affective primacy (see also Zajonc, 1980) As we detail in this article, the problem of stimulus control is central to human self-regulation, so understanding the system that drives this behavior and its interaction with modulating systems is crucial. The hot and cool systems work in concert to produce experiences that are both cognitive and emotional.

Hot Spots and Cool Nodes

A subset of the internal nodes are hot nodes, or *hot spots,* contained within the hot system, and a second subset are *cool representations,* or "nodes" within the cool system. Hot spots and cool nodes have different characteristics, different qualities, different connectivities to one another, lead to different responses, and are linked respectively to the hot system and the cool system gain-control mechanisms that filter or amplify the input activation on the specific nodes within their spheres of influence.

Hot Fragments of Feelings

Hot spots can be thought of as fragments of feeling. They have direct connections to an output response buffer yielding the output motor programs. The responses determined by the hot spots are typically either approach or avoidance patterns. Hot spots do not connect to other hot spots, and hence there is little cycling of activity within the hot system. The motor and response programs that are generated from the hot system, like those stemming from the cool system, may be either simple or quite elaborate, running off immediately or taking a considerable amount of time to execute. (Thus, the pathway to the hidden cigarette, or to the refrigerator for the chocolate cake, may take some time to traverse.) The connections to these response programs from the hot system, though, are direct and rapid. Neither the hot nor the cool system participates in the execution of actions; their domains extend only to the point at which the action plan or the response program are set in motion. Thus, it is assumed that there is a separate response buffer that is responsible for overt behavior.

Cool Node Interconnections

In contrast to hot spots, cool nodes are elaborately interconnected to one another within the cool system and connect at specific points to hot nodes as well. Some cool nodes are extensively interconnected, whereas others are only connected to a few other cool nodes. The interconnections within the cool system tend to lead to a complex system of relations and to cycling within the system. Responses, of course, may be initiated from the cool system, but they are typically not immediate or direct approach–avoid patterns but rather verbal or nonverbal descriptions, statements, assertions, and commentaries—reflections rather than reflexes. Extensive interconnectedness is inherent to the cool system yielding the relational properties, the complexity of thought, the spatiotemporal characteristics, and the temporal lag that may be conceptualized as deliberation before a response pattern is initiated.

Hot and Cool Stimulus Coding

The same nominal feature of the situation or stimulus configuration may be represented by both a hot spot and a cool node:

Activation of the former gives rise to affect and emotional reactions related to that stimulus; activation of the latter records its occurrence, context, and consequences, allows access to its interrelations and connections to other concepts and features, and allows self-reflection and metacognition, providing knowledge *about* the state, but not the state itself. Note, though, that the hot spots and corresponding cool nodes do not represent entire stimuli but rather are featural fragments. In the mature organism, whereas most hot spots have corresponding cool nodes, few cool nodes have corresponding hot spots: Much of the informational content of an event is devoid of feeling and hence is represented in the cool system but not in the hot system. However, it is possible for a hot node to exist without a corresponding cool node. This is especially likely in the young child before the cool system is fully developed.

Hot/Cool Interconnections

Hot spots and cool nodes that have the same external referent are, within the model, directly connected to one another and interact, linking the hot and cool systems. If a hot spot is activated, its corresponding cool representation will tend to be activated, although the extent of activation may vary depending on such factors as priming, the developmental state of the organism that is important for the development of nodes, the activation of the cool-system gain control mechanism, and so on. Similarly, if the cool node that corresponds to a hot spot is activated, activation may spread to the hot system, again depending on priming, development, and overall system activation.

The interconnections between hot spots and cool nodes have important implications for control processes and for communications between the two systems. One method of activating particular hot feelings and reactions, for example, is by evoking their corresponding cool nodes in thinking and fantasy. Merely thinking about an object, though, is not enough: The person must specifically think about the aspects of the object that have a corresponding hot spot. This entails thinking about the object of desire in a particular way that we could summarize as giving it a hot framing because of the connection of these particular nodes to the hot system. With sufficient activation of a particular cool node that has a corresponding hot spot, activation spreads automatically across systems. Thus, thinking directed at appropriate locations in the cool network may result in hot activation, which motivates action (e.g., ringing the bell in the delay situation when committed to persist).

Conversely, the activation of a hot spot under normal conditions will result automatically in some activation of the knowledge that the emotional reaction occurred because the corresponding cool node also will become activated. The fact that the cool nodes that have direct hot spot counterparts are normally connected to many other surrounding cool nodes that do not have such cross-system connections can have control value: Cool intervention and mediation becomes possible because most of the ideation can become captured within the cool system, even though the initially provoking event was hot.

It is crucial that the cool nodes that do not have hot connections (but are connected to one of the special cool nodes that does have such a connection) become activated and cycle the resultant activation among themselves, without returning it entirely back to the focal node that will back activate the hot system. Thus, a selective cool "set," involving activation of the relevant cool nodes that lack hot connections, is essential for control. The cross-system interconnections, along with selective activation of the relevant cool nodes, enable the individual to divert activation away from the hot system and its attendant immediate action by engaging instead—automatically as well as strategically and purposefully—in cool thinking, including fantasy, ruminating, remembering, and planning, as we illustrate in subsequent research examples.

Priming

The activation levels of particular nodes within the two systems are modified by the presence of particular stimuli, and also by priming due to past stimulation, resulting in short-term effects on behavior and contributing to learning. Priming temporarily increases the activation levels of certain nodes, making their reactivation more likely. Priming also increases the probability that the activation of a nearby or associated node will result in activation of the primed node. Such priming is essential to enhance control, for example, in therapeutic contexts or in the context of temptation, by strategically diverting activation away from the hot system to enable cool ideation in response to a problematic hot stimulus.

Learning

Learning, which has long term effects, refers to changes in the chronic activation levels of nodes, in the transition probabilities among nodes, and in the probability and speed of responses. Learning and priming are, of course, related, with the latter conceptualized as a short-term divergence from the baseline activation level, and the former as a more permanent change. We consider nodes to have benefited from learning to the extent that they are (relatively) permanently activated above some starting level. (The difference between priming and learning is blurry insofar as in a dynamic system such as this; all nodes are changing to some extent and so it becomes a matter of rate of change rather than an all-or-none matter, where some nodes are changing quickly and some not at all.) The starting levels may be biologically determined at least in part. Thus, in this view, learning is a relativistic concept that is inherently variable both across people and across nodes within people. The degree of learning varies radically depending on biologically programmed starting states, predispositions, experience, stress levels (which give preference to certain nodes over certain others), and maturity of the person and of the systems responsible for the learning.

The fact that some nodes are more chronically activated and salient than others, that is, that the baseline activation varies, has implications for self-regulation. For example, characteristics of an individual's personal identity, including one's name, are highly learned, and thus nodes related to this personal information will have a chronically high activation level. The resultant control consequences are that self-relevant information should be intensely involving (Cervone, 1993; Kruglanski, 1996a, 1996b; Markus, 1977; Weiner, 1990, 1991), though whether the result is preservation and ideational cycling within the cool system or very fast responses emanating from the hot system depends on the momentary balance of dominance of those systems.

Individuals are also expected to have different subsets of other nodes chronically activated, whether because of different environmental contingencies, different self-concepts, goals, values, expectancies, interests, or predispositions (e.g., Andersen, Reznik, & Manzella, 1996; Baldwin & Sinclair, 1996; Cervone, 1996; Deaux, 1996; Gollwitzer & Moskowitz, 1996; Kunda & Thagard, 1996). Such differences are subject to learning and thus to change over time (e.g., Andersen et al., 1996; Weiner, 1974, 1991). These differences in background network activation levels lead in a natural way to individual differences, not only in knowledge and impulsivity but also in self-control.

Learning also allows the genesis of new conditioned emotional hot spots, in the hot system, and new informational nodes, in the cool system. Thus, although initially only innately determined consummatory or fight-or-flight spots are represented in the hot system, with learning (i.e., conditioning) previously neutral stimuli may become emotional hot spots within the hot system. Similarly, sensitivity to nuances and interconnections may increase with learning in the cool system, resulting in the genesis of cool nodes.

Determinants of Hot- Versus Cool-System Dominance

Although normally there is a correspondence between hot spots and their cool-system representations, the conditions under which hot spots do not have, or cannot access, corresponding cool representations, and vice versa, are important theoretically and have significant consequences. Following are the conditions under which cool control of hot impulses are predicted to be radically impaired or nonexistent.

Developmental Factors

One of the main conditions determining the dominance of the hot versus the cool system is the developmental phase of the organism. The hot system develops early, whereas the cool system develops later. Thus, during the earliest years of life the hot system is functioning, whereas the cool system remains largely undeveloped. As the person ages, there is a shift of dominance from the hot to the cool system. The young child is responsive primarily to the urgencies of internally activated hot spots and the pushes and pulls of hot stimuli in the external world, with much learning that is based on emotional conditioning. To the degree that hot spots in early life do not have corresponding cool nodes (because the cool system is still undeveloped), they are not subject to cool-system control and may elicit feelings and behaviors, even in later life, that seem irrational, inexplicable, and particularly difficult to regulate (Jacobs & Nadel, 1985).

Our assumption that the hot system dominates in the early years of life is consistent with evidence that the amygdala, which some researchers have suggested is implicated in typical hot-system behavior such as appetitive learning and responding (Gaffan, 1992), is functioning at birth, whereas the hippocampus and frontal lobe structures, which seem more akin to what we here call the *cool system, become fully mature only sometime well after birth* (Altman & Bayer, 1990). The assumption of different developmental schedules of the two systems fits well with behavioral data as well. It also suggests the prediction that with increasing age the gradual attenuation of the hot system may be reflected in motivational decreases and increased withdrawal and distancing behavior.

Stress

A second factor that modulates the two systems differentially is acute stress. Following the work of Jacobs and Nadel (1985) and Metcalfe and Jacobs (1998), we assume that the impact of stress on the hot and cool systems is different, with the hot system being potentiated by stress up to very high levels, whereas the cool system is at first potentiated (at levels that one might better label "arousal" rather than "stress"). However, as the stress level increases, the cool system becomes increasingly dysfunctional, leaving the hot system to dominate processing. Cool-system functioning thus follows the Yerkes–Dodson Law (1908); (see also Diamond, Bennett, Fleshner, & Rose, 1992). Metcalfe and Jacobs suggested that this trade-off between the hot and cool systems may have adaptive functions. At low levels of stress, it is to the organism's advantage to take in as much information as possible and to store it in a neutral manner for later remembrances and uses. This allows for complex thinking, planning, and remembering. However, when the stress level is high—conditions in which an animal may be under threat for its life—quick responding driven by innately determined stimuli or stimuli that have been conditioned to produce immediate responding is essential. The animal needs to quickly recognize the trigger stimuli that may threaten survival and take immediate action; it is not the time for cognitive complexity or rumination.

Chronic Environmental Factors

The chronic selective activation of either hot nodes or cool nodes can result in learning that can affect the dominance of the entire system. Such biased activation may come about because of practiced ideation and may be under strategic control. In addition, though, environmental factors, such as chronic stress, can affect the dominance of the hot versus the cool systems. Exposure to chronic stress has been shown to be correlated with volume decreases in the hippocampus (Sapolsky, 1996), a brain structure associated with episodic memory, which is a central function of the cool system. Chronic stress might result in a systematic shift in the preponderance of hot-system as opposed to cool-system activation. This shift may be relatively stable in people who have experienced severe and chronic stress and may necessitate special procedures to offset its impact.

Dispositional and Organic Factors

Finally, endogenous conditions, innate predispositions, physiological conditions, and diseases can impact selectively on the relative functioning of the cool or the hot system with predictable cognitive, emotional, and behavioral consequences (e.g., Bechara et al., 1995). Certain diseases may affect selectively one system more than the other. In general, then, individual differences may reflect stable person differences (e.g., in temperament) in the a priori dominance of the two systems, differences in learning and chronic accessibility in the two systems, differences in chronic stress levels, developmental differences, and differences in acute priming.

Pharmacological Factors

Certain drugs may selectively augment or decrease hot- or cool-system functioning. For example, epinephrine or adrenaline appears to act primarily to enhance hot-system processing. Propranolol, a drug sometimes used to alleviate hypertension, may have the opposite effect. Cahill and McGaugh (1996) have shown that when a person is administered propranolol, emotional situations that would normally be given preferential treatment in perception and memory are processed in an emotionally flat manner. Thus, propranolol may impair hot-system processing, stripping emotional events of their significance. In contrast, corticosteroids, especially at high levels, may have a selective inhibiting effect on the cool system.

Hot/Cool Analysis of Delay of Gratification

To concretely illustrate the hot/cool-system analysis of willpower in the context of the delay of gratification paradigm we consider the specific predictions it allows us to generate. The framework yields expectations that help explain a wide range of findings that have long been resistant to coherent integration. In this major section we first outline the default state of the system, in which no self-control is exerted and the individual succumbs to temptation. Then we outline three types of control strategies that people may use in the interest of willpower, going from the simplest to the most complex and difficult. The first control strategy entails the direct diminution of activation of the hot spot that produces the impulsive response by obscuring or ignoring the stimulus. This decrease in hot-spot activation can be accomplished externally (by obscuring) or internally (by ignoring). The second strategy entails selective activation of nonrelevant parts of the hot/cool system, that is, distraction. Distraction can be both external and internal, and also can involve either the cool system or the hot system. The third major strategy involves reframing the meaning of the stimulus that produces the impulsive responses.

After we outline these potential control strategies, describe why they work, and delineate the experimental situations that illustrate their impact, we address the differential development of the two systems and metacognitive knowledge about the control mechanisms that unfolds with development. The control strategies depend, of course, on adequate development of both systems, particularly the cool system. Finally, we also make predictions about how stress, which is postulated to affect the two systems differentially, should affect control strategy usage.

Yielding to Temptation: The Default

Prediction 1. When the hot system is dominant (e.g., when the cool system is not well developed, when it is temporally or chronically dysfunctional, or when the person does not activate his or her control strategies), salient exposure of the hot stimulus will tend to elicit the automatic relevant response.

This situation, in which a person is faced with an object of desire, is notated in the hot/cool framework as a highly salient hot stimulus that evokes an immediate and direct response mediated by the hot system alone, as Figure 1 illustrates. (Note that the thickness of the lines indicates the probability of traversing that pathway. The prominence of the circles indicates the salience and "hotness" of the input stimulus and the degree of activation of the node.) If the child wishes to obtain the two marshmallows, then in order to be able to sustain the required delay of gratification—to

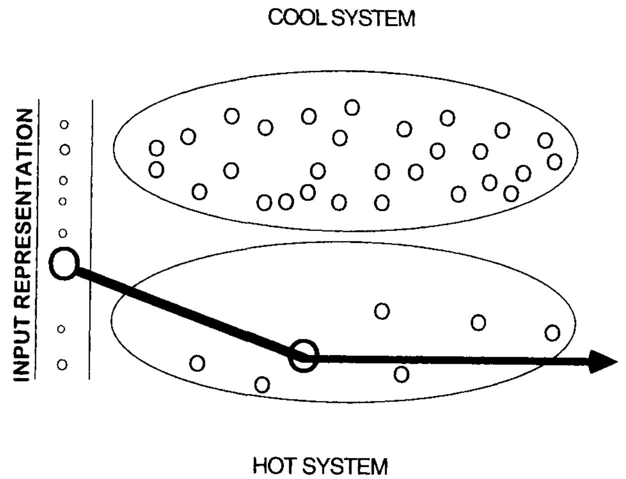

Figure 1. The default situation in which the hot stimulus, prominently displayed, leads directly to the hot spot; the hot spot's strong activation provokes a go reaction, and the young child succumbs, producing the unwanted response.

bridge the aversive delay period—some time-devouring mental events must come into play, diverting activation away from the hot stimulus, with its pull toward the immediately gratifying response. This is difficult for the young child in the situation in which the stimulus is "hotly" displayed (e.g., directly and saliently exposed to attention with no offsetting priming in the cool system).

Evidence that speaks directly to this prediction comes from studies with preschool children in the delay of gratification paradigm that tested the effect of leaving exposed, during the delay period, the rewards in the contingency. On the basis of a number of theoretical considerations (e.g., Freud, 1911/1959; Jones & Gerard, 1967), consistent both with psychodynamic and learning theory, the researchers originally made the opposite prediction, namely that delay behavior should be facilitated by "any cues that make the delayed gratification more salient—that help the person to make deferred consequences more psychologically vivid or immediate, i.e., by letting him look at them" (Mischel & Ebbesen, 1970, p. 330). Such cues, they thought, should enhance trust or the expectancy that the rewards would really be there ("a bird in the hand"). In addition, they anticipated that exposure to the reward would facilitate the children's "time binding" (e.g., Rapaport, 1967) by providing reminders of the objects for which they were waiting, thus helping them to sustain their delay.

To the researchers' surprise, however, their initial theorizing led to the prediction that was the opposite of the obtained findings—findings that were unequivocally replicated in follow-up studies and are predicted by the present model. The effect of exposure proved to be powerful, but it tended to prevent rather than to enable delay of gratification: When the rewards were exposed, the mean delay time was only about 1 min, whereas 15 min were needed to obtain the desired outcome. Thus, exposure to the hot stimuli made it virtually impossible for most of these preschoolers to attain their chosen outcomes, defeating their efforts at willful control and leaving them disappointed.

Control Strategies

Decreasing the Activation of the Hot Spot Leading to Impulsive Action

External strategies: Obscuring the stimulus. *Prediction 2. The eliciting power of the hot stimulus will be diminished when it is present but not saliently exposed during the period in which the individual is trying to inhibit the go response. Operationally, obscuring (e.g., covering) the tempting object should facilitate delay of gratification.*

This situation can be illustrated in the hot/cool framework as a decrease in the salience of the external stimulus, which triggers the hot system. To the extent that this external stimulus is decreased in salience, the probability of traversing the hot pathway should be correspondingly decreased, and thus the stimulus pull is decreased. This is shown in Figure 2, left panel.

The results of studies on this point likewise contradicted Mischel and Ebbesen's (1970) predictions that the salience of the rewards would facilitate the ability to control oneself and persist to attain them. Again, the results were in accord with expectations from the hot/cool framework: When the rewards were out of sight, 75% of the children were able to wait the full time (15 min), in contrast to their failure to delay sufficiently when the rewards were exposed, as noted above.

In vivo examples that may be related to this phenomenon are seen when the parent helps the child wait until it is time for dessert by putting the cookies into the cookie jar. In a similar way, attempts may be made to control an addict's craving for chocolate, tobacco, cocaine, or alcohol by removing the desired objects from view. Although such control attempts may sometimes be useful, they are expected to fail should the individual think about the temptations, accidentally encounter them, or actively seek them out.

Internal strategies: Attentional allocation. *Prediction 3. When the hot stimulus is present during the period in which the individual is trying to inhibit the go response, its eliciting power can be diminished by avoiding attending to it. This is the internal self-control parallel to external control by obscuring (e.g., covering) the rewards and should facilitate control in the same manner.*

This situation can be represented in the model in a manner similar to that given under Prediction 2, in which the salience of the stimulus is decreased. The difference is only that, here, the dampening of the salience of the hot object of desire is enacted internally rather than externally, as shown in the right panel of Figure 2.

Relevant data come from a study extending the delay paradigm to 6- to 12-year-olds who were having problems of adjustment and impulse control (Rodriguez, Mischel, & Shoda, 1989). During the delay period, the child's attention deployment was recorded continuously but unobtrusively with regard to the rewards as opposed to other stimuli in the room as the foci of attention. The amount of attention spontaneously directed at stimuli in the room irrelevant to the rewards (i.e., elsewhere) significantly predicted seconds of delay time ($r = .49$, $p < .01$).

In related studies, the single most important correlate of delay time with older youngsters (ages 5 to 13 years) was *attention deployment,* where the children focused their attention during the delay period: Those who attended to the rewards, thus activating the hot system more, tended to delay for a shorter time than those who focused their attention elsewhere, thus activating the cool system by distracting themselves from the hot spots (Rodriguez et al., 1989).

Shifting the Balance of Activation Away From the Hot Stimulus to Other, Irrelevant Parts of the System

External strategies: Physically present distractors. *Prediction 4. When the hot stimulus is present, its salience and power can be decreased by concurrent exposure to external stimuli that activate nonrelevant hot- or cool-system networks.*

Figure 3, left panel, illustrates the effect of external distraction in the hot/cool framework. A feature configuration, other than that

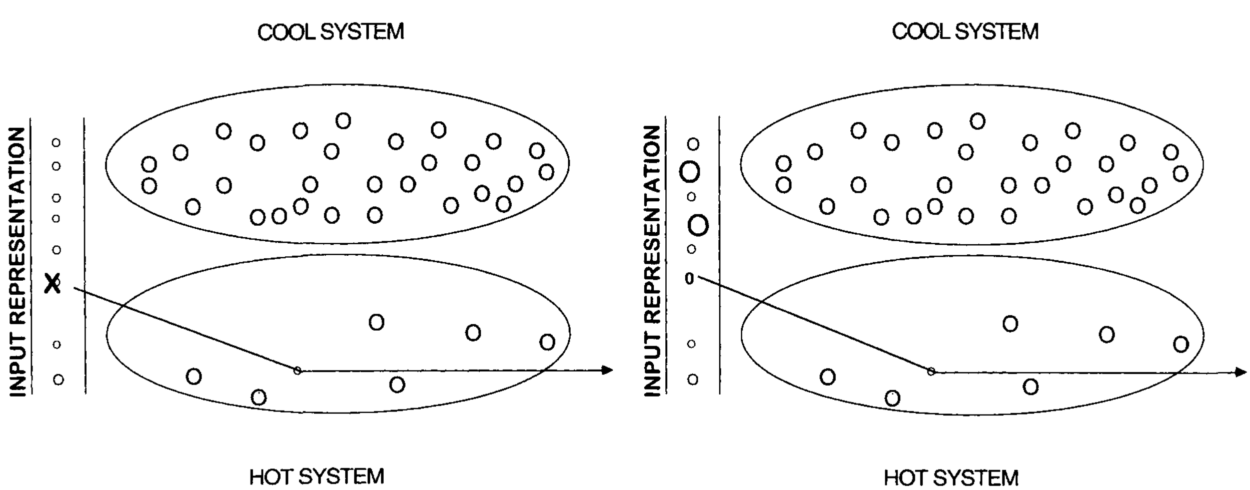

Figure 2. The left panel shows the effects of hiding or obscuring the temptation, thereby decreasing the power of the hot spot and the likelihood of a go reaction. In the right panel, the stimulus in the world is not physically hidden, but instead attention is diverted away from it and is given to other aspects of the perceptual field. The result is a decrease in the power of the hot spot, just as when the stimulus is covered.

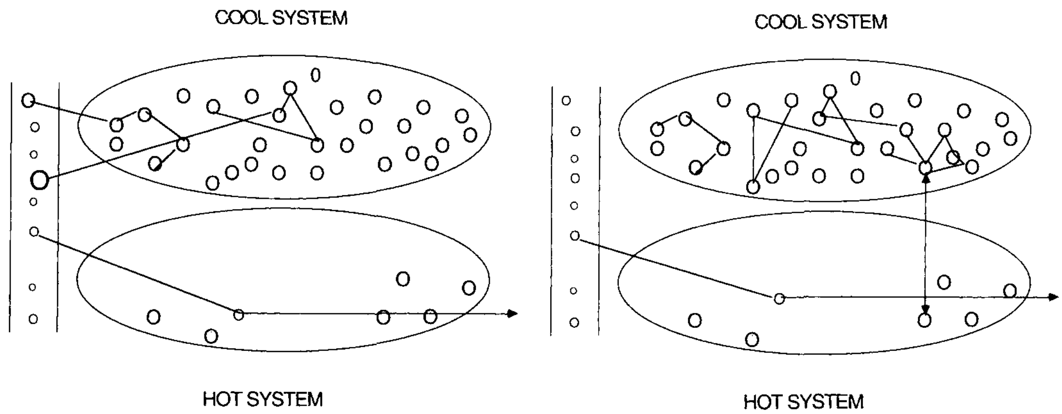

Figure 3. The left panel shows the effect of an externally presented distractor. The right panel shows a similar situation, but one in which the person is thinking only about a distracting situation. Note that the distractor may be particularly effective if it triggers a hot spot that does not lead to a response in the immediate environment, as is shown in the right panel.

triggering the relevant hot spot, is shown activating a network of associations in the cool system. External distraction that activates irrelevant hot spots is equally (or sometimes more) effective at drawing excitation away from the hot spot that is connected to the response that the person wishes to inhibit. In either case, activation is divided, impulsive (go) responding is lessened, and the individual can pass the time without emitting the hot response.

Data on this point come from studies testing the effects of providing a potential distracting activity (playing with a Slinky toy) on delay time (Mischel et al., 1972). More than half of the children waiting in this condition were able to delay the requisite 15 min even with the rewards exposed, whereas none of those children waiting without a distractor were able to do so. In a control condition, in which the children simply were given the Slinky to play with as long as they wished but there was no delay contingency, they played with the toy only for moments. Thus, in the experimental condition the toy had instrumental value for bridging the delay interval by distracting attention away from the hot stimulus. It was not simply that the children enjoyed playing with the Slinky: They did so only when they were waiting for the exposed reward.

Presumably, though, the efficacy of the distractor depends in part on how interesting and involving it is. If the distracting object were itself intriguing, it would have an even greater effect on diverting activation away from the relevant hot spot. To the extent that other hot spots are intrinsically interesting, it is postulated that distraction by hot external distractors may be more effective than distraction by cool and emotionally uninvolving distractors.

One of the hazards of external distraction is that when the person inadvertently happens to activate the cool node that leads directly to the hot spot, the go response may be triggered. The cool nodes that need to be avoided are the ones that contain the knowledge about the specifically appetitive characteristics of the object of desire, because those characteristics connect directly to the parallel hot spots. Activation of other cool nodes, even those related to the object of desire, allows purely cool thought patterning without triggering the go response. Thus, if the child thinks about the object of desire or happens onto it by looking at it, it is likely to be the appetitive rather than the purely informational characteristics of that object that are primed, salient, and hence activated, and these characteristics lead to the hot spots and the self-defeating go response. In either case, through stray thoughts toward or accidental encounters with the object of desire, the distracting activity may fail to have its intended effect.

Internal strategies. Prediction 5. When the hot stimulus is present, the individual can decrease its salience and power by internally activating nonrelevant cool- or hot-system networks.

This situation is identical to that given in the left panel of Figure 3, in which nonrelevant cool or hot nodes are primed or activated, and hence cognitive–affective energy is diverted to them, except that in this case the activation is internally generated and no external distractor is presented. Self-generated cognitive distractions can serve to enhance control and attenuate the power of the hot stimulus as effectively as externally provided distraction. This was demonstrated with preschoolers in the delay paradigm by comparing the effects of making a toy (the Slinky) available versus by priming distracting "fun" ideation. Here, the experimenter suggested that while she was gone, the child could think of anything that is fun, adding, "You can also think about singing songs or playing with toys, or anything that is fun to think of" (Mischel et al., 1972, pp. 207–208). Delay in this condition when waiting with the rewards exposed averaged more than 12 min, compared with less than 1 min when no distractions were introduced or primed.

The right panel of Figure 3 shows a situation in which self-distraction is internally generated, and a nonrelevant hot node is involved. Internal activation of irrelevant hot nodes allows the diversion of considerable cognitive-affective energy and hence serves as an effective distractor. In the delay of gratification paradigm, this is instantiated when the participant who is trying to delay gratification to attain the desired object (e.g., a marshmallow) is primed to think of the hot aspects of other objects that are simply not available within the situation (e.g., pretzels) with phrases such as, "Think about how crunchy and salty pretzels are." In this condition, preschoolers waited for their desired objects on average almost 17 min, which is considerably longer than they waited when hot thoughts were cued about the object for which they were actually waiting or when nonhot aspects of the irrelevant stimulus were cued, as in, "Think about how the pretzels are long and thin like little logs" (Mischel & Baker, 1975). It is possible that hot ideation about stimuli that are unattainable in the delay situation can provide particularly powerful distractors—vivid fantasies—that facilitate purposeful delay for the available object for which one is waiting in the situation.

Sabotage of Prediction 5 by counterpriming. Control by the kind of distraction strategy given by Prediction 5 is particularly susceptible to sabotage in which people sometimes unwittingly make self-defeating efforts (see Figure 4). Wegner (1994) has documented situations in which people were instructed to not think of white bears or some other object. Presumably, what people should do is try to distract themselves by thinking of anything except white bears. The difficulty arises from the fact that white bears are specifically primed in this situation and thus likely to be more salient rather than less salient given this instruction. The success of the Prediction 5 strategy depends critically on the hot stimulus (or the taboo thought, in Wegner's case) not, inadvertently, being activated, because the strategy allows no defense against the hot stimulus itself. Wegner outlined many interesting ironic phenomena that occur when people are told to not think certain thoughts—thoughts that are always made crisply apparent and vivid in the instructions.

In the hot/cool-system model, the explicit mention of the not-to-be-thought-of object would prime the nodes for that object and thereby draw activation toward it—subverting the instructions and the person's attempt to obey them. This counter-priming by the instructions to not think about the object of desire is accompanied by the increased activation of the hot node. Wegner's (1994) instructions to participants to continuously monitor their success at avoiding the hot node and to make an overt response whenever they are failing to comply, continuously activates the hot node and hence increases the priming, foiling the effort to obey the instruction.

A situation similar to Wegner's (1994) experimental paradigm may occur commonly in dieters who are trying to not think about food but are trying to do so by constantly referring to their often complex diets. The abstinence from excessive amounts of food is readily undone by constant priming by the attention to the diet.

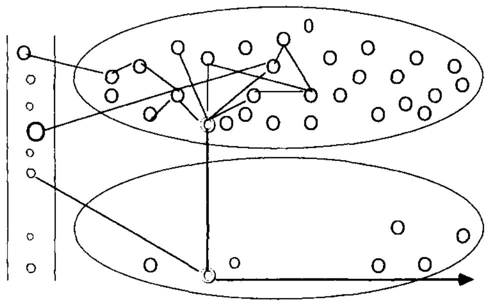

Figure 4. Ironically, the hot node that will trigger the go response can be primed by instructions not to think about it (and by the repeated instruction to monitor how well one is not thinking of it). This figure shows the result of this counterproductive priming.

Food and food deprivation are emphasized by the diet, and therefore the intent to ignore food is subverted (Heatherton et al., 1990). In the delay of gratification studies, illustrating Prediction 5, it is important that the children were not told not to think of the treats but were given only the suggestion to think about something else, like the Slinky.

Reconstruing the Meaning of the Hot Stimulus

External strategies: Cool presentation. Prediction 6. When the cool rather than the hot characteristics of the nominal stimulus are presented, as when a picture of the object rather than the object itself is shown, cool-system control is enhanced and the go response is inhibited.

This situation is illustrated in the hot/cool framework in Figure 5, left panel, which shows that the picture activates cool features that are merely informative and that interconnect only with one another. They give knowledge that the stimulus has appetitive value but do not connect directly to the hot spots, in the hot system. Only very specific appetitive nodes connect to the hot spots for the object. As can be seen in Figure 5, a cool picture of the object is closely related to the object itself in the input vector. Although related, the two inputs are different. The actual object connects both to the cool knowledge, which includes features like its shape, size, figure–ground relations, nutritional value, knowledge that it tastes good, spatiotemporal context, and so on, and also to the hot spots, which are feeling fragments, such as the feeling of "yumminess," "deliciousness," and "chewiness"—appetitive feelings that the person has or expects to have when consuming the treat. In contrast to the real object (which can be consumed), the picture of the object contains the cool information about the object, such as its appearance, color, shape, figure–ground relations, and the knowledge that it depicts a marshmallow, but, significantly, it lacks precisely those consummatory fragments that make it desirable and that elicit the go response. As one child put it, you can't eat the picture. While calling attention to the object of desire, it simultaneously diverts attention away from the hot aspects that would cause the person to lose control. As long as one thinks about the picture of the object of desire as *a picture,* it provides a near-ideal distractor.

From the present perspective, whereas exposure to the actual objects (rewards) should elicit the go response, particularly if the hot, appetitive aspects of the stimulus are emphasized, exposure to cooler versions of the stimulus, as in pictorial or symbolic representations, should attenuate the hot system, activate the cool system, and facilitate control efforts. Consistent with this expectation, exposure to realistic life-size color images of the rewards shown on a slide displayed throughout the delay period enhanced delay time appreciably (Mischel & Moore, 1973). Whereas in the baseline condition of exposure to the actual rewards average delay time tended to be about 1 min, when the images of the rewards were exposed during the delay period, the mean rose to about 9 min, with 13 of 16 children waiting the full 15 min until they obtained the delayed reward.

Internal strategies: Cool self-generated ideation about the object of desire. Prediction 7. When a person thinks about the cool properties and aspects of the stimulus rather than the hot properties, delay behavior is enhanced.

The hot/cool framework suggests that a pictorial representation

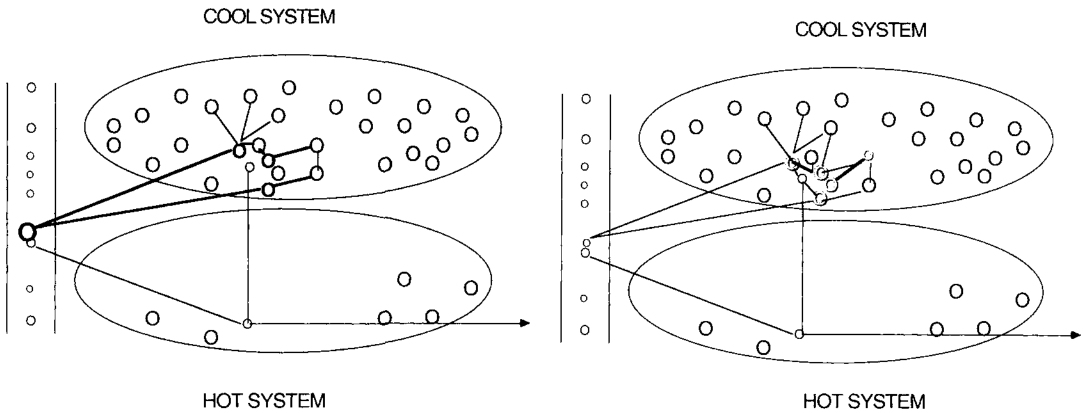

Figure 5. The left panel shows the effect of presenting an external stimulus that emphasized the cool, nonappetitive aspects of the stimulus. The right panel shows the effects of priming and thinking about the cool aspects of the stimulus without external input.

of the desired object, rather than the object itself, can enhance control efforts by directly activating that object's cool nodes rather than hot nodes. Likewise, a near-ideal control strategy to resist impulsive responding consists of internal activation of the cool aspects of the desired stimulus. If the individual is appropriately primed, activation of a hot spot, rather than triggering the go response, can evoke the object's cool representation, which then activates extensively primed networks of thought and reflection in the cool system that serve to bridge the delay interval. Cognitive control should be increased by cognitive transformations of the object of desire to access its cool aspects, for example, by mentally turning it into "just a picture."

Figure 5, right panel, shows a situation in which, rather than the cool aspects of the stimulus situation being driven by an afferent cool stimulus, the stimulus is in its canonical form and the cool aspects are self-generated internally. These cool aspects to the stimulus may gain ascendancy, despite the presence of the actual hot stimulus, because those aspects are highly primed in advance of the temptation challenge, because they have been highly learned, or because the gain control on the cool system is high, whereas that on the hot system is low. Under these conditions, activation is captured in the cool system, and the interval to response is lengthened.

A number of experimental studies speak to this prediction. In one such study, preschoolers were exposed to either the real rewards or pictures of them. The preschoolers were also instructed to transform the rewards "in your head" during the delay, turning the real objects into pictures of them (e.g., "just put a frame around them in your head") or the pictures into the real objects by making believe "they're really there in front of you. . .you can see them and touch them and they're real" (Moore, Mischel, & Zeiss, 1976, p. 421). Delay behavior was influenced much more by how the children represented the objects mentally than by whether the children were actually facing them or their pictures. Thus, even when exposed to the real rewards, the children waited for them almost 18 min if they imagined them to be pictures rather than real. Likewise, delay was dramatically reduced when the children transformed the pictures into the real objects. It was their mental representation of the stimulus, either as real or as a picture, not its physical presence and reality, that controlled their behavior.

In perhaps the most direct test of the effects of focusing on the hot feeling aspects of the stimulus or on its cool representation, one group of children was primed to focus their thoughts on such qualities of the objects as the pretzels' crunchy, salty taste, whereas another group focused on cool properties and associations with other irrelevant stimuli, for example, by thinking about the pretzel sticks as thin, long logs (Mischel & Baker, 1975). (In control groups, similar ideation was suggested but directed at objects that were not the rewards in the delay situation.) Consistent with the present expectations, a focus on the hot aspects of the objects of desire in the situation made delay exceedingly difficult, whereas a focus on their cool representations and associations enabled successful self-control.

Developmental Effects

Implications of Overall System Development

Prediction 8. Because development of the cool system trails that of the hot system, with increasing age, control should become easier.

Figure 6, left panel, illustrates the start of this process, with a poorly developed cool system capable of only limited diversion from the hot system. The right panel shows the effects of further aging, with a cool system in danger of being overly developed, thus, in the extreme, risking becoming full of internal monologues and unable to feel or act. The left panel, then, refers to the state of the two systems one would expect in a young child; the right panel shows the system in maturity.

If the cool system is well developed, the activated hot spot, corresponding to the hot properties of the treat, will automatically activate corresponding cool nodes, which then allow access to all of the complex associations in the cool system diverting activation rather than leading directly to the hot response. As the cool system itself becomes more elaborate and developed, the possibility of this redirection away from the hot system into the cool system increases, and cool control can replace stimulus control.

Empirically consistent with these expectations, delay of gratification tends to become less difficult and more likely with increasing age (Gollwitzer, 1996; Mischel et al., 1996; Mischel &

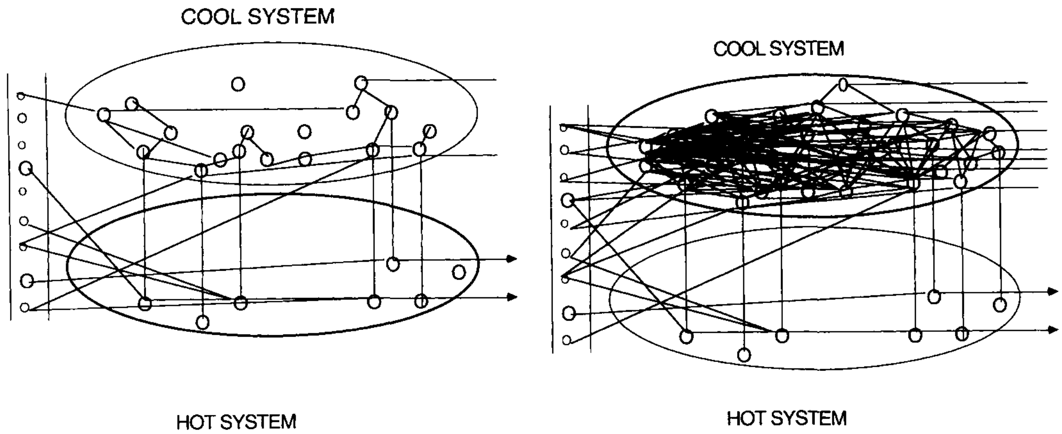

Figure 6. The left panel shows the development of the hot and cool systems in a young child, whereas the right panel shows the increasing development, especially of the cool system, with maturation.

Metzner, 1962; Mischel & Patterson, 1976, 1978) and appears to be virtually impossible for most children before approximately 4 years of age (Mischel, 1974). It also has been found that effective attention deployment tends to be related to both verbal intelligence and age (Rodriguez et al., 1989). In children from ages 6 to 12 years, presumably as the cool system continues to develop and internal control strategies become increasingly available, whether or not the object of desire is physically exposed or obscured from attention no longer influences delay ability (Rodriguez et al., 1989). Instead, delay time depends on the individual's attention deployment during the delay period and related internal cooling strategies that distract attention from the hot features of the stimulus.

The developmental predictions of this framework for impulse control in old age are straightforward: It should become easier. Indeed, it may be important for the well-being of the person to attempt to activate the hot system rather than the cool system to allow sustained motivation and prevent a pattern of possible apathy and withdrawal. Although this prediction follows directly from the model, we know of no experimental data bearing on this issue.

The Development of Metacognitive Awareness

The increasing development of the cool system with age is reflected in the systematic growth of the child's metacognitive understanding. In the delay of gratification situation, explicit knowledge of the value and nature of various cooling strategies emerges in a systematic manner that is in keeping with the strategies outlined above. Data from several studies (e.g., Mischel, 1981; Yates & Mischel, 1979) suggest that in the course of development most children become increasingly aware of the principles of self-regulation needed to sustain self-imposed delay of gratification in the pursuit of a desired but delayed contingent goal, and their growing metacognitive insight into these processes appears to follow an orderly developmental progression.

When children between 3 and 8 years old were asked whether they would prefer to have the rewards exposed or covered if they were required to wait in the self-imposed delay paradigm (Mischel & Mischel, 1983), those under 4 showed no preference for covering or exposing the rewards and were generally unable to justify their choice, thus essentially guessing. Children between 4 and 4.5 years old showed a strong preference for waiting with the rewards exposed and thus selected the very strategies that made it most difficult for them to wait. This strong preference for the worst strategy for self-control fits the "negativistic" and stubborn behavior patterns typically attributed to this age group, but the self-defeating preference for waiting with the rewards uncovered diminishes by the end of the 4th year. It is not until the end of the 5th year, however, that most children clearly preferred to wait with the rewards hidden from view and began to offer reasons for their choices that indicated they understood the frustration-reducing effect of obscuring the desired rewards.

The same study also investigated whether the children would prefer thinking about the task (e.g., "I am waiting for the treats") or thinking about the hot consummatory aspects of the treats (e.g., how yummy they are). Children less than 5 years old showed no clear preference in this choice, but by the age of 5 they began to systematically prefer to think about the task rather than the hot features of the treats, and with increasing age their reasons for this choice became more lucid: The older children more often realized that telling themselves how desirable the treats were would only make it harder to wait for them. This study also found that by Grade 6, children understand the value of choosing cool, abstract ideation (e.g., thinking about marshmallows as clouds) rather than hot ideation, an understanding not apparent in children third grade and younger. This recognition becomes evident at about the same stage of development in which Piaget noted the emergence of operational thought, the types of cool mental operations that would enable use of an abstraction strategy.

Stress

Effect of Acute Stress on Control Strategies

Prediction 9. As stress increases, dominance should increasingly shift from the cool system to the hot system, making delay of gratification more difficult.

As we noted earlier, the hot system is increasingly potentiated by stress, whereas the cool system is potentiated by low levels of stress but then is inhibited by high levels. Figure 7 shows the

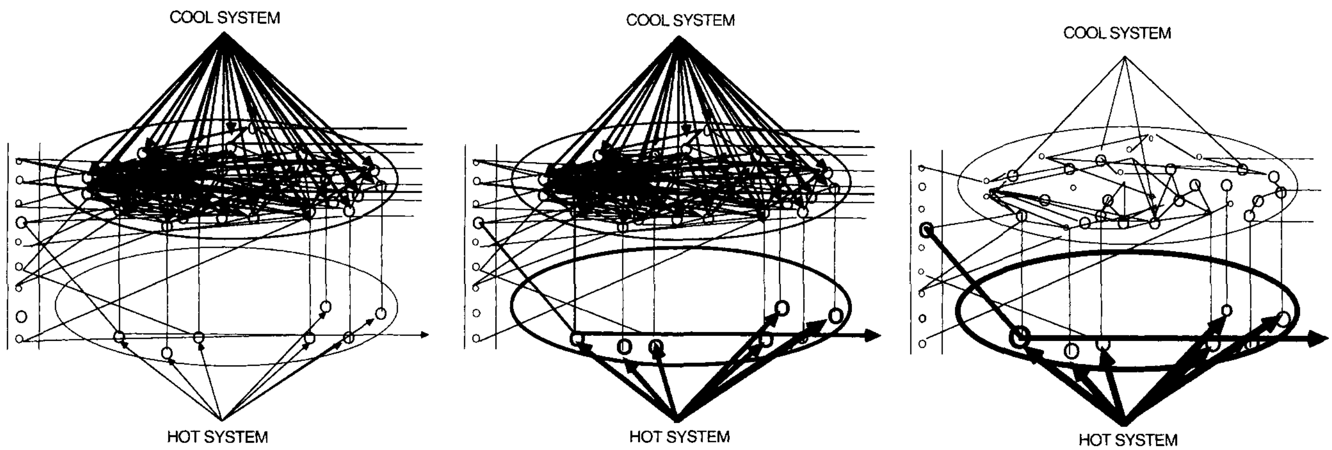

Figure 7. The left panel shows the hot and cool systems under low levels of stress. Both the hot and cool systems are somewhat activated, as shown by the extrasystem (but internal) inputs into the systems. The central panel shows the hot system being increasingly activated as a function of higher levels of stress, as indicated by the increasing input by the extrasystem arrows. All hot-system responses begin to be potentiated. The right panel shows the effects of traumatic stress. The hot system is hyperresponsive, whereas the cool system is becoming dysfunctional.

relative activation of the hot and cool systems at low, high, and traumatic stress levels.

Some data relevant to the prediction that increasing stress attenuates the cool system and activates the hot system is available from the delay of gratification situation, if we allow that negative ideation might be considered a stressor. Sapolsky (1996; Jacobson & Sapolsky, 1991) has argued that psychological stressors are physiological stressors as well, and it can be demonstrated that psychological stressors can profoundly inflate physiological stress mechanisms, such as the release of glucocorticoids (Joels & de Kloet, 1992). Thus, we describe the following studies as stress studies, with the caveat that physiological measures of stress and more direct measures of the stressfulness of certain situations and thought processes need further investigation.

Instructing individuals to "think fun," thereby decreasing stress, facilitated control (Mischel et al., 1972). Children in this condition were able to delay over 13 min, whereas children who were given either no instructions or were instructed to think negative thoughts such as "falling down and getting a bloody nose which hurts a lot, or you can think of crying with no one to help" delayed 5 min or less. Consistent with present predictions, then, distraction that is stress inducing is likely to be ineffective.

In other domains, both stress itself and negative ideation are related to self-regulatory breakdown. As Baumeister and Heatherton (1996) noted in their review of self-regulation failures, when people are under stress they not only become more emotional and irritable but they are also more likely to increase smoking, break their diets, abuse alcohol and other drugs, and engage in other hot-system behaviors. Baumeister and Heatherton attributed this systematic finding to a strength model, whereby different self-regulatory functions compete for a limited cognitive strength, which is depleted under stress. We augment and elaborate on their interpretation in the present framework grounded in the physiological impact of stressors because the hot-system function is enhanced by stress, whereas the cool-system functions are specifically inhibited.

Effects of Chronic Stress on Willpower

Prediction 10. Chronic stress has a selective negative impact on the cool system, and hence chronic stress should be reflected in systematic and relatively stable decreases in impulse control.

Sapolsky (1996) provided considerable evidence to suggest that people and animals who have been subjected to chronic stressors have measurably smaller hippocampal volume. As a result of the selective vulnerability of the hippocampus to stress, we should find that chronic stress results in an inhibition of the cool system. The effects of stress on other brain structures are not yet well documented. Given the selective effects of chronic stress on at least one cool-system structure, though, we expect that children who live under conditions of chronic stress should be less likely to delay gratification.

Rutter (1987) showed a correspondence between living in environments of high stress and low delay of gratification. It is of considerable interest that the same children and young adolescents who showed impaired ability to delay gratification are also those who are more likely to show higher levels of physical and verbal aggression interpersonally (Rodriguez, Shoda, Mischel, & Wright, 1998). As Gottfredson and Hirschi (1990) have noted, self-regulation deficits often show a broad spectrum, with a "typical" criminal, for example, engaging in a variety of different crimes, being likely to smoke, abuse drugs and alcohol, spend money impulsively, become involved in unwanted pregnancies, and have a high absentee rate from school or work. An imbalance between the two systems that favors the hot system may help account for this pattern of disregulation.

Discussion

The foregoing illustrated in detail that predictions generated by the hot/cool framework closely fit the empirical findings of studies with preschoolers trying to wait for bigger treats later instead of taking an available smaller one immediately—findings that initially contradicted the researchers' own theoretical expectations. Does such behavior speak to the real dilemmas of life that require strategic self-control?

Long-Term Implications of Delay of Gratification

A series of longitudinal follow-up studies of these preschoolers (Mischel, Shoda, & Peake, 1988; Shoda et al., 1990) provided parental ratings and objective test scores for them years later in adolescence and young adulthood. It thus was possible to examine whether the delay of gratification shown by the preschoolers in the relevant laboratory conditions (e.g., when the strategies for delay were self-supplied spontaneously rather than primed by the experimenter) predicted their later self-regulatory competencies and adaptive long-term developmental outcomes (e.g., Mischel et al., 1988; Shoda et al., 1990). The lengths of time the 4-year-olds were able to delay in the relevant conditions were clearly linked to indexes of their cognitive competence as adolescents and young adults. For example, seconds of preschool delay time significantly predicted verbal and quantitative scores on the SAT administered in adolescence (Shoda et al., 1990). It also correlated significantly with parental ratings of competencies, including ability to use and respond to reason, planfulness, ability to handle stress, ability to delay gratification, self-control in frustrating situations, and ability to concentrate without becoming distracted.

These findings, which support the meaningfulness of the delay situation as a measure of self-control and are a key component of the emerging construct of emotional intelligence (Cantor & Kihlstrom, 1987; Goleman, 1995), lend some credence to the value and generality of the hot/cool framework that directly predicts delay of gratification or its failure in that situation. Beyond the laboratory and in daily life, the importance of delay of gratification is self-evident: It is a commonplace recognition that, although some people seem able to adhere to stringent diets, give up cigarettes after years of smoking them addictively, or continue to labor for distant goals even when sorely frustrated, others fail at these efforts even when they know it may cost them their health and life. Such failures were called *akrasia* (a deficiency of the will) by the ancient Greeks, and contemporary lay (and sometimes professional) explanations using similar concepts of a character trait leave it equally mysterious today.

Willpower as Strategic Use of Hot/Cool Interactions

The hot/cool framework, as illustrated in the predictions generated for the delay of gratification paradigm, attempts a systematic analysis of how the hot and cool systems interact in ways that can easily and inadvertently undermine willpower—making its common failures understandable—but that also can be harnessed in its service. In the hot/cool analysis of willpower, rather than strive to be a stoic, the individual converts the aversive aspects of the struggle by the types of thought and actions suggested in the preceding analyses. The analysis suggests that what matters most for purposeful self-regulation and mental control is the representation of hot versus cool, self-primed ideation and distraction, cooling operations, transformations of the hot stimulus, avoiding drift to hot spots, and enriching the cool network. Individuals who have such self-regulatory competencies, who have the attention skills, the necessary metacognitive knowledge, and who manage to tame the dominance of the hot system in the service of cool goal pursuit also will be able to use them to effectively manage other academic and social complex tasks requiring extensive delay of gratification, as, for example, those needed to achieve high SAT scores and attain good academic grades.

It remains to be seen if the hot/cool framework also allows characterization of the dynamics of a range of self-defeating and self-destructive behaviors such as impulsivity and failures of self-control, irrational fears, and addictions of many sorts, that theoretically reflect distinctive dysfunctional interactions between the hot and cool systems. Conversely, it should be interesting to explore how strategic control of the hot/cool system might be used to overcome the power of stimulus control, to exert "volitional control" (by use of heating and cooling strategies) to facilitate social–emotional functioning in diverse contexts (Gollwitzer & Moskowitz, 1996; Mischel, Cantor, & Feldman, 1996), and perhaps even to reframe traumatic memories and cope with intrusive ideation (Metcalfe & Jacobs, 1998).

Understanding and mastering the phenomena of willpower has long been a human preoccupation, articulated in ancient times by the classic Greek philosophers and represented in civilization and history ever since Adam failed to overcome the immediate temptations of Eve and so lost paradise forever. In Freud's metaphor a century ago, the challenge was to find a way to get the ego to be where the id was. In psychology's current agenda, the analysis of self-regulation, and especially the failure to self-regulate, remains central, playing an increasingly dominant role in theories of the self and in conceptions of how humans can manage to achieve mastery over their own self-defeating vulnerabilities (e.g., Baumeister & Heatherton, 1996; Cantor & Kihlstrom, 1987; Heatherton & Ambady, 1993; Mischel et al., 1996; Rutter, 1987). An important basic ingredient in these analyses is the concept of *strength* (Baumeister, Heatherton, & Tice, 1993)—perhaps a less unscientific term than *willpower* but just as much in need of a theory that specifies how it comes about and operates and when it goes up and down, and who has it and who lacks it.

The present two-system analysis attempts to provide at least the outlines for such a theory. Each of the two distinct systems that are postulated—hot and cool—and that in different forms and metaphors have so persistently resurfaced in analyses of the cognition–emotion interplay within human nature, has held center stage at different points in the history of the field. The hot system as here defined, with its largely unmediated automatic reflexive reactions to the hot stimuli in the environment that push and pull and control it, was the focus of half a century of behaviorism. In recent decades, the cognitive revolution's discovery of the depths and riches of the cool system have made it dominant and even preemptive, and in the excitement it is easy to lose altogether some of the fundamental phenomena subsumed by the hot one. Even so, much, if not most, of what people think, feel, and even consciously experience may be elicited virtually automatically (Bargh, 1996) and under stimulus control, reflexive more than reflective, elicited more than mediated. It is not just that it is important to take account of both hot and cool representations or framings of stimuli—like the tempting treats in the delay of gratification paradigm—and the differential impact that each type of framing has predictably on the ability to sustain self-control. These effects have long been known and documented particularly within the delay of gratification paradigm. It is, rather, in the dynamics—in the exquisite details—of the interactions between the two systems that the mechanisms that manifest as human strength or willpower may reside.

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Received September 22, 1997
Revision received March 23, 1998
Accepted March 27, 1998 ■