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'Willpower' over the life span: decomposing self-regulation

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In the 1960s, Mischel and colleagues developed a simple 'marshmallow test' to measure preschoolers' ability to delay gratification. In numerous follow-up studies over 40 years, this 'test' proved to have surprisingly significant predictive validity for consequential social, cognitive and mental health outcomes over the life course. In this article, we review key findings from the longitudinal work and from earlier delay-of-gratification experiments examining the cognitive appraisal and attention control strategies that underlie this ability. Further, we outline a set of hypotheses that emerge from the intersection of these findings with research on 'cognitive control' mechanisms and their neural bases. We discuss implications of these hypotheses for decomposing the phenomena of 'willpower' and the lifelong individual differences in self-regulatory ability that were identified in the earlier research and that are currently being pursued.

Keywords: self-regulation; delay of gratification

INTRODUCTION

Resisting temptation in favor of long-term goals is an essential component of social and cognitive development and of societal and economic gain. In the late 1960s, Mischel and colleagues sought to identify and demystify the processes that underlie 'willpower' or self-control in the face of temptation in preschoolers. With that goal, Mischel developed the delay-of-gratification paradigm (popularized in the media as the 'marshmallow test'). This now-classic laboratory situation measures how long a child can resist settling for a small, immediately available reward (e.g. one mini-marshmallow) in order to get a larger reward later (e.g. two mini-marshmallows; e.g. Mischel *et al.*, 1972; Mischel *et al.*, 1989; Mischel and Ayduk, 2004).

What began as a set of experiments with preschoolers turned into a life-span developmental study, providing a unique behavioral archive for tracing the development and implications of early self-regulatory ability over the life course. Four decades later, this research is continuing to reveal remarkable patterns of coherence in consequential psychological, behavioral, health and economic outcomes from early childhood to mid-life—the current age of the original preschool participants. Given these provocative findings and the methodological advances now available for probing self-control with increasing depth at multiple levels of analysis, this longitudinal sample provides a unique opportunity for understanding the basic cognitive and neural mechanisms underlying 'willpower' and enabling effective self-regulation. In this article, we highlight the important early findings from this research program, and then describe a new era in this research currently being pursued by an interdisciplinary team of investigators working with samples from the original studies, now focused on the biological substrates of self-regulation.

To describe our sample briefly, over 500 original participants, primarily children of faculty and graduate students at Stanford University during the late 1960s and early 1970s, completed the delay-of-gratification task at the age of 4 years at Stanford's Bing Nursery School. The study was not originally designed as a longitudinal study; consequently, records of participants' addresses were not kept up-to-date. Nevertheless, over one-third of the participants responded to follow-up mailings sent to their original addresses and to addresses identified through an Internet search about a decade after their initial testing, and once a decade thereafter. The current data collection effort focuses on these participants, who now reside in a variety of locations throughout the USA and beyond.

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PREDICTIVE VALIDITY OF DELAY OF GRATIFICATION: THE LONGITUDINAL STUDIES

The significance and predictive validity of delay ability in preschoolers for social, cognitive and mental health outcomes in later life have been demonstrated in a variety of domains. For example, the number of seconds preschoolers waited to obtain a preferred but delayed treat in this diagnostic laboratory situation predicted significantly higher SAT scores and better social cognitive and emotional coping in adolescence (Mischel *et al.*, 1988; Shoda *et al.*, 1990). In follow-up studies, preschool delay ability continued to predict later outcomes in adulthood including higher educational achievement, higher sense of self-worth, better ability to cope with stress and less cocaine/crack use particularly in individuals vulnerable to psychosocial maladjustment (Ayduk *et al.*, 2000). Such findings are consistent with prospective, longitudinal studies in separate samples using different assessments of 'willpower'. For instance, Kubzansky *et al.* (2008) found that ratings of the ability to stay focused on a task and persistence in problem solving at the age of 7 years by a trained psychologist predicted physical health 30 years later, even when controlling for childhood social environment and child health. Another study found that preschoolers who, after initially deciding to wait for a more desirable delayed reward, settled for an immediately available but less desirable reward, were 30% more likely to be overweight at the age of 11 years than those who continued to wait for the delayed reward (Seeyave *et al.*, 2009; see also Francis and Susman, 2009 for a similar finding).

Especially exciting, early delay ability seems to buffer against the development of a variety of dispositional vulnerabilities later in life, such as features of borderline personality disorder (Ayduk *et al.*, 2008). Parallel findings have been reported with diverse demographic populations, including middle school children in the South Bronx, NY (Ayduk *et al.*, 2000), and children in a summer residential treatment program for youths at high risk for problems of aggression/externalization and depression/withdrawal (e.g. Rodriguez *et al.*, 1989). For example, delay ability predicted less physical and verbal aggression, less bullying behavior and higher self-worth and self-esteem. These findings underline the importance of uncovering strategies that children can use to self-regulate and overcome immediate temptations. These strategies may ultimately help them later in life to overcome increasingly demanding contexts that require exertion of 'willpower'.

EXPERIMENTS ON COGNITIVE TRANSFORMATIONS/ REAPPRAISAL: STRATEGIES TO ENHANCE DELAY

A series of early experiments revealed a number of strategies that enable delay of gratification, allowing individuals to resist temptation in favor of long-term goals. Broadly speaking, these strategies involve redirection of attentional focus or altering the cognitive representation of the object of temptation. For example, self-distraction by looking away from the temptation can be an effective strategy to reduce the frustration of continuing to wait; this is observed in successful preschool delayers compared with those who cannot delay (Mischel *et al.*, 1972, 1989; Mischel 1974). Another strategy is reappraisal or reframing of a situation away from the 'hot', appetitive or consummatory features of the tempting stimuli toward 'cooler' representations. For example, in an effort to resist the temptation to get the one marshmallow available immediately, rather than continuing to wait for two marshmallows, an effective strategy is to envision the marshmallow as a cloud or a little cotton ball, rather than as a sweet, delectable treat. Such reappraisal processes have been shown to be highly effective in enhancing delay of gratification. The same preschool child who yielded immediately to the temptation by representing the rewards focusing on consummatory features (e.g. its yummy, sweet, chewy taste) could wait for long periods of delay for the same tempting stimulus by focusing on its non-consummatory qualities (e.g. its shape). These results have been fully described elsewhere (see e.g. Mischel *et al.*, 1972; Mischel, 1974; Mischel *et al.*, 1989; Mischel and Ayduk, 2004). Although these experimental demonstrations have been short term and confined to brief laboratory situations, they suggest that the strategies required to successfully self-regulate can be taught.

In sum, the early experiments examining delay of gratification showed that mental representations that are 'hot' or appetitive (consummatory) hinder delay because they make it too difficult to resist the prepotent response of reaching for the immediately available treat. In contrast, representations based on attention to the 'cool', cognitive, abstract aspects of the situation have the opposite effect (Metcalfe and Mischel, 1999; Mischel and Ayduk, 2004). Thus, it follows that delay of gratification in this paradigm depends on the ability to control the aspects of the situation to which one attends and on the ability to control how it is mentally represented.

IN SEARCH OF UNDERLYING COGNITIVE MECHANISMS: CURRENT DIRECTIONS

The ability to resist temptation in favor of long-term goals, as observed in the delay-of-gratification task, has been suggested to be a form of cognitive control (Eigsti *et al.*, 2006). A key component of cognitive control processes is the ability to suppress or override competing attentional and behavioral responses (Kahneman *et al.*, 1983; Allport, 1987; Cohen and Servan-Schreiber, 1992, Casey *et al.*, 2000, 2002; Jonides and Nee, 2006). This process has been included in a number of theories of attention and memory (Baddeley, 1986; Shallice, 1988; Cohen *et al.*, 1992; Desimone and Duncan, 1995) and referred to using a variety of terms (e.g. 'central executive', 'attentional bias', 'cognitive control'). The terminology suggests a mechanism that is required to direct or guide appropriate actions (Miller and Cohen, 2001). For example, Shallice (1988) proposed a 'supervisory attention system' as a system for inhibiting or replacing routine, reflexive behaviors with more appropriate behaviors. Desimone and Duncan (1995) describe top-down biasing signals as important in attending to relevant information by virtue of mutual inhibition or suppression of irrelevant information (see also Jonides and Nee, 2006).

Although the description of cognitive control suggests a unitary process, the neural mechanisms underlying control may differ as a function of the type of information being suppressed and the stage of processing at which control must be exerted (Casey *et al.*, 2000; Casey 2005). A recent meta-analysis of over 40 neuroimaging studies of a variety of tasks measuring cognitive control supports this notion (Nee *et al.*, 2007). Nee *et al.* (2007) showed non-overlapping patterns of brain activation across a number of cognitive control tasks including Stroop, Go/Nogo and Flanker tasks. This conclusion is supported by the lack of (or low) behavioral correlations among diverse tasks that all allegedly recruit cognitive control (Tipper and Baylis, 1987; Kramer *et al.*, 1994; Earles *et al.*, 1997; Grant and Dagenbach, 2000; Shilling *et al.*, 2002). Thus, both imaging and behavioral evidence suggests that processes involved in resolving interference come from a 'family of functions' rather than from a 'single unitary construct' (Dempster, 1993; Harnishfeger, 1995; Nigg, 2000; Nelson *et al.*, 2003; Friedman and Miyake, 2004; Nee *et al.*, 2007; Nee and Jonides, 2008, 2009), and that these distinct functions can be linked to distinct underlying neurobiology.

From a behavioral perspective, the critical component of the delay task is to resolve the conflict between taking one treat now *vs* waiting for two treats later. However, the specific cognitive information processes that enable delay of gratification have not been well characterized. Is delay achieved by: (i) blocking the entry of unwanted information (e.g. shutting out information by paying attention to something else); (ii) suppressing unwanted thoughts (e.g. by thinking about something else) or (iii) stopping an action in favor of an alternative one (e.g. suppressing a response or impulse)? We are using a set of laboratory procedures designed to measure each of these possible cognitive processes to further delineate the basic mechanisms underlying delay.

EXPLORING BRAIN FUNCTIONS AND STRUCTURES UNDERLYING DELAY OF GRATIFICATION

Ultimately, our goal is to delineate the neural correlates of these processes using magnetic resonance imaging. These studies are underway, although we are still in the early stages of data collection. Prior research has identified areas of the brain that become differentially activated when people engage in the three processes described above (blocking unwanted information, suppressing unwanted thoughts and inhibiting responses), as well as connections among areas of the brain that seem to play a key role in these tasks. We are currently assessing these functional and anatomical features to examine whether they are related to these three aspects of effective self-control.

Specifically, we predict that participants with consistently low levels of self-control, compared with their consistently high-control counterparts, will be characterized by less refined connectivity (e.g. less myelination and orientation regularity) in frontostriatal (Liston *et al.*, 2006; Casey *et al.*, 2007) and frontoparietal circuitry (Jonides *et al.*, 1998, 2000; Nagy *et al.*, 2004), which are critical for effective cognitive control, but elevated activity in this circuitry when correctly performing cognitive control tasks, especially those that require control in the face of incentives. We are testing this prediction by conducting diffusion tensor imaging (DTI) and functional MRI. Participants in this study have been invited to come to the Lucas Center for Imaging at Stanford University; several individuals have now been scanned.

Finally, because the participants are reaching middle adulthood and the most productive years of their lives, we are assessing consequential outcomes such as occupational and marital status, social, cognitive and emotional functioning as well as mental and physical health and behavior patterns relevant to mental and physical health and economic and social well-being.

IMPLICATIONS AND NEXT CHALLENGES

In our ongoing interdisciplinary project, we suggest that the preschoolers who were able to delay gratification made more use of certain inhibitory processes than did those who were low-delayers, and that it is this difference in inhibitory ability that persisted into adulthood and led to the sequelae of their ability to delay gratification in preschool, such as advantageous health-protective outcomes and adaptive social cognitive development. The relation we propose between cognitive control and willpower, as manifested in the delay-of-gratification studies and their resulting sequelae, is as follows: willpower requires skill in overcoming tempting immediate rewards, distractions and frustrations in favor of greater but delayed rewards. This skill, in turn, requires that individuals encode only information from the environment that is relevant, keeping wanted information active in working memory and suppressing unwanted information and selecting desired responses while withholding responses that are not optimal. Findings so far are encouraging but still tentative: with further follow-up assessments we hope to test these hypotheses with greater precision.

Concluding remarks

Taken collectively, findings from the Bing study over many decades converge with those from other studies of 'willpower' and executive functions at the social cognitive (e.g. Mischel and Ayduk, 2004) and brain levels of analysis (Casey *et al.*, 1997, 2000; Ainslie and Monterosso, 2004; McClure *et al.*, 2004; Hare *et al.*, 2005; Aron and Poldrack, 2006; Nee and Jonides, 2008; Somerville *et al.*, in press). They lead to a clear, albeit still tentative, set of hypotheses about the underlying cognitive mechanisms, as discussed above, that we are currently testing.

Ultimately, it may be possible to target and harness the underlying mechanisms into readily teachable interventions to achieve sustained and consequential behavior change. The early experimental studies of the cognitive strategies that enable delay of gratification demonstrated that at least in laboratory situations, it is possible to dramatically enhance this ability through the use of relatively simple attention control and cognitive re-appraisal manipulations (Mischel *et al.*, 1989; Mischel and Ayduk, 2004).

To recapitulate, the skills and motivations that enable the phenomenon of 'willpower', and particularly the ability to inhibit prepotent 'hot' responses and impulses in the service of future consequences, appear to be important early-life markers for long-term adaptive mental and physical development. The health protective and other adaptive consequential life outcomes predicted by delay of gratification ability early in life, as reviewed at the start of this article, document the importance of this ability for well-being from childhood into mid-life.

For those who are interested in the skills, behavior patterns, cognitive and neural mechanisms underlying adaptive and healthy aging, the Bing Longitudinal cohort provides a truly unique opportunity. As these participants move into the next phase of the lives, the possibility that the self-regulatory competencies reflected in the ability to delay gratification exert adaptive and protective influences on the aging process is a particularly exciting prospect for further investigation. Such work is certain to benefit from interdisciplinary teams working at multiple levels of analysis from the social cognitive and behavioral, to the neural and genetic. This work will also permit a close examination of individual differences and psychobiological processes that underlie important outcomes, ranging from physical and mental health and well-being to economic, social and educational achievement over the life course.

Conflict of Interest

None declared.

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