Zooming in on Children's Behavior During Delay of Gratification:
Disentangling Impulsigenic and Volitional Processes Underlying Self-
regulation

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Abstract

When delaying gratification, both motivational and regulatory processes are likely to be at play; however, the relative contributions of motivational and regulatory influences on delay behavior are unclear. By examining behavioral responses during a delay task, this study sought to examine the motivational (anticipatory behavior) and regulatory mechanisms (executive function and self-control strategies) underlying children's self-regulation. Sixty-five 5- to 9-year-old children ($M_{age} = 7.19$ years, $SD = 0.89$) were video-recorded during a delay procedure and later coded for anticipatory behaviors (e.g., gazing intensely at the tablet) and self-control strategies. Children also completed two executive function (EF) tasks. We found that anticipatory behavior was curvilinearly related to delay time. Children showing either very low or very high levels of anticipatory behavior were not able to wait the entire time. Furthermore, our results indicated that anticipatory behavior interacted with EF to predict delay time. Specifically, anticipatory behavior was negatively related to delay time only if EF abilities were low. Finally, self-control strategies also interacted with EF to predict children's ability to delay. Spontaneous engagement in self-control strategies such as fidgeting and engagement in alternative activities were beneficial for children with low EF but were unrelated to delay time for children with high EF. Results indicate the value of examining motivational and regulatory influences on delay behavior. Lapses in self-regulation may be due to the combination of powerful impulsogenic (i.e., anticipatory behavior) and weak volitional processes (i.e., EF, self-control strategies).

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Zooming in on Children's Behavior During Delay of Gratification:

Disentangling Impulsigenic and Volitional Processes Underlying Self-regulation

Delaying gratification is challenging. Yet, children encounter many *don't contexts* (cf. Kochanska, Coy, & Murray, 2001) in which they are requested to suppress pleasant, rewarding behavior. Learning to resist temptation in favor of long-term goals requires self-regulation which is an essential component of social and cognitive development and predicts important later life outcomes (e.g., Blair & Raver, 2015; Moffitt et al., 2011). When delaying gratification, both motivational and regulatory processes are likely to be at play (e.g., Duckworth & Steinberg, 2015; Metcalfe & Mischel, 1999); however, how and why children are able to wait for a reward is still poorly understood. Even when delaying successfully, there is variation in what children do during the waiting time. Recent research suggests that these behaviorally observable differences (e.g., some children look directly at the rewards whereas others divert their gaze away; some children wait calmly while others fidget) are associated with differences in physiological and behavioral profiles (Wilson, Lengua, Tininenko, Taylor, & Trancik, 2009) and predict performance more than 10 years later on a task that requires cognitive control at the level of response execution (Eigsti et al., 2006). By examining behavioral responses during a delay task, the present study sought to examine the motivational and regulatory mechanisms underlying children's delay behavior. Specifically, we hypothesized that regulatory (executive function) and motivational processes (anticipatory behavior) would interact to predict 5- to 9-year-olds' ability to delay. Further, we hypothesized that various regulatory processes (executive function, observed self-control strategies) would also interact to predict children's ability to delay.

Volitional and Impulsigenic Processes Underlying Self-regulation

Delay of gratification tasks are complex in that they likely elicit both motivational and regulatory processes. Variation in children's motivational and/or regulatory systems may therefore explain successful self-regulatory behavior during delay tasks. Indeed, "(...) lapses in self-control may be due to deficiencies in volitional processes, but they may also be due to excessively powerful impulsogenic processes" as Duckworth and Steinberg put it in their recent review titled *Unpacking Self-control* (2015, p. 35). The authors argue for distinguishing the overt expression of self-control (the term is used synonymously with the construct we refer to as self-regulation) from its underlying psychological processes which they group into two functionally distinct categories: *volitional processes* (e.g., executive function, metacognitive/ self-control strategies) that facilitate self-controlled behavior and *impulsogenic processes* (e.g., reward sensitivity/ temptation, reactive undercontrol, cravings, anxiety) that undermine self-controlled behavior by inclining individuals to act on immediately rewarding but ultimately costly and potentially harmful actions. Many influential theories of self-regulation reflect this taxonomy by using various terms to describe these two processes at play: for example, reactive attentional processes related to fear vs. effortful control (Derryberry & Rothbart, 1997), reactive vs. effortful control (Eisenberg & Morris, 2002), or hot vs. cool systems (Metcalf & Mischel, 1999). Research has shown that both impulsogenic and volitional processes contribute to adjustment (Lengua, 2003) and that taking both into account may differentiate the types of problems children are likely to develop (Eisenberg et al., 2004; Rubin, Stewart, & Coplan, 1995). Therefore, disentangling impulsogenic from volitional processes underlying children's self-regulation is crucial as it may have potential implications for children's adjustment.

Teasing volitional processes apart from impulsogenic processes, however, is challenging. First, children with high effortful control may partially modulate the

expression of impulsive tendencies and behaviors (Spinrad, Eisenberg, & Gaertner, 2007). In the context of a delay task for instance, those who delay are likely high on effortful control, but it is difficult to assess the degree to which they are impulsive. Second, whereas greater effort has been devoted to assess, describe, and train volitional processes underlying self-regulation (e.g., Diamond & Lee, 2011; Duckworth, Szabó Gendler, & Gross, 2014; Hughes, 2011), developmental researchers have examined to a lesser extent impulsogenic processes underlying self-regulation (Duckworth & Steinberg, 2015). In the present study, we aim to disentangle impulsogenic (anticipatory behavior) and volitional (executive function, self-control strategies) processes underlying children's ability to wait. First, we aim to assess by behavioral coding how tempted a child is to act on the immediate action (operationalized by anticipatory behavior) and then determine how levels of anticipatory behavior are related to delay time. Second, we will examine the role of executive function in regulating high levels of anticipatory behavior. Finally, by distinguishing various volitional processes (executive function, self-control strategies), we ask the question how they interact to contribute to children's ability to delay.

Volitional Processes: Executive Function and Self-control Strategies

Performance in the classic delay of gratification task has been shown to be facilitated by different cognitive strategies that children use (Mischel, Shoda, & Rodriguez, 1989). In this paradigm, preschoolers try to postpone immediate gratification in order to attain a more valued outcome later (e.g., two cookies instead of just one). Children's ability to control their attention in the face of temptation (i.e., attention deployment, reappraisal, engagement in alternative activities) has been shown to be the single most important correlate of delay time with older children (ages 5 to 13 years) (Metcalf & Mischel, 1999). At present, however, we do not

really know what leads children to spontaneously distract themselves from rewards, nor do we know much about the cognitive processes that underlie these self-control strategies in goal-directed self-regulatory situations.

Among the volitional processes facilitating goal-directed actions are executive function (EF). EF represent a complex and interrelated set of higher order cognitive processes, including the maintenance and manipulation of relevant information (updating/ working memory), inhibition of predominant responses (inhibition), and mental set shifting (shifting) (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). In the presence of temptations, EF may facilitate goal-directed behavior by allowing a child to keep abstract goals as active mental representations (working memory), voluntarily suppress the urge to give in the temptation (inhibition), and flexibly shift the focus of attention (shifting). Empirical evidence relating performance on traditional “cool” EF tasks (e.g., self-ordered pointing, Stroop) to delay tasks in young children, however, has been mixed, with some studies finding little support for an association (Hongwanishkul, Happaney, Lee, & Zelazo, 2005), others finding that these two types of tasks load onto distinct (although correlated) factors (Kim, Nordling, Yoon, Boldt, & Kochanska, 2013; Willoughby, Kupersmidt, Voegler-Lee, & Bryant, 2011), and still others finding support for one single latent factor (Allan & Lonigan, 2011; Sulik et al., 2010).

Only recently research has begun to examine how EF and self-control strategies are related to each other. For instance, psychological distancing from one's egocentric perspective (i.e., taking a psychologically self-distanced as opposed to a self-immersed perspective) improved performance on EF tasks (i.e., Minnesota Executive Function Scale which requires inhibition, working memory and shifting) in young children (White & Carlson, 2015). Children's ability to improve EF by mentally transcending their context underscores the potential of a mutual enforcing

relationship between EF and self-control strategies. In the present study, we therefore explore the interplay of different volitional processes (self-control strategies and EF) in order to examine how they interact to facilitate successful delay behavior.

All correlational studies (Eigsti et al., 2006; Peake, Hebl, & Mischel, 2002; Rodriguez, Mischel, & Shoda, 1989), showing that children who spontaneously diverted their gaze away from rewards waited longer than children who looked directly at the rewards, have treated attention deployment as dichotomous, (i.e., attention is either directed towards rewards or away from them). There may be good reasons, however, to think of attention deployment as a gradual process as opposed to just being present or absent. For instance, a child may look at the reward (low attention/ temptation focus), gaze intensely at it (moderate focus), or even touch it (high focus). Similarly, there may be observable differences in the intensity that a child attends to or engages in other activities: e.g., the child orients away from the reward (low engagement), plays around with something else (moderate engagement), or engages with something else (high engagement). The latter behaviors, however, have been rarely investigated in this research tradition.

Indeed, delay of gratification researchers have been mostly interested in the proportion of time that the child spend attending to consummatory aspects of the task (bell or rewards) (cf. temptation focus, Eigsti et al., 2006). Only one study, to our knowledge, coded separately for the proportion of time the child spent attending away from the reward – e.g., looking at the ceiling or singing – thus distinguishing between *hot* and *cool attentional focus* (Sethi, Mischel, Aber, Shoda, & Rodriguez, 2000). Interestingly, these two indices were moderately correlated but non-redundant as *hot* but not *cool focus* was significantly associated with delay time. The authors argue that exhibiting a cooling strategy may not predict success as strongly

as exhibiting a hot strategy predicts failure, because there is wider variability in both the type of cooling strategy used and the thoughts that may be occurring in the context of that cool strategy as opposed to the use of a hot strategy. To better understand the differential impact of these two distinct foci of attention on the ability to delay, the present study will consider both. Furthermore, we will assess the intensity of attentive behavior to capture individual differences on a continuum rather than the proportion of time attention is absent or present as it has been done in previous studies.

In order to measure self-control strategies as gradual processes, we will capitalize on temperamental research, which is per se interested in individual differences in the intensity of certain behaviors. Specifically, with the Laboratory Temperament Assessment Battery (Lab-TAB, Goldsmith, Reilly, Lemery, Longley, & Prescott, 1999) we will measure the intensity of a child's temptation by looking at intensities of anticipatory behavior which is identical with *temptation focus* (Eigsti et al., 2006) or *hot focus* (Sethi et al., 2000). In the same vein, we will assess intensities of engagement in alternative activities which is similar to *cool focus* (Sethi et al., 2000) and in the highest intensity (high engagement in alternative activities) somewhat overlapping with concurrent exposure to external stimuli (cf., playing with a slinky toy, Mischel, Ebbesen, & Zeiss, 1972). Whereas Mischel and colleagues provided a distracting activity to their participants (which helped more than half of the children to wait successfully), in our study, however, we will measure the spontaneous use of this strategy.

Furthermore, by relying on the same inhibitory control episode of the Lab-TAB we will assess degree of fidgeting. We consider fidgeting as a form of arousal-regulating strategy (Zentall & Zentall, 1983) with presumably highly aroused children engaging in fidgeting to calm themselves down, or alternatively, under-

aroused children engaging in fidgeting in order to increase cortical arousal and facilitating alertness (Sarver, Rapport, Kofler, Raiker, & Friedman, 2015). Thus, moderate levels of fidgeting may be ideal as indicated in the optimal stimulation model that explains motor activity in terms of the Yerkes and Dodson (1908) inverted U relation between arousal and performance. Taken together, in the present study, we aim to explore the intensity of important, naturally existing individual differences in the spontaneous use of self-control strategies.

Impulsigenic Processes: Anticipatory Behavior

To conclude that during a delay of gratification task a child is tempted, and thus exercising self-regulation, one must be confident that his/her personally valued long-term goals are in conflict with competing, short-term desires. Therefore, the crucial question is: How do we measure the strength of an individual's desires, impulses or motives? Whereas in Mischel's experiments it was always assumed that temptation was constant and high for all children (although allowing a child to choose from a selection of treats the one he or she likes best may increase the probability that all children are truly tempted), actually measuring how tempted a child is seems to be an important prerequisite to better understand why some children are able to wait and others are not. Neuroimaging, event-related potential, or physiological measures such as heart rate and pupil dilation may certainly provide valuable insights into these impulsigenic processes (Casey et al., 2011; Hepach, Vaish, & Tomasello; Wilson et al., 2009). Here, however, we take a different approach and will examine children's behavioral cues of temptation during delay.

As outlined above, we will assess a child's temptation (perceived attractiveness of the game or the strength of a child's desires and impulses for the game) by behavioral coding of anticipatory behavior. In line with the Yerkes and Dodson law (1908), we assume a curvilinear relationship between temptation and

delay time. The upward part of the inverted U can be thought of as the energizing effect of temptation/ arousal whereas the downward part is characterized by deteriorating effects of arousal on higher cognitive functions like self-regulatory abilities necessary to delay gratification (Blair & Ursache, 2011). The positive effect of temptation on delay time at the lower end of the scale can be thought of as a positive motivating value (Hebb, 1955) with children experiencing moderate levels of temptation possibly being motivated to wait whereas children experiencing no or very little temptation being too bored to wait. On the other hand, children who experience high levels of temptation are assumed to be experiencing negative effects of temptation thus being too excited to wait, or in other words too tempted to eat the cookie.

The Present Study

Our specific research questions and hypotheses are as follows. First, how tempted is the child to play with the game (i.e., how attractive is the task for the child) and how is temptation related to delay time? We hypothesized that anticipatory behavior and delay time would be curvilinearly related. Second, how do EF and temptation interact to predict children's ability to delay? We hypothesized that children who show high levels of anticipatory behavior would not be able to wait the entire time if they had low EF, however, high EF would allow them to wait successfully (interaction between anticipatory behavior and EF). Note that issues of multicollinearity prevented us from testing interactions among anticipatory behavior and self-control strategies. Third, how do different volitional processes interact with each other to contribute to children's ability to delay? We hypothesized that EF and self-control strategies would mutually enforce each other, thus children with high EF would benefit the most from self-control strategies (interactions between fidgeting/ engagement in alternative activities and EF).

Method

Participants

Sixty-five children (53.8% male) between 5 and 9 years ($M = 7.19$, $SD = 0.89$) attending either kindergarten, first or second grade participated in the present study. Children were recruited from private schools in New York City with high tuition requirements and were fluent English speakers. The majority of the children (72.3%) were non-Hispanic white. Participation was voluntary and parents and teachers gave their written informed consent. The Institutional Research Board (IRB) at New York University approved the study.

Procedure

Trained research assistants individually tested children from the end of March 2014 until February 2015 during a 1-hour session in a quiet room at the children's school. Fixed order of task administration was used, where all children first gave a little public speech (either adapted version of the Trier Social Stress Test–Modified, (TSST-M, Yim, Quas, Cahill, & Hayakawa, 2010) or a placebo TSST-M)¹, completed EF tasks, an emotional memory and fluid intelligence test (not part of the present study), and finally participated in the delay of gratification task which was videotaped and later coded second by second for temptation (anticipatory behavior) and self-control strategies (engagement in alternative activities and fidgeting). All children were praised for their hard work and received stickers and a \$25 gift card as a thank you for their participation.

Measures

Delay of gratification. The Bzz!INH task is a highly attractive computerized game that measures how well children can inhibit themselves from acting out a

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¹as both groups showed similar stress responses (Neuenschwander, Eberhart, Wang, & Blair, 2015), in the present study all analyses were performed across both groups. Note that results did not change if we did account for the two groups.

certain rewarding behavior. It is part of the comprehensive battery of the Child Neuropsychological Assessment Test (TENI, its Spanish acronym, Tenorio, Arango, Aparicio, & Rosas, 2012) and the Bzz!IHN task itself is based on a paradigm designed by Mischel and colleagues (1972). In this task flies appear on the screen of a tablet flying around at different speeds making buzzing noises. Touching the flies squishes them, which makes a squishing sound. Flies continue to appear so there are always ample flies to squish. This task consists of two phases. After a short practice trial, the child was instructed for the first phase: "Squish all the flies you can until I tell you to stop." This phase measures reaction time and engages the child. After one minute the research assistant told the child in a natural voice: "I have to leave the room for a while. I am going to leave the tablet here with the game running, but you must NOT play with it. When I come back we will keep on playing, okay?" Phase two began when the research assistant pressed the play button to initiate the "delay of gratification" phase and left the room for five minutes. The tablet recorded the time when the child touched the screen. The maximum waiting time was 300 seconds. Forty-three (67.7 %) of 65 children waited the entire delay period. The delay time in seconds is the dependent variable for this task.

Behavioral coding. Behavioral responses during the delay of gratification phase of the Bzz!INH task were coded second by second from videotapes using a computerized video coding system (*Better.Coding.Approach: Real-Time Coding*, 2013) that records frequencies and durations of specific behaviors. Within each category, only one specific behavior could be coded for at each second (i.e., specific behaviors within a category are mutually exclusive). Because a child could perform behaviors from multiple categories at the same time each category was coded for successively. Thus for each second of videotape, it was possible to have three behavior codes, but only one from each category. Coders were trained to achieve

80% of inter-rater agreement. A primary coder scored every variable. A second coder scored 30% of the data to ensure inter-rater reliability. Disagreements and initial refinement of the categories were resolved and accomplished through discussion.

The behavioral rating system was adapted from the Inhibitory Control Episodes (Snack Delay) of the Laboratory Temperament Assessment Battery (Lab-TAB) Preschool version (Goldsmith et al., 1999) which is based on Kochanska's work on individual differences in inhibitory control during a waiting task (Kochanska, Murray, & Harlan, 2000).

Anticipatory behavior. Intensity of anticipatory behavior was coded to measure children's temptation to play with the game. Four levels of anticipatory behavior were coded: *no* anticipatory behavior including behaviors such as displaying wandering attention, spacing out, and doing something completely different; *low* anticipatory behavior including behaviors such as sitting relaxed in the chair and having the tablet in one's view; *moderate* anticipatory behavior including gazing intensely at the tablet and body is indicating some tension; and *high* anticipatory behavior including touching and playing with the tablet. Mean inter-rater reliability was 90%. A composite score indicating mean intensity for anticipatory behavior was created by summing the weighted duration of each level (seconds of no anticipatory behavior multiplied by 0 + seconds of low anticipatory behavior multiplied by 1 + seconds of medium anticipatory behavior multiplied by 2 + seconds of high anticipatory behavior multiplied by 3). The mean was then calculated by dividing the sum score by the total duration of the task. The dependent variable was the mean intensity of anticipatory behavior.

Engagement in alternative activities. Intensity of engagement in alternative activities was coded to measure one type of children's self-control strategies. Four

levels of engagement in alternative activities were coded: *no* engagement in alternative activities including behaviors such as orienting towards the tablet; *low* engagement in alternative activities including behaviors such as orienting away from the tablet, looking around the room; *moderate* engagement in alternative activities including turning head or body away from the tablet, playing around with something else (e.g., pencil, hair); and *high* engagement in alternative activities including engaging with something completely different, getting out of seat. Mean inter-rater reliability was 87%. A composite score indicating mean intensity for engagement in alternative activities was created by summing the weighted duration of each level (analogue to anticipatory behavior). The mean was then calculated by dividing the sum score by the total duration of the task. The dependent variable was the mean intensity of engagement in alternative activities.

Fidgeting. Degree of fidgeting was coded to measure another type of children's self-control strategies. Four levels of fidgeting were coded: *no* fidgeting including behaviors such as sitting still at the table; *low* fidgeting including behaviors such as fidgeting discreetly; *moderate* fidgeting including behaviors such as fidgeting consistently, moving head, arms, legs in excitement, singing repetitive words in low voice, humming; and *high* fidgeting including kicking legs, clapping hands, singing repetitive words in a loud voice. For this category we needed to include a code "not codable" applicable whenever the child was out of camera view. Mean inter-rater reliability was 80%. A composite score indicating mean intensity for fidgeting was created by summing the weighted duration of each level (analogue to the previous two categories). The mean was then calculated by dividing the sum score by the total duration of the task. The dependent variable was the mean intensity of fidgeting.

EF. EF was assessed with two tasks described below.

Working memory. The Forward Backward Digit-Span task, was used to measure simple as well as complex working memory (Wechsler, 2002). The task consists of two parts. In the first part, the research assistant reads out numbers in 1-second-intervals and the child is asked to recall them in the same order. In the second part, the research assistant reads out numbers and the child has to recall them in a backward order. Both of these tasks start with two numbers per trial and advance until seven numbers per trial, with two trials per span. If the child fails in both trials of a given span the task is aborted. The dependent variable was the number of trials correctly recalled across both parts.

Shifting. The Hearts & Flowers task (Davidson, Amso, Anderson, & Diamond, 2006; Diamond, Barnett, Thomas, & Munro, 2007) is a computerized task that measures attention shifting. In this task, children have to react to a stimulus (heart or flower) that was presented for 2500 milliseconds by pressing one of two fuzzy buttons located on opposite sides of the keyboard. There are three blocks of trials in this game. During the first block consisting of 12 trials, hearts appear on either the left or the right side of the screen and children were instructed to press the fuzzy button on the same side as the heart. In the second block consisting of 12 trials, flowers appear on either the left or the right side of the screen and children were instructed to press the fuzzy button on the opposite side of the flower. Both blocks include a short instruction with eight practice trials. The last block consists of 33 trials in which hearts and flowers appear on either side of the screen in a pseudo-randomized order (mixed block). Children were instructed to press the fuzzy button according to the previously learned rules that is, they had to shift between the two rules depending on the presented stimuli (heart or flower). The dependent variable was the proportion of correct responses in the mixed block.

For the following analyses, we created an EF composite score by computing the mean of the two z-standardized variables ($r = .24, p < .05$).

Missing data. Overall, missingness was low and was due to either laptop malfunction or behavioral coding issues. Specifically, for two children the Hearts & Flowers task was not recorded. Their EF composite score is therefore only based on their performance on the working memory task. For behavioral coding, engagement in alternative activities was not codable for one child due to ambiguities in the behavior recorded on the video (this did not affect the rating of the other two channels). Outlier analysis revealed that no scores had values ± 3.3 standard deviations from the sample's mean.

Statistical Analyses

Data were analyzed with SPSS 22. To test our hypotheses multiple regression predicting delay time were run. Significant interactions were tested for significance in simple slopes to find areas of significance. Cohen's d will be reported as an estimate of the effect size.

Results

Table 1 presents the descriptive data for all measures incorporated in the present study and shows zero-order correlations among the included variables as well as their correlations with age and gender. As expected, significant associations with age were found in delay time and EF; that is, the older the children the longer they were able to wait and the better they performed on EF tasks. Interestingly, age did not correlate with behavior during delay (anticipatory behavior, engagement in alternative activities, fidgeting). Regarding gender, no significant effects were observed. Therefore, in the following regression analyses, only age will be included as a covariate. Regarding behavior during delay, as expected, anticipatory behavior

was highly negatively correlated with engagement in alternative activities.

Somewhat surprisingly, however, anticipatory behavior was also negatively (modestly) correlated with fidgeting. The two self-control strategies (engagement in alternative activities and fidgeting) were modestly correlated with each other. Note that regarding delay time, only anticipatory behavior showed a significant, modest negative correlation with delay time. As to EF, surprisingly, there was no significant correlation with any of the behaviors during delay nor with delay time.

Note that because of concerns regarding the skewness of the delay time variable, extensive diagnostic statistics were performed on all of the following regression models. Overall, regression models fit the data well, i.e., assumptions were met (normally distributed and independent errors; Durbin-Watson: all values < 1.2 and > 2.1; tolerance statistics: all values > .7, except for the model with quadratic effects) and no cases exerted undue influence over the parameters of the model (Cook's distance: all values < .30; DFBeta: all values < .85).

Table 1

Descriptives and Correlations of Delay Time and Study Variables Including Age and Gender

		1	2	3	4	Age	Gender	Mean	SD	Min-Max
1	Anticipatory behavior	--				-.12	-.03	1.20	.63	.02 – 2.99
2	Engagement in altern activities	-.83***	--			.03	-.04	.76	.61	0 – 2.69
3	Fidgeting	-.50***	.51***	--		-.10	-.03	.45	.32	0 – 1.58
4	Delay time	-.31*	.07	.19	--	.27*	-.03	233.12	108.16	2 – 300
5	EF composite	.12	-.09	.05	.00	.28*	-.14	0	.64	-1.51 – 1.90

Note. * $p < .05$, *** $p < .001$; Gender: 1 = girls, 2 = boys. EF = Executive Function. Behaviors during delay (i.e., anticipatory behavior, engagement in alternative activities, fidgeting) were rated on a scale from 0 to 3.

Anticipatory Behavior and Delay Time

To test the relation between anticipatory behavior and delay time, a linear regression was run with anticipatory behavior as well as the quadratic term of anticipatory behavior as predictors of delay time while controlling for age (z-score). After controlling for age ($B = 20.97$, $SE = 11.94$, $p = .084$), delay time was significantly associated with increases followed by decreases in anticipatory behavior as indicated by non-significant linear, ($B = 77.78$, $SE = 60.98$, $p = .207$), and significant curvilinear (quadratic) effects ($B = -48.88$, $SE = 22.34$, $p = .033$). The model accounted for 21.7% of the variance in delay time. As can be seen in Figure 1 there was a pronounced decline in delay time for children showing high levels of anticipatory behavior.

Figure 1. Children's temptation to play with the game (anticipatory behavior) as a function of delay time (sec). Age and linear effects of anticipatory behavior are being controlled for.

Anticipatory Behavior and EF Predicting Delay Time

Results from a multiple regression model predicting delay time from impulsogenic (anticipatory behavior) and volitional processes (EF) are presented in

Table 2. Results indicated that while controlling for age, EF interacted with anticipatory behavior to predict delay time ($B = 47.38, p = .017$). The interaction of anticipatory behavior and EF in predicting children's ability to wait is presented in Figure 2. We found that high levels of anticipatory behavior were associated with shorter delay times compared to low levels of anticipatory behavior and this difference was especially pronounced in children with low EF. Testing for significance in simple slopes revealed that for children with low EF (1 *SD* below the mean), there was a steep decline in delay time for children showing high anticipatory behavior (1 *SD* above the mean) ($B = -89.01, p < .01$) compared to children with low anticipatory behavior (1 *SD* below the mean); such that for each additional *SD* of anticipatory behavior, delay time declined by 56.1 seconds, or almost $\frac{1}{2}$ of a *SD* in delay time. This resulted in a difference of 112.2 seconds, yielding a large effect of Cohen's $d = .73$. For children with high EF (1 *SD* above the mean), however, anticipatory behavior was statistically unrelated to their delay time ($B = -28.37, p = .193$).

In sum, our results indicate that children with high levels of anticipatory behavior show especially pronounced declines (indicative of a large effect) in delay time if they suffer from low EF. High levels of anticipatory behavior, however, do not impair the ability to wait in children with high EF.

Table 2
Interplay of Anticipatory Behavior and Executive Function: Multiple Linear Regression Predicting Delay Time

	B	SE	p-value
Intercept	295.09	26.89	.000
Age	23.97	12.41	.058
Anticipatory behavior	-58.69	20.42	.006
EF	20.60	22.44	.362
Anticipatory behavior x EF	47.38	19.29	.017
R^2			23.3

Note. Significant p -values are in bold face. B = Unstandardized Beta coefficients, SE = Standard errors, R^2 = explained variance; EF = Executive Function.

Figure 2. Children's temptation to play with the game (anticipatory behavior) interacts with executive function (EF) to predict children's ability to delay (sec). For children with low EF (1 SD below the mean), high anticipatory behavior (1 SD above the mean) was associated with a shorter delay time compared to children with low anticipatory behavior. For children with high EF (1 SD above the mean), however, anticipatory behavior was unrelated to their delay time.

Interplay of Volitional Processes Predicting Delay Time

Results from multiple regression models predicting delay time from interactions among EF and each of the self-control strategies (fidgeting/ engagement in alternative activities) are depicted in Table 3.

EF and engagement in alternative activities. We found that while controlling for age, EF and engagement in alternative activities significantly interact to predict delay time ($B = -43.87, p = .007$). As can be seen in Figure 3, for children with low EF (1 *SD* below the mean) high engagement in alternative activities (1 *SD* above the mean) was associated with a prolonged delay time compared to children with low engagement in alternative activities ($B = 56.02, p = 0.39$), such that for each additional *SD* of engagement in alternative activities, delay time increased by 34.2 seconds, or nearly 1/3 of a *SD* in delay time. This resulted in a difference of 68.4 seconds, yielding a moderate effect of Cohen's $d = .45$. For children with high EF (1 *SD* above the mean), however, engagement in alternative activities was unrelated to their delay time ($B = -0.14, p = .995$).

Table 3

Interplay of Volitional Processes: Multiple Linear Regressions Predicting Delay Time

	Model including the following self-control strategy					
	Engagement in alternative activities			Fidgeting		
	B	SE	<i>p</i> -value	B	SE	<i>p</i> -value
Intercept	206.55	21.15	.000	193.89	21.97	.000
Age	26.68	12.76	.041	36.14	12.75	.006
EF	13.83	22.43	.540	-7.80	21.13	.713
Engagement in alternative activities	27.94	21.78	.205			
Fidgeting				89.94	40.45	.030
EF x self-control strategy	-43.87	15.71	.007	-22.65	11.61	.056
<i>R</i> ²	19.7			18.3		

Note. Significant *p*-values are in bold face. B = Unstandardized Beta coefficients, SE = Standard errors, *R*² = explained variance; EF = Executive Function.

Figure 3. Engagement in alternative activities interacts with executive function (EF) to predict children's ability to delay (sec). For children with low EF (1 *SD* below the mean), high engagement in alternative activities (1 *SD* above the mean) was associated with a prolonged delay time compared to children with low engagement in alternative activities. For children with high EF (1 *SD* above the mean), however, engagement in alternative activities was unrelated to their delay time.

EF and fidgeting. As to fidgeting, the interaction with EF was only marginally significant (see Table 3, $B = -22.65$, $p = .056$). However, a significant main effect of fidgeting was found ($B = 89.94$, $SE = 40.45$, $p = .030$) which is depicted in Figure 4. We found that high levels of fidgeting were associated with a prolonged delay time compared to low levels of fidgeting and this difference was more pronounced in children with low EF. Testing for simple slopes revealed that for children with low EF (1 *SD* below the mean), high fidgeting (1 *SD* above the mean) was associated with a significantly prolonged delay time compared to children with low fidgeting ($B = 104.44$, $p = .017$). Whereas for children with high EF (1 *SD* above the mean), fidgeting was only marginally related to their delay time ($B = 75.44$, $p = .063$). Overall, a moderate effect for fidgeting of Cohen's $d = .38$ was found.

Figure 4. High levels of fidgeting are associated with a prolonged delay time (sec) compared to low levels of fidgeting. Together with executive function (EF), this difference, however, is only statistically significant in children with low EF (1 *SD* above the mean) compared to children with high EF (1 *SD* above the mean) for whom fidgeting was only marginally related to their delay time.

In sum, EF and self-control strategies interacted to predict children's ability to delay. Thereby both engagement in alternative activities and fidgeting were found to be beneficial for children with low EF, whereas children with high EF do not seem to benefit from these spontaneous self-control strategies. Overall, our models explained substantial proportions of variance in delay time (around 20%) and differences for children with low EF engaging in self-control strategies vs. not engaging in self-control strategies yielded moderate effect sizes.

Discussion

How and why children are able to wait for a reward is still poorly understood. Delay of gratification tasks are complex in that they likely elicit both motivational and regulatory processes. Yet, developmental researchers have mainly examined the latter. By examining behavioral responses during a delay task, this study sought to examine both impulsogenic and volitional mechanisms underlying children's self-

regulation. We found that temptation (assessed as anticipatory behavior) was curvilinearly related to delay time with children who showed either very low or very high levels of anticipatory behavior not being able to wait the entire time. Furthermore, our results indicated that anticipatory behavior interacted with EF to predict delay time. Specifically, anticipatory behavior was negatively related to delay time only if EF abilities were low. Finally, EF and self-control strategies interacted to predict children's ability to delay. Spontaneous engagement in self-control strategies such as fidgeting and engagement in alternative activities, were beneficial for children with low EF but were unrelated to delay time for children with high EF. Our results expand on classical accounts of cognitive strategies facilitating performance in delay tasks within a more comprehensive framework and shed light on various reasons for lapses in self-regulation when delaying gratification.

Impulsigenic Processes

It is crucial to know how tempted a child is during a delay of gratification procedure in order to understand his or her ability to wait. Despite the fact that children with high regulatory abilities may modulate the expression of impulsive tendencies and behaviors (Spinrad et al., 2007), our approach to measure impulsigenic processes (temptation) underlying self-regulation by observing children's anticipatory behavior during delay time proved to be informative. In line with our hypothesis of an optimal balance model of self-regulation highlighting bidirectional relations between arousal and self-regulation (Blair & Ursache, 2011), we found a curvilinear relation with a pronounced decline in delay time for children showing high levels of anticipatory behavior. This suggests that children may fail to wait the entire time because of either being too bored to wait or too tempted to play. We thus found a positive (i.e., motivating) effect of temptation on delay time at the lower end of the scale, whereas children who experienced high levels of temptation

passed optimal level of arousal. These children experienced pronounced negative effects of temptation on their self-regulatory abilities (i.e., they were too excited to wait) and were unable to resist temptation.

To measure behavioral manifestations of impulsogenic processes we drew on temperamental research (Goldsmith et al., 1999). One can thus assume that inter-individual differences in impulsogenic processes are reflecting children's temperament. It is important to acknowledge that temperamental characteristics may not only moderate the process if a situation is perceived as tempting or stressful (Strelau, 1995) but even more basically relate to inter-individual differences in arousal and regulation thereof (Gray, 1982; Rothbart, Ahadi, Hershey, & Fisher, 2001). Temperament is thereby defined as individual differences in emotional, motor, and attentional reactivity as well as self-regulation (Rothbart & Bates, 2006). Apart from temperament, contextual influences on impulsogenic processes (i.e., impulsivity/approach/reward orientation) may play a significant role too. Perhaps the strongest evidence of the role of environmental factors shaping children's self-regulatory abilities comes from the literature on parenting practices. For instance, children who had experienced a highly mutually responsive relationship with their mothers were better able to overcome their temptation/impulsivity than children who had not (Kochanska, Askan, Prisco, & Adams, 2008).

Unpredictability may be another key contextual factor influencing children's delay abilities. For instance, when a later reward is potentially less likely to be delivered or when there is doubt about the person promising it (i.e., the unknown experimenter is perceived as unreliable/untrustworthy), preferences for immediate gratification increase in children (Kidd, Palmeri, & Aslin, 2012) and adults (Michaelson, de la Vega, Chatham, & Munakata, 2013). Given that low-income children are disproportionately exposed to higher levels of unstable rearing

environments (Ackerman, Kogos, Youngstrom, Schoff, & Izard, 1999), uncertainty and unpredictability in the context of poverty may be a potent factor in understanding the adaptability of decreases in children's delay of gratification (Sturge-Apple, Davies, Cicchetti, Hentges, & Coe, 2016). Thus, while within normative psychological models, the ability to delay and control impulses is considered healthy and indicates optimal functioning, for children growing up in poverty it may be quite adaptive to choose immediate gratification over waiting for a more valued but also less certain delayed outcome (Blair & Raver, 2012). Interestingly, volitional processes underlying children's self-regulation may not be similarly affected by poverty. In support of this, Lengua and colleagues (Lengua et al., 2015) found that cumulative risk scores (aggregate of demographic and psychosocial risk factors) accounted for the effect of income on preschooler's delay ability (gift delay task) but not executive control (battery of EF tasks). Similarly, Sturge-Apple and colleagues (2016) reported that elevated family instability in economically distressed families was associated with decreased hot effortful control (reward dominance task) but not cool effortful control (peg tapping task) over the span of 2 years in 4- to 6-year-olds.

Our findings emphasize the importance to take a closer look at inter-individual differences in impulsogenic processes underlying children's self-regulation as important implications for interventions may be derived. Whereas great advances have been made in training volitional processes such as EF, these interventions usually did not lead to improvements on delay tasks (Diamond & Lee, 2011; Lillard, 2006; Raver et al., 2011). This may be due to the fact that lapses in self-regulation may also have to do with the relative strength of an individual's impulsogenic tendencies and not only with deficiencies of volitional processes to which failures in self-regulation have often been attributed to. Mindfulness-based practices may be promising candidates of intervention approaches to weakening immediately

gratifying impulses in children (Shapiro et al., 2015; Zelazo & Lyons, 2012).

Indeed, mindfulness training may be regarded as an ideal intervention for promoting healthy development of self-regulation because it has the potential to target both volitional (top-down processes of reflection) and impulsogenic (bottom-up influences such as anxiety or motivation) aspects of self-regulation (Zelazo & Lyons, 2012).

Clearly, however, more research is needed. Whereas initial studies of mindfulness training in children have shown promising effects on EF (Flook et al., 2010; Schonert-Reichl et al., 2015), a very recent rigorous study did not find significant effects on a delay of gratification task (Flook, Goldberg, Pinger, & Davidson, 2015).

Future research may also address the question how inter-individual differences in temptation and their relation to delay behavior may change over time. At present the implicit model of self-regulation that guides most developmental research wrongly assumes that an individual's impulsogenic tendencies remain constant across development (Duckworth & Steinberg, 2015). However, there are reasons to believe that changes in the nature and intensity of children's impulsogenic processes may also contribute to changes in self-regulation during childhood (e.g., Spear, 2000). The dual-systems model of adolescent neurobiological development, for instance, proposes that because sensation-seeking rises and falls across this age span, whereas impulse control increases into the 20s, adolescents are more likely to engage in risk-taking behavior (Steinberg et al., 2008). Future research on the developmental course of impulsogenic processes may also differentiate between different goal-directed self-regulatory situations, as impulsive behaviors have been shown to vary systematically by domain (schoolwork-related vs. interpersonal-related impulsivity, Tsukayama, Duckworth, & Kim, 2013). Lastly, in the present study we only investigated temptation; however, it is also important to keep in mind

that other impulsogenic processes such as anxiety and reactive undercontrol may interact differently with volitional processes to promote self-regulation.

Volitional Processes

In terms of regulating high levels of temptation, our findings indicated that EF may be crucial. Children with high levels of anticipatory behavior only showed pronounced – and meaningful – declines in delay time if they had low EF. High levels of anticipatory behavior, however, did not impair the ability to wait in children with high EF. Even thus both self-control strategies showed strong negative associations with anticipatory behavior, an open question remains as to how efficient spontaneous self-control strategies are in regulating high levels of temptation in order to successfully delay. Unfortunately, our design did not allow to test the interaction of anticipatory behavior with self-control strategies due to concerns of multicollinearity. However, recent research suggests that self-control strategies such as spontaneous self-distancing during reflection on an anger-related interpersonal experience predicted lower levels of emotional reactivity in 11-to 20-year-olds (White, Kross, & Duckworth, 2015). The authors also found that this inverse relation between self-distancing and emotional reactivity strengthened with age; therefore, future research needs to investigate the efficiency of spontaneous self-control strategies in early to middle childhood.

Yet, we were able to explore the efficiency in the spontaneous use of self-control strategies on delay time. Surprisingly, neither of the self-control strategies were significantly associated with delay time. At first sight this seems to be inconsistent with previous findings showing consistent benefits of self-control strategies on delay behavior (Metcalf & Mischel, 1999). However, as mentioned before, most correlational studies looking at spontaneous attention deployment have relied on the proportion of time the child spent looking at consummatory aspects of

the task (cf. temptation or hot focus). Thus, compared with Sethi and colleagues' (2000) study, our results appear to replicate theirs: They also found that only *hot* ($r = -.24, p < .01$) and not *cool focus* ($r = .13, p > .05$) was significantly associated with delay time. Furthermore, because we coded the intensity of self-control strategies (rather than self-control strategies being present or absent), our findings allow consolidating Sethi and colleagues' interpretation of a hot strategy being more predictive of unsuccessful delay than a cool strategy being predictive of successful delay because of the narrower range of behaviors being captured with the hot compared to the cool strategy. In our coding scheme, anticipatory behavior (cf. *hot focus*) indeed involved a narrower set of behaviors as opposed to engagement in alternative activities (cf. *cool focus*) which in its highest intensity also included playing with something else (cf. slinky toy, Mischel et al., 1972).

Within a broader perspective, it is important, however, to acknowledge – as Sethi and colleagues (2000) pointed out – that the adaptiveness of a cooling strategy (i.e., distraction, avoidance) depends on the context. For instance, attachment research has shown that for toddlers with controlling, intrusive mothers exhibiting avoidance of the mother (in the strange situation) is a strategic behavior because it represents “deactivation” of the attachment system in the service of other goals (Ainsworth, 1985). For a toddler whose mother is not controlling, however, a strategy of approach may be more adaptive than cooling or avoidance. Thus, cooling is adaptive or successful when applied to stimuli that are aversive, unattainable, or frustrating as part of goal attainment. In contrast, the use of a cooling strategy when something is non-aversive, attainable and satisfying is not necessarily adaptive.

In our study, somewhat surprisingly, EF was not related to delay time. As reviewed above, findings relating performance on “cool” EF tasks to performance on “hot” delay tasks have been mixed and possibly depend on the age group and the

tasks used (Hongwanishkul et al., 2005; Sulik et al., 2010). Of more interest, however, we found that EF and self-control strategies interacted to predict children's ability to delay. Both, engagement in alternative activities and fidgeting, were found to be only beneficial for children with low EF. Moderate effect sizes point to the practical relevance of our findings with meaningful differences for children with low EF engaging in self-control strategies. This has implications for targeted interventions: Children with low EF who do not engage spontaneously in self-control strategies may benefit tremendously if they were taught these strategies. However, this is speculative at best and requires further investigation in future studies.

At present, we do not know what leads children to spontaneously engage in self-control strategies. In our sample it did not seem to be true that children with higher EF would engage more likely in self-control strategies, as EF was neither correlated with engagement in alternative activities nor with fidgeting. One would argue that the realization that one needs to engage in self-control strategies in order to resist temptation would most probably rely on EF (Zelazo & Cunningham, 2007) but the current research suggests that other factors may play a crucial role too. Furthermore, the realization that one is struggling to resist and needs to engage in self-control strategies is possibly only half of the battle, the efficient execution of the self-control strategy the other half.

This, however, suggests that self-control strategies are purely volitional. In the present paper we conceptualized EF and self-control strategies as volitional processes and contrasted them with impulsogenic processes (Duckworth & Steinberg, 2015). This taxonomy, however, obscures the fact that more automatic, bottom-up types of regulation also exist (cf. reactive control, Eisenberg & Morris, 2002; or hot EF, Zelazo, Qu, & Kesek, 2010). The question then is how conscious is a given self-control strategy? Even thus proponents of more extreme positions would argue that

the ability to exercise conscious, intentional control is actually quite limited (Bargh & Chartrand, 1999), most people would possibly agree that fidgeting can be classified as a somewhat less conscious self-control strategy than attention deployment, at least in our age group. For instance, data from several studies (Mischel, 1981) suggest that growing metacognitive insight into self-control strategies follows an orderly developmental progression: whereas 4-year-olds have a strong preference for the worst strategy (waiting with the rewards exposed), already at 5 most children prefer to wait with the rewards hidden from their view. This indicates that children in our study most certainly consciously diverted their gaze away from the tablet with assuming that this behavior would help them to resist temptation.

Whereas fidgeting, hypothesized to serve an arousal-regulating function (Zentall & Zentall, 1983), is probably of a more reactive and automatic nature. The behaviorally observable differences in body tensing, fidgeting, and facial grimaces as assessed in Wilson and colleagues' study (2009) may be similarly considered as more reactive forms of regulation. Apart from fidgeting reflecting the need or the attempt at regulating arousal, it could simply also reflect *under- or over-arousal*. For instance, Liew and colleagues (2004) coded self-soothing and fidgeting behaviors in preschoolers and found that such behaviors may reflect both over-arousal (distress) and behavioral attempts to regulate that arousal. Similarly, Erath and colleagues (2007) coded for youths' self-reported motor fidgeting or self-soothing, and viewed it as self-directed coping strategies, which were associated with peer victimization, suggesting that fidgeting reflects both social anxiety and coping or self-soothing.

In our study, fidgeting was beneficial for all children, although it was slightly more so for low EF children. Moreover, in our sample the overall mean of fidgeting was modest as indicated in the relatively low mean and narrow range of the fidgeting

code. This finding is consistent with Sarver and colleagues' (2015) who found that typically developing children performed optimally on EF tasks when moving 43-57% of the time, and comparatively less well when moving 67-87%. Therefore, moderate levels of physical activity (i.e., fidgeting) may be indicative of optimal stimulation (Zentall & Zentall, 1983).

An open question remains as to why low EF children who engaged in self-control strategies outperformed high EF children who also engaged in self-control strategies? Or put differently, why were self-control strategies either not supportive of delaying in high EF children (engagement in alternative activities) or not as much as for low EF children (fidgeting)? Clearly, the relation between EF and spontaneous self-control strategies needs to be further investigated. An interesting avenue for future research in order to better understand how EF relates to different self-control strategies, as well as how attention deployment strategies relate to other self-control strategies (e.g., fidgeting) would be to investigate underlying physiological and cognitive processes (Wilson et al., 2009). Recent advances in the coping literature (Wadsworth, 2015) that may guide future research show that different types of coping look physiologically different, and experimentally manipulated coping yields physiological differences. Overall, our findings speak to the importance of examining both volitional and impulsogenic processes in the overt expression of control over action from a young age and suggest a promising new avenue for research in self-regulation.

Limitations

Several caveats merit consideration when considering the present findings. Importantly, the current study relied on observations of children's naturally occurring self-control strategies and behaviors indicative of temptation during a delay task administered at the end of a rather ambitious test session. As such, our a posteriori

coding of behavior as a function of the ability to delay was non-experimental, and causal attributions cannot be drawn. Carefully controlled studies inducing various levels of temptation and self-control strategies are needed to corroborate and extend the current findings.

It should also be noted that our sample size was somewhat small for the rather large age range included in our study. Furthermore, the sample was quite homogeneous with regards to children's socioeconomic background and at relatively low risk for failures in self-regulation. Therefore, caution is needed in generalizing to other populations. A sample at greater risk for failures in self-regulation (e.g., children from disadvantaged backgrounds) may exhibit different patterns in delay behavior, as discussed above. However, the fact that significant relations were found in this relatively restricted sample suggests that even stronger relations may be detected in a more heterogeneous sample.

Lastly, as design of our delay task did not allow the reward to increase with time (cf. Kochanska battery of inhibitory control), some may argue that we measured obedience, compliance, or even stress tolerance rather than delay of gratification per se. Fact is, a variety of different delay tasks have been used with preschool and older children what lead some researchers to categorize them into hot delay tasks (e.g., Marshmallow test) vs. prohibition tasks (e.g., Snack delay or task in present study; Peterson & Welsh, 2014). We agree that the field would benefit from more consensus in the measures used to assess self-regulation and a thorough investigation and disentanglement of various reasons underlying a child's decision or ability to wait (i.e., is it fear of punishment? Or the expectation of a positive outcome?). Nevertheless, for the present study the newly developed Bzz!INH task was not only highly age-appropriate as all children showed some signs of temptation (which is often an issue with older children) but also theoretically it seems justifiable to

administer a task that taps on children's compliance. As it has been argued, compliance with caregivers' request is a prototypic form of early self-regulation, because it requires the capacity to initiate, cease, or modulate one's behavior in accord with parental or teacher standards (Kochanska et al., 2001). Clearly, replication of our findings with other delay tasks is required.

Conclusion

This work shows that the use of direct observation methods (i.e., video coding) can be considered as an effective tool for parsing the psychological processes underlying children's self-regulation. By observing several behaviors during delay we were able to get an estimate of the strength of an individual's desires, which is a challenging methodological question of the field as underlying processes of behavior are often either internal or are partially based on expressive behaviors that occur briefly and rapidly in succession (Hepach et al., 2015). More importantly, our findings contribute to the investigation of impulsogenic processes underlying self-regulation and their interplay with volitional processes. Just as Metcalfe and Mischel (1999, p. 16) wrote nearly twenty years ago: "It is, rather, in the dynamics – in the exquisite details – of the interactions between the two systems [hot and cool] that the mechanisms that manifest as human strength or willpower may reside".

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