

# Inhibitory control and emotion regulation in preschool children

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## Abstract

This research investigated the relation between individual differences in inhibitory control and emotion regulation. Preschool children ( $N=53$ ) ages 4–6 ( $M=5;0$ ) were assessed on brief batteries of inhibitory control of prepotent responses and emotion regulation. Individual differences in inhibitory control were significantly correlated with children's ability to regulate their emotions. This relation held up even after controlling for age and verbal ability, and persisted for both Emotion Understanding and "online" control of emotional expressions that were negative (Disappointing Gift) or positive (Secret Keeping). Parent report of children's self-control and emotion regulation corroborated the behavioral results. These findings suggest that executive control of attention, action, and emotion are skills that develop in concert in the preschool period. However, there was also evidence of a quadratic relation in which emotion regulation was optimal at intermediate levels of inhibition, highlighting the interplay of both cognitive control and temperament in socio-emotional functioning.

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## 1. Introduction

The ability to control potentially interfering thought processes and actions develops rapidly in the preschool period. Children of age 3 years have difficulty on tasks that require inhibitory control of attention and motor responses, such as suppressing a dominant response in accordance with rules. By 5 years of age they are much more proficient at these tasks (for a summary see Carlson, 2005). At the same time, children improve in the ability to regulate the experience of emotions by monitoring their expressive behavior. Saarni (1984) found that young children made an attempt to inhibit negative expressions upon receiving an undesirable gift, but they had trouble neutralizing

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their expressions. Older children were more likely to attempt to feign positive expressions of emotion, although there were individual differences in these skills at all ages. Explaining individual differences in emotion regulation that appear early in childhood is an important undertaking because older children who have difficulty managing emotions (e.g., anger) are at risk for developing behavioral disorders (Cole, Michel, & Teti, 1994; Dodge & Garber, 1991). Both the control of attention and action in relatively unemotional “cool” contexts and the control of emotional expressions in affectively charged “hot” contexts appear to have key requirements in common: prevention of an impulsive response and carrying out an opposite act. Furthermore, deficits in attention and emotion regulation tend to co-occur in certain atypical and at-risk populations, such as children with Attention Deficit/Hyperactivity Disorder (Barkley, 1997). Surprisingly, however, little research has examined the relation between children’s regulation of action and emotion. Zelazo and Müller (2002) described potentially separate and shared neuroanatomical pathways for executive function in cool and hot task paradigms, but the question remains as to whether inhibitory control of prepotent responses and online emotion regulation in a social context are overlapping or independent skills at the level of individual differences. The aim of the present study was to assess the relation between individual differences in the deliberate control over actions and emotional expressions in typically developing preschool children.

### 1.1. *Executive function*

Executive function (EF), defined as the conscious control of thought and action needed for future-oriented and purposeful behavior (Welsh, Pennington, & Groisser, 1991; Zelazo, Carter, Reznick, & Frye, 1997), involves a diverse set of cognitive processes, including planning, working memory, set-shifting, error detection and correction, and the inhibitory control of prepotent responses (e.g., Roberts, Robbins, & Weiskrantz, 1998; Stuss & Benson, 1986). EF is required for goal-directed behaviors to solve novel problems, particularly those calling for the inhibition of automatic or established thoughts and responses (e.g., Casey, Tottenham, & Fossella, 2002; Roberts & Pennington, 1996). Inhibitory control (IC), then, refers to *the ability to inhibit or suppress salient thought processes or actions that are not relevant to the goal or task at hand* (Rothbart & Posner, 1985). Note that flexible employment of inhibitory control in problem-solving situations may involve not only the suppression of a dominant (but incorrect) response, but also the activation of a subdominant (but adaptive) response, or alternation between initiating and inhibiting a prepotent response according to setting conditions. For example, in the Bear/Dragon task (a simplified version of Simons Says), children are told to perform all actions commanded by a “nice” bear puppet but to suppress all actions commanded by a “naughty” dragon puppet, in an alternating fashion. Young 3-year-olds have difficulty inhibiting their actions in this task despite understanding the rule, whereas older 3-year-olds and most 4-year-olds can do so selectively (Reed, Pien, & Rothbart, 1984). This example illustrates one of many similar EF tasks showing marked improvement between ages 3 and 6, when children become much better at resolving conflict of attention and/or motor responses, waiting for a reward, and staying on-task in the face of tempting distractions (Carlson, 2005; Kochanska, Murray, & Harlan, 2000).

Diverse problem-solving scenarios are likely to require flexible suppression and selection of information in working memory and ensuing responses. Indeed, inhibitory control is thought to contribute to individual differences and/or developmental changes in a wide array of cognitive abilities including attention, memory, reading comprehension, and theory of mind (e.g., Carlson, Mandell, & Williams, 2004; Dempster, 1992; Harnishfeger & Bjorklund, 1993; Posner & Rothbart, 2000). EF in general is strongly associated with prefrontal cortex (PFC), which has an extremely

protracted maturational period (e.g., Bunge & Zelazo, 2006; Diamond, 2002; Giedd, Blumenthal, & Jeffries, 1999), however, age-related changes in EF are apparent early on in development and are most striking during the preschool period.

### 1.2. *Emotion regulation*

Emotional development includes changes in emotion expression, understanding, and regulation. Of these, emotion regulation (ER) is particularly likely to be related to EF. It has been difficult to achieve consensus on a single definition of ER (see Bridges, Denham, & Ganiban, 2004; Cole, Martin, & Dennis, 2004; Eisenberg & Spinrad, 2004). Our behavioral research examines children's online modulation of their own emotion expression as the social situation calls for it (down-regulation of negative or excitatory states and potential up-regulation/activation of the opposite feeling state). Hence, we will use the definition provided by Saarni (1984) in which ER refers to *regulating the experience of emotion by monitoring one's expressive behavior*. This conceptualization of ER relies on intrinsic regulatory processes as well as extrinsic factors, particularly children's growing awareness of cultural display rules as they move from early to later childhood. Display rules are social conventions that dictate where, when, and how emotion-related behaviors should be expressed (Ekman & Friesen, 1969).

In Saarni's (1984) classic disappointment paradigm, children were given an undesirable gift (e.g., a babyish toy) and then observed to see how much they tried to disassemble or hide their disappointment. Six-year-olds (especially boys) were openly negative in their expressions, older children showed transitional behavior in which arousal level was apparent (e.g., lip biting) but were less overtly negative, and it was not until 10–11 years of age that children were able to exhibit positive behavior (e.g., exaggerate a smile). However, other studies using this procedure have found developmental change and individual differences in ER among preschoolers (Cole, 1986; Garner & Power, 1996; Josephs, 1994; Liew, Eisenberg, & Reiser, 2004). Even toddlers begin to become aware of their own distress and take steps to alleviate negative feelings, such as distracting themselves from a forbidden toy by playing with a substitute object (Grolnick, Bridges, & Connell, 1996; Kopp, 1989). Infants, too, engage in rudimentary forms of ER including gaze aversion, sucking, and proximity seeking (Buss & Goldsmith, 1998; Rothbart, Ziaie, & O'Boyle, 1992). Thus, similar to EF, ER is an early emerging set of skills that takes a long time to develop but shows marked improvement in the preschool period.

ER has been linked to several aspects of social functioning in preschoolers, including social competence, popularity with peers and teachers, adjustment, shyness/introversion, and sympathy. It is seen as a vital aspect of social competence and one that determines, in large measure, the crucial social task of preschool children: positive engagement and self-regulation during peer interaction (Denham et al., 2003). The increasing complexity and demands of the social world of a preschooler make it necessary for children to modify their emotional reactions, made possible by way of developmental increases in both the comprehension and control of emotionality (Denham et al., 2003; Lewis, Sullivan, & Vasen, 1987).

Uncontrolled negative emotionality, in particular, is a serious detriment to children's social interactions (e.g., Denham, Blair, Schmidt, & DeMulder, 2002; Underwood, Coie, & Herbsman, 1992). In examining individual differences in preschool and school-age children's social competence, Eisenberg and colleagues have identified an interaction between negative emotionality and effortful control, defined by Rothbart and Bates (1998) as the ability to voluntarily inhibit a dominant response to activate a subdominant response. Specifically, children rated by adults as high in negativity tended to have poorer social outcomes, but this effect was moderated by individual

differences in effortful control (e.g., Eisenberg et al., 1995; Eisenberg et al., 1996; Eisenberg et al., 1997; Liew et al., 2004; see also Denham et al., 2003). Children high in effortful control (as reported by parents and/or teachers) are less likely to *express* negative emotionality, presumably because they can better manage their attention, emotions, and behavioral responses. Hence, effortful control is thought to contribute to the modulation (e.g., maintaining, activating, inhibiting) of emotion-related activities in specific situations, but also to reflect individual/dispositional differences across situations (i.e., a key aspect of temperament) (Eisenberg & Spinrad, 2004).

Eisenberg and Fabes (1992) proposed a tripartite model to account for this pattern of interactions between temperament and self-regulation. *Undercontrolled* children are considered low in emotion regulation, impulsive, and high in emotional intensity; they are easily frustrated and prone to reactive aggression. *Highly inhibited* children exhibit self-control but lack flexibility; they tend to be socially withdrawn and sad or anxious. Children who are *optimally regulated* are controlled but flexible and use adaptive means of coping with emotions; they are described as relatively popular and socially competent.

### 1.3. Theory and research on the relation between executive function and emotion regulation

Research on the development of EF has taken place largely independently of investigations of emotional development. Increasingly, however, along with research with adults (e.g., Ochsner & Gross, 2005), developmental scientists are interested in the role of cognition in the control of emotion expression and experience. Most definitions of ER suggest that it includes not only affective experiences, but cognitive and behavioral processes as well (e.g., Cole et al., 2004; Thompson, 1994). As yet, however, the precise nature of the cognition-emotion interactions in development remains to be delineated and understood in reference to contemporary theories of EF. From a developmental cognitive neuroscience perspective, emotion and cognition are intricately linked and work together to process information and execute action (Bell & Wolfe, 2004; Cacioppo & Berntson, 1999). Bidirectional influences are likely: Emotions can help organize one's thinking, learning and action (emotion as regulating), and cognitive processes play a role in regulating emotions (emotions as regulated).

Zelazo and Cunningham (2007) proposed an interactive model in which emotion corresponds to the motivational aspect of cognition in conscious, goal-directed problem-solving. On this view, ER is either primary or secondary, but never entirely divorced from EF. When the "problem" to be solved (the represented goal in working memory) is to modulate emotion (e.g., "don't show my disappointment"), in fact, ER and EF are isomorphic. However, when modulation of emotion is secondary and occurs in the service of solving another problem (e.g., suppressing frustration so that one can muster greater self-control during a game of Simon Says), then EF is said to *involve* ER, but other non-affective, higher-order control and reflection processes likely to be activated as well. Hence, according to Zelazo and Cunningham's model, EF and ER bear a reciprocal relation, the precise nature of which will depend on the motivational significance of the problem and whether the problem itself is hot or cool.

There is limited research on the relation between EF and ER in young children. We have already noted the shared developmental timetable in the preschool period. In addition, there is increasing evidence that EF and ER have underlying neural mechanisms in common (for reviews see Zelazo & Müller, 2002; Zelazo & Cunningham, 2007). Further supporting a potential link between EF and ER, some investigators have found that individual differences in EF laboratory performance correlate moderately with parent report of child temperament, particularly effortful control (e.g., Carlson & Moses, 2001; Gerardi-Caulton, 2000; Hongwanishkul, Happaney, Lee, &

Zelazo, 2005; Jones, Rothbart & Posner, 2003; Kochanska et al., 2000; Rothbart, Ellis, & Posner, 2004). Many of these studies, however, administered only the temperament scales relevant to effortful control, and/or only limited measures of EF. In an aggregate analysis of 420 preschool children's EF battery scores and full-scale temperament dimensions, Beck, Carlson, and Rothbart (2007) found that a combination of *both* effortful control (high) and extraversion/surgency (low) best characterized the children with relatively advanced EF skills.

#### 1.4. Goals of the present study

To summarize, there is evidence to suggest that (a) EF and ER undergo dramatic development in the preschool period; (b) EF and ER have important developmental outcomes in common, particularly school readiness and social competence; (c) EF and ER likely draw on common neural substrates; and (d) temperament may exert similar influences on EF as those that have been demonstrated for ER. Previous studies examining the role of cognitive processes in ER, or of emotion/temperament processes in EF, have tended to use adult-report methods for either one or both constructs. Parent- and teacher-reports are useful but inter-rater reliability across contexts can be weak (e.g., Liew et al., 2004). What is needed is an examination of preschool children's performance on behavioral measures that call for inhibition of action in direct comparison with those that call for inhibiting an emotional expression. We set out to address this gap and hypothesized that *inhibitory control serves as a common underlying process in the executive control of both representation/action and emotional expressions in accordance with cognitively represented (but socially mediated) goals*. Consistent with Zelazo and Cunningham's (2007) model, we framed our design according to whether emotion-suppression could be considered the *primary* or *secondary* goal.

For the ER battery, we included measures in which the control of emotional expression was primary: Saarni's (1984) disappointment paradigm (suppression of a negative expression) and a new Secret Keeping task in which children were told an exciting secret (that a fish in the room could talk) and asked not to reveal this knowledge to an experimenter (suppression of a positive/excited expression). In addition, emotion *understanding* is also likely to be important, as it contributes to the understanding of and adherence to social display rules, as well as increased self-awareness of emotionally arousing events and the (often negative) consequences of dysregulated behavior. For example, Saarni (1984) speculated that older children become better able to mask their true feelings when they understand how their expressions might affect others. As children's cognitive development progresses, they become increasingly aware that emotional signals do not always represent the true internal feeling state of the signaler (e.g., Banerjee, 1997; Harris, 1989; Josephs, 1994; Meerum Terwogt, Koops, Oosterhoff, & Olthof, 1986). Furthermore, Denham et al. (2003) found significant inter-relations among emotion expression, emotion regulation, and emotion understanding in preschoolers. Given these theoretical and empirical arguments, we included a measure of Emotion Understanding in our ER battery in addition to the emotion-suppression tasks.

For the IC battery, we selected measures in which children had to selectively suppress dominant/activate subdominant responses. They included suppression of motor responses over a temporal delay (Forbidden Toy, Gift Delay), and flexible selection of motor inhibition and activation (Simon Says). In each case, ER was considered secondary to the goal. For example, in the Forbidden Toy task, although emotions might influence performance, the primary goal was to inhibit touching an attractive toy, rather than controlling one's facial expression of emotion toward the toy.

Children also were given the PPVT-III (Dunn & Dunn, 1997) in order to control for verbal ability, which has not typically been done in previous studies of IC and ER. We predicted that children who had difficulty on the IC tasks would also demonstrate difficulty on the ER tasks, independent of age and verbal ability. We also examined potential effects of age group (4 versus 5) and gender on the magnitude of the correlations, and tested both linear and curvilinear regressions of IC on ER performance.

## 2. Method

### 2.1. Participants

Fifty-three children ages 51–72 months ( $M = 60.21$ ,  $S.D. = 8.09$ ; 25 boys and 28 girls) were observed in a single laboratory visit. They included 30 4-year-olds ( $M = 53.7$  months,  $S.D. = 3.15$ ; 14 boys and 16 girls) and 23 5-year-olds ( $M = 68.7$ ,  $S.D. = 2.88$ ; 11 boys and 12 girls). An additional six children were excluded because of either experimenter error or failure to complete the procedure. Recruitment took place by telephoning parents listed in a university database who had agreed to be contacted about developmental research and by posting flyers in local preschools of a large metropolitan area. The participants were predominantly European-American and middle class.

### 2.2. Procedure

Children were tested individually by two experimenters in a quiet laboratory playroom. Sessions lasted approximately 45 min. Measures were administered in a fixed order, as follows: PPVT-III; Simon Says; Forbidden Toy; Emotion Understanding; Secret Keeping; Gift Delay; Disappointing Gift. All measures were videotaped and later coded by trained research assistants who were blind to the hypotheses of the study. The one exception was the PPVT-III, which was scored during the session.

We were interested in the extent that individual differences in inhibitory control would correlate with individual differences in emotion regulation. A fixed task order is standard practice in individual differences research (Rothbart & Bates, 1998; see also Carlson & Moses, 2001). The rationale is that if one is interested primarily in locating individuals with respect to one another in a multidimensional space (rather than drawing inferences about means), it is critical that the individuals be exposed to identical stimulus contexts. That context includes not only the stimuli themselves but also the order in which they are presented and its potential consequences for performance (e.g., fatigue effects on the final task administered).

Parents (one for each child, usually the mother) participated by filling out questionnaires during the laboratory session. Parents were seated in a room next-door to the testing room and could observe their child on a video monitor.

### 2.3. Verbal ability measure

*PPVT-III.* The Peabody Picture Vocabulary Test (3rd ed.; Dunn & Dunn, 1997) was administered to assess children's level of receptive vocabulary. The experimenter said a word from a standardized list and children pointed to one of four pictures that they thought correctly depicted the word. Testing proceeded until children erred on at least eight items from a block of 12. Raw scores were used in data analysis.

#### 2.4. Inhibitory control measures

*Simon Says.* The traditional game of “Simon Says” was adapted (Strommen, 1973). The experimenter began by modeling 10 simple motions and asking children to do them too (e.g., “touch your nose”), and then went on to explain the rules of the game. Children were told to imitate her actions only when the commanded motion was preceded by the words, “Simon Says.” Otherwise, they were to remain perfectly still. The experimenter performed all actions, regardless of whether it was an imitation (“Simon Says”) trial or an anti-imitation trial. Two practice trials were given to ensure that children understood the rules (one of each type), followed by a verbal rule check (“So, when I say ‘Simon Says’ do you do what I say and what I do? And when I *don’t* say ‘Simon Says,’ do you do what I say and what I do?”). Children were corrected as needed. There were 10 test trials (five “Simon Says” trials, and five anti-imitation trials in a fixed interspersed order without feedback: Simon, Simon, no Simon, Simon, no Simon, rule reminder, no Simon, Simon, no Simon, no Simon, Simon). Each trial was scored on a 4-point scale according to whether it was a Simon/anti-imitation trial as follows: 0 = no movement/full commanded movement; 1 = flinch/partial commanded movement; 2 = partial commanded movement/flinch; 3 = full commanded movement/no movement. Total scores (0–30) were used in data analysis. Note that although anti-imitation trials were hypothesized to be sensitive to individual differences in inhibitory control, some children adopted a strategy of not doing *any* movements (even on Simon trials) to resolve the conflict in the task, and so it was informative to sum across all trials to index children’s selective inhibition and activation of a motor response.

*Forbidden Toy.* This procedure was modeled after Lewis, Stanger, and Sullivan’s (1989) study of young children’s deception. Children were introduced to Playskool’s Magic Screen Learning Pal toy, which was referred to as a “Magic Robot.” The experimenter told children that she needed to leave the room for a while to finish up some work, and asked them to wait and *not* touch the toy in the following manner: “Do you know what this is? It’s a Magic Robot! But before we start playing with it, I have to go out of the room to do some work. So sit here, stay seated, and wait for me to come back all right? I really want us to play together, so before I come back, try not to touch the toy, okay? So see how long you can stay in your seat without touching the toy okay?” She then placed the toy directly in front of the child (approximately 10 cm) and turned it on so that it started to make noise and speak. The experimenter then left the room. The toy makes sounds (e.g., sneezes, says “Let’s play!”) whenever it is touched but falls silent when untouched. At any point that children touched the toy when alone, the experimenter returned to the room. Otherwise, the total wait period was 5 min. When the experimenter returned, regardless of children’s performance, she asked, “Did you touch the toy while I was gone?” to assess whether children could suppress the truth (lie) if they had in fact touched it. If children answered yes, she said: “You did? Well, thank you for being honest and telling me. That’s okay even if you did. I know it’s hard to wait and not play with something you really like. Let’s play with the toy now!” If children answered no, she said: “That’s okay even if you did. I know it’s hard to wait and not play with something you really like. Let’s play with the toy now!” A touch score (0 = touched; 1 = did not touch) and lying (0 = truth; 1 = lie) were recorded as separate dependent variables of interest following Lewis et al. (1989).

*Gift Delay.* This task was adapted from Kochanska et al. (2000). Children were told they would be given a present because they did so well on the games. The experimenter turned the child’s chair around and asked children to face the other way (toward a hidden camera) and told them not to peek while the present was being wrapped so that it would be a “big surprise.” She wrapped the present noisily during a 60-s period (measured with a stopwatch) in a standardized manner:

rifling through a paper bag for the gift; placing it in a box; cutting wrapping paper; tearing off tape; and taping the paper around the box. A peeking score was assigned as follows: 0 = fully turned around; 1 = peeked over the shoulder; 2 = no peek. Latency to the first peek (over the shoulder) and total number of peeks (reversed) also were recorded. All three variables were significantly intercorrelated,  $r_s(51)$  ranged from .67 to .87,  $ps < .0001$ , and so were standardized and averaged to compute a composite Gift Delay score, following Kochanska et al. (2000).

### 2.5. *Emotion regulation measures*

*Disappointing Gift.* Following the Gift Delay in which children waited while a gift was being wrapped, the experimenter presented the gift to children and encouraged them to open it right away. As children unwrapped the present (a plain brown woodchip), they were reminded that the gift is “really cool” and their facial expression was closely observed. Upon seeing the gift they were asked, “Isn’t it cool? Do you like your present?” Children’s reaction to the gift was coded using Saarni’s (1984) facial expression of emotion coding system for 15 s or until the child had clearly finished reacting to the gift (see scoring items in Appendix A). Then E1 pretended to realize that she had given children the wrong gift by mistake and presented them with a desirable gift to take home. Note that children were not presented with choices for their favorite toy before the disappointment task because we wanted to ensure that they had no idea what their present would be for the Gift Delay portion of the procedure (thus highly tempted to peek). However, in a pilot study of 4- to 5-year-olds in which we asked them to rank a set of items from most to least liked, we confirmed that a wood chip was least liked when presented alongside a baby rattle and a broken toy, and importantly, it was uniformly disliked by both boys and girls. Dependent variables were a Like/Dislike score (their answer to whether or not they liked the Disappointing Gift; yes = 1; no = 0), and Negative Expression Score, which included 1 point for each of the following behaviors: Nose wrinkling; Lowered brow as in a frown or as in annoyance or disappointment; Omitted “thank you”; Puckered or pursed mouth; Tight, straight-line mouth; Avoids eye contact with experimenter; Negative noise emitted (e.g., snort, “ugh”); Makes a negative comment (e.g., “This is *just* a woodchip!” or “I don’t want this”); Shoulder shrug. Consistent with previous reports using this task with preschoolers (e.g., Cole, 1986), we found that very few children were able to muster positive expressions, and so we used only the sum of negative expressions in data analysis. Note that higher scores meant poorer emotion regulation on this measure.

*Secret Keeping.* We designed this task to assess children’s ability to suppress a positive emotion. Children were led to believe some very exciting news that a real goldfish could talk. Then they were asked to keep it a secret. The experimenter first introduced them to a pet goldfish (“Sammy”) in a clear tank that was situated in a corner of the laboratory room. Then she said she had to leave the room for a while to “finish up some work.” Children were asked to please wait with Sammy in the room. One minute after the experimenter departed, a confederate researcher, who was hidden in an adjacent room behind a one-way mirror, spoke in a high-pitched voice into a closed-circuit radio. Her voice was transmitted to a receiver hidden in a concealed container behind the fish tank. The confederate said, “Psst! Hey kid, over here! Yeah, that’s right, in the fish tank on the table! It’s me, Sammy the goldfish! What’s your name? Wow (*C’s name*), that’s a very nice name! Sure, I can talk! But do me a favor all right? Let’s keep this a little secret between you and me, okay? I don’t want (*E’s name*) to know about it because she would tell the whole world and then EVERYONE will want to talk to me, and I would get too tired! Yikes, shh, here she comes now!” At this point, the experimenter returned to the room saying that she had forgotten her papers and asked the child if everything was all right in the room. If children answered yes (1



point), she would leave the room again, promising to return soon. Upon this second departure, the confederate said “Whew! That was a close one! Thanks for helping me keep this a secret and not telling (*E’s name*). Hmm . . . all this talking sure makes me hungry! I’m very hungry right now, are you? Mmm, I wish I could have my favorite food right now. Pizza, I love pizza. Mmm, I really wish someone would feed me some pizza! (*E’s name*) always feeds me broccoli, yuck! I hate broccoli! Uh-oh! Here, she comes again, remember to keep our secret ok? Shh!” Small canisters of fish food were located on the table next to the tank, with one depicting pizza on the outside and one depicting broccoli. The experimenter then returned to the room and proceeded to ask children a series of questions about whether or not the fish was hungry, what the fish liked or did not like to eat (she suggested broccoli), and how they knew these things about the fish, thus giving them several opportunities to reveal the secret. At any time that children gave away the secret, the experimenter ended the task and debriefed them on what they actually heard and introduced them to the confederate researcher in the control room. Children were then invited to feed the fish together. The degree to which children were able to keep the secret was scored as the number of correct (secret-maintaining) responses given to the experimenter’s prompts, ranging from 0 (revealed immediately upon the first return to the room) to 5 (never revealed). Note that all but four children tested were credulous of the fish’s ability to speak until they were debriefed (and several persisted in their excitement about the fish even after debriefing). Non-believers were excluded from data analysis of this task.

*Emotion Understanding.* Children were given a version of Gnepp and Chilamkurti’s (1988) Emotion Understanding task. The experimenter told two stories about two different boys or girls (gender was matched to the participant). Each story was accompanied by four drawings. The first story depicted Eric/Erica as someone who “doesn’t like to share” and ended with the mother asking Eric/Erica to share cookies with friends. The experimenter first asked four memory questions to ensure that children correctly understood and remembered the story. Then they were asked to predict how Eric/Erica would feel upon being asked by his/her mother to share the cookies (prediction question: “Do you think Eric/Erica felt happy or sad when his/her mom said that?”), and the reason for their prediction (justification question: “Why do you think Eric/Erica felt [happy/sad]?”). The second story depicted Tommy/Tammy as someone “who likes to help other people” and ended with the mother asking Tommy/Tammy to help his/her little sister clean her room. Again, children were first asked memory questions and then asked to predict how Tommy/Tammy would feel upon being asked by his/her mother to help the sister, and why. Children received a point for each correct response to prediction and justification questions (whether the justification corresponded appropriately to the prediction), for a total maximum score of 4.

## 2.6. Parent questionnaires

*Self-Control Rating Scale* (Kendall & Wilcox, 1979). This questionnaire includes 33 statements about the child’s inhibitory control (e.g., “Does the child think before he or she acts?”). Parents were asked to rate their child’s tendencies on a 7-point scale (1 = always; 7 = never, for all items). To reduce the potential confusion of negative correlations, we later reverse-scored items so that higher scores meant better self-control. Item scores had good internal consistency, Cronbach’s  $\alpha = .92$ , and were summed and then averaged for data analysis.

*Emotion Regulation Rating Scale.* We developed a brief 6-item questionnaire to obtain parent-report information about children’s ability to regulate their behavior in emotionally charged situations. Items are listed in Table 1. The response scale ranged from 1 (not likely) to 7 (very likely). Individual items were reverse-scored as needed and averaged for data analysis. Higher

Table 1  
The emotion regulation rating scale

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*Instructions*

Please rate this child according to the descriptions below by circling the appropriate number. The underlined 4 in the center of each item represents where the average child would fall on this item. Please feel free to use the entire range of possible ratings.

*Items*

1. After receiving a Disappointing Gift from someone, how likely is your child to pretend to like the gift?
  2. After seeing someone trip or fall down in a funny way, how likely is your child to laugh out loud?
  3. After eating something that is distasteful to your child, how likely is he/she to spit out the food or react negatively?
  4. In a more serious setting, such as church or a funeral, how likely is your child to understand and behave appropriately to the solemn situation?
  5. If asked to keep a secret (e.g., not telling a sibling about a surprise birthday party), how likely is your child to keep the secret?
  6. How likely is your child to help others (e.g., friend/sibling) keep a secret in order to prevent punishment? (e.g., not telling mom that a sibling knocked over a vase)
- 

*Note:* All items were accompanied by the following 7-point scale:

1      2      3      4      5      6      7

not likely

very likely

scores meant greater emotional control. This exploratory questionnaire had adequate internal consistency, Cronbach's  $\alpha = .68$ .

### 3. Results

#### 3.1. Reliability of coding

Following initial training and refinement of coding schemes for the new measures, we obtained inter-rater reliability between the main coder and a second coder on all behavioral measures for 11 participants (21%). Percent agreement was  $\geq 90\%$  (Cohen's  $kappa \geq .80$ ) on all dependent measures and reaction times were all within 1 s on Gift Delay.

#### 3.2. Descriptive statistics

Means and standard deviations for all dependent variables are shown in Table 2. These results suggested sufficient variability to detect individual differences, however, there was some evidence of positive skew on Gift Delay, and negative skew on Disappointing Gift.

#### 3.3. Relations with age, sex, and verbal ability

Correlations among all variables and their relations to age (in months), sex, and verbal ability (indexed by PPVT-III) are provided in Table 3. Age was significantly positively related to Simon Says, Gift Delay, Emotion Understanding, Disappointing Gift (reporting they liked the gift), and parent report on the Self-Control and Emotion Regulation Rating Scales. With increasing age, children also were significantly *less* likely to display negative emotional expressions in the Disappointing Gift task.

Table 2  
Measures and descriptive statistics by age group

Variable	<i>N</i>	Min	Max	Overall Mean (S.D.)	4-year-olds Mean (S.D.)	5-year-olds Mean (S.D.)
PPVT-III (raw)	53	45	126	86.60 (19.17)	78.96 (16.49)	95.16 (18.60)
Simon Says	53	7	30	21.17 (5.84)	18.79 (5.87)	23.84 (4.59)
Forbidden Toy						
No Touch	53	0	1	.55 (.50)	.46 (.51)	.64 (.49)
Lie	52	0	1	.37 (.49)	.36 (.49)	.38 (.49)
Gift Delay						
Peek score	53	0	2	1.43 (.82)	1.14 (.89)	1.76 (.60)
# of peeks	53	0	4	.67 (1.09)	1.04 (1.28)	.28 (.68)
latency (second)	53	1.00	60.00	49.45 (18.13)	44.73 (20.19)	54.36 (14.52)
Conflict Emotion	53	1	4	3.02 (1.03)	2.68 (1.07)	3.38 (.88)
Secret Keeping	48	0	5	2.54 (1.83)	2.33 (2.06)	2.81 (1.5)
Disappointing Gift						
Like/Dislike	43	0	1	.56 (.50)	.38 (.49)	.79 (.42)
Negative Expression	53	1	4	1.72 (.84)	2.04 (.92)	1.36 (.57)
Self-Control RS	53	1.88	4.73	3.24 (.73)	3.43 (.72)	3.03 (.69)
Emotion Regulation RS	53	1.33	5.67	3.57 (.97)	3.32 (1.11)	3.90 (.62)

Note: Gift Delay # Peeks and the Self-Control Rating Scale were reverse-scored for data analyses; original scores are shown.

A similar pattern of results emerged for verbal ability. PPVT-III scores were significantly related to Simon Says, Gift Delay, Emotion Understanding, Secret Keeping, Self-Control Rating Scale, and the Emotion Regulation Rating Scale. These findings suggested, as we expected, that aspects of inhibitory control of action and emotion were strongly related to both age and verbal ability. Hence, we controlled for these factors in partial correlations presented in parentheses in Table 3.

Sex was not related to study variables in any consistent manner. Girls were somewhat more likely to succeed on Simon Says, but performed less well than boys on Gift Delay and Disappointing Gift (the “like” question). Sex will be considered in later analyses but these results suggested it was not necessary to include it as a covariate in the main analyses.

#### 3.4. Correlations among inhibitory control measures

As shown in Table 3, Simon Says performance was unrelated to the two delay variables (Forbidden Toy and Gift Delay) but was significantly positively related to parent report of children’s self-control, and remained so even after controlling for age and verbal ability. Forbidden Toy and Gift Delay were significantly correlated with each other and to the Self-Control Rating Scale in both bivariate and partial correlations. Given this overall pattern of inter-correlation, we present findings for individual tasks as well as the Inhibitory Control Composite scores consisting of the average standardized (*z*) scores across Simon Says, Forbidden Toy (touch minus lie scores), and Gift Delay. A principle components analysis indicated a one-factor solution accounting for 58% of the variance with the following factor loadings: Gift Delay (.82); Forbidden Toy (.76); Simon Says (.47). Parent report of self-control was significantly correlated with children’s performance on the Inhibitory Control Composite and remained so after controlling for age and verbal ability (see Table 3).

Table 3  
Correlations and partial correlations between measures

	Sex	PPVT	Simon Says	Forbidden Toy Touch	Forbidden Toy Lie	Gift delay	Emotion Understd.	Secret Keeping	Disappoint Gift like	Gift Negative Express.	IC COMP	ER COMP	Self-Control Rating Scale	Emot. Reg. Rating Scale
Age	-.14	.54***	.56***	.01	.19	.33*	.47***	.13	.32*	-.34*	.27†	.43**	.30*	.38**
Sex	1.000	-.11	.24†	.05	-.02	-.28*	.04	-.12	-.32*	.04	.02	-.20	.14	.12
PPVT-III		1.000	.43**	-.08	.06	.33*	.56***	.34*	.19	-.15	.23†	.46**	.32*	.29*
Simon Says			1.000	.09	.04	.19	.50*** (.27†)	-.01	-.01	-.39** (-.27†)	.46** (.38**)	.28* (.00)	.42** (.30*)	.48*** (.34*)
Forbidden Toy Touch				1.000	-.82*** (-.85***)	.38** (.43**)	.01	.09	.25	-.31* (-.32*)	.85*** (.90***)	.22 (.28*)	.33* (.37**)	.22 (.25†)
Forbidden Toy Lie					1.000	-.19 (-.27†)	.11	-.12	-.08	.29* (.39**)	-.73*** (-.83***)	-.11 (-.21)	-.19 (-.26†)	-.14
Gift Delay						1.000	.36** (.19)	.25† (.18)	.41** (.34*)	-.31* (-.23†)	.65*** (.62***)	.55*** (.45**)	.28* (.16)	.16
Emotion Understd.							1.000	.43** (.34*)	.28† (.16)	-.23	.28* (.16)	.76*** (.66**)	.23	.35** (.18)
Secret keeping								1.000	.32* (.31†)	-.12	.17	.73*** (.73***)	.04	-.07
Disappoint Gift Like/Dislike									1.000	-.26† (-.17)	.26* (.19)	.68*** (.66***)	.03	.01
Disappoint Gift Negative Express.										1.000	-.48*** (-.44**)	-.48*** (-.43**)	-.12	-.31* (-.21)
IC COMP											1.000	.43** (.35*)	.45** (.39**)	.37** (.29*)
ER COMP												1.000	.17	.21
Self-Control Rating System													1.000	.62*** (.57***)

Note: Selected partial correlations controlling for age and verbal ability are shown in parentheses. IC COMP = Inhibitory Control Composite; ER COMP = Emotion Regulation Composite.

\*  $p < .05$ .

\*\*  $p < .01$ .

\*\*\*  $p < .0001$ .

†  $p < .10$ .

### 3.5. Correlations among emotion regulation measures

The emotion variables also are displayed in Table 3. Emotion Understanding was significantly positively related to Secret Keeping, and remained so even after controlling for age and verbal ability. The relations between Emotion Understanding and Disappointing Gift (Like/Dislike) and the Emotion Regulation Rating Scale were marginal or significant in bivariate analyses but were nonsignificant in partial correlations. Secret Keeping was significantly related to Disappointing Gift; the ability to keep an exciting secret (positive emotion-suppression) predicted children's ability to say they "liked" the undesirable gift (negative emotion-suppression and initiation of an opposite response to the way one really feels), although it was not related to their ability to suppress negative emotional expressions upon opening the gift. Disappointing Gift (negative expressions) was significantly negatively related to scores on the Emotion Regulation Rating Scale, but fell below significance after controlling for age and verbal ability. Given this pattern of results, we computed an aggregate Emotion Regulation Composite for each participant consisting of standardized and averaged Emotion Understanding, Secret Keeping, and Disappointing Gift ("like" minus negative expression) scores. A principal components analysis indicated a one-factor solution accounting for 68% of the variance with the following factor scores: Emotion Understanding (.79); Secret Keeping (.78); Disappointing Gift (.72). Parent report of emotion regulation was moderately but nonsignificantly related to children's performance on the Emotion Regulation Composite,  $r(53) = .21, p > .10$ . Parent report was considered separately in further analyses.

### 3.6. Relation between inhibitory control and emotion regulation

Next we examined the key question of interest in this study. First, using the aggregate measures, we found that IC and ER were significantly correlated,  $r(53) = .43, p = .001$ . After controlling for the effects of age and verbal ability, this relation remained significant,  $r(49) = .35, p < .05$ .

As shown in Table 3, several of the individual task variables were correlated. Simon Says was significantly related to Emotion Understanding (positively) and to Disappointing Gift Negative Expressions (negatively). Both coefficients were reduced to trends in partial correlations controlling for age and verbal ability. In addition, Forbidden Toy (Touch) was negatively related to Disappointing Gift Negative Expressions, even in partial correlations, indicating that children who were able to inhibit touching the toy ( $n = 29$ ) also were able to suppress negative expressions upon receiving an undesirable gift. Conversely, children who lied about having touched the toy ( $n = 19$ ) tended to exhibit negative emotional responses in the Disappointing Gift task. (Note that none of the children who did not touch the toy lied by saying they *had* touched it.) Lastly, Gift Delay was related to all three of the Emotion Regulation tasks. The relation to Disappointing Gift ("like" response) remained significant and that to negative expressions was marginally significant in partial correlations. The relations of Gift Delay to Emotion Understanding and Secret Keeping were nonsignificant after controlling for age and verbal ability. Hence, as expected, the aggregate measures produced more reliable and robust coefficients estimating the relation between IC and ER than did the individual task variables.

Although there is precedent in the literature showing that emotion knowledge and regulatory skills co-develop (e.g., Denham et al., 2003), it might be argued that our inclusion of Emotion Understanding in the ER Composite unduly influenced the relation to IC. The story task in which children were asked about others' emotional states is somewhat analogous to theory of mind (Banerjee, 1997), which is known to have a robust relation to individual differences in inhibitory

control in the preschool period (e.g., Carlson & Moses, 2001), but perhaps it should not be considered emotion regulation, per se. Therefore, we computed a separate Emotion-Suppression Composite score for each participant that reflected the average performance across positive (Secret Keeping) and negative (Disappointing Gift) emotion-suppression. Emotion-suppression was significantly related to IC Composite scores,  $r(50) = .46, p = .001$ , and remained so after controlling for age and verbal ability,  $r(46) = .41, p < .01$ .

The parent-report measures (Self-Control and Emotion Regulation Rating Scales) were highly correlated with each other, and remained so after controlling for age and verbal ability (see Table 3). The Self-Control Rating Scale was unrelated to children's ER Composite scores. However, the Emotion Regulation Rating Scale was significantly correlated with children's performance on the IC Composite and remained so after controlling for age and verbal ability.

In the next set of analyses, we considered the 4- and 5-year-old age groups and males and females separately, to determine whether the magnitude of the relation between IC and ER differed as a function of age or sex. The results indicated that the IC and ER Composites were significantly related in the 4-year-olds,  $r(30) = .42, p < .05$ , but not the 5-year-olds,  $r(23) = .10, p > .10$ . Among 4-year-olds, the relation held up independent of verbal ability as measured by the PPVT-III,  $r(28) = .41, p < .05$ . Furthermore, the Inhibitory Control and Emotion Regulation Composites were significantly related in girls,  $r(28) = .55, p < .01$ , but less strongly in boys,  $r(25) = .25, p > .10$ .

In the final set of analyses, we compared linear and nonlinear models of hierarchical regression with ER scores as the criterion. In particular, we wanted to explore Eisenberg and Fabes' (1992) model that suggested there might be an inverted U function in the relation between IC and ER, such that low and high levels of inhibition could be associated with ER difficulties. Consistent with the correlation analyses, IC Composite scores significantly predicted the ER Composite,  $F(1, 48) = 15.05, p < .001$ . In this linear model, multiple  $R = .49, R^2 = .24, \beta = .49, t = 3.88, p < .001$ . The quadratic model also was significant,  $F(2, 47) = 11.77, p < .001$ , and furthermore, the quadratic fit the data significantly over and above the linear effect, multiple  $R = .58, R^2 = .33, \beta = -.33, t = -2.59, p < .05$ . The nonlinear function explained an additional 9.5% of the variance in ER. Given these results, we categorized children evenly into low, medium, and high on IC and plotted their ER scores for 4-year-olds and 5-year-olds separately. Fig. 1 illustrates

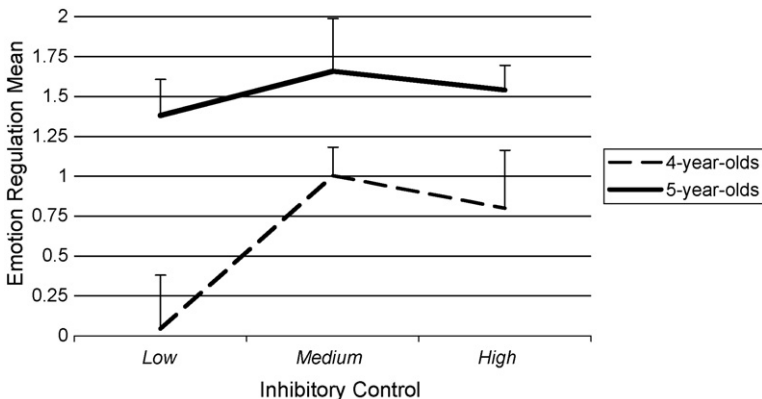


Fig. 1. Quadratic relation between emotion regulation and inhibitory control as a function of age group. *Note:* Emotion regulation scores reflect the mean  $z + 1$  to avoid negative numbers in the illustration. Bars represent standard error.

how *medium* levels of IC were associated with the highest levels of ER performance in both age groups.

#### 4. Discussion

The aim of this research was to investigate the nature and strength of the relation between inhibitory control (a key aspect of EF) and emotion regulation in typically developing preschoolers. Our approach was novel in that it examined behavioral and parent-report methods of both constructs, included assessments of emotion understanding and both positive and negative emotion-suppression, and controlled for verbal ability.

##### 4.1. Summary of results

As we hypothesized, individual differences in IC and ER were significantly positively related. The magnitude of the zero-order correlation between the composite scores in the total sample was moderate ( $r = .43$ ). Each construct also was related to age and verbal ability; nevertheless, the relation between IC and ER remained significant when these factors were held constant. Furthermore, the relation remained (and was even stronger) for IC and Emotion-Suppression scores, suggesting that our inclusion of Emotion Understanding in the ER Composite did not spuriously inflate the correlation. Individual tasks from each construct were correlated, however, as is commonly found in the EF literature, the relation was stronger at the aggregate level. Rushton, Brainerd, and Pressley (1983) advocated aggregation across individual measures of a construct for greater psychometric precision. It is also noteworthy that the parent-report measures of the constructs of interest (Self-Control and Emotion Regulation Rating Scales) were significantly correlated, and remained so over and above child age and verbal ability. There was also evidence of an association across constructs and reporting methods: parent report of emotion regulation was significantly related to children's IC scores, independent of age and verbal ability. The converse pattern (parent report of self-control predicting children's ER scores), was nonsignificant, however.

Although it is important not to lose sight of the omnibus result, the strength of the relation between IC and ER varied somewhat according to age and sex. It was significant in 4-year-olds but not in 5-year-olds, and quite strong in girls ( $r = .55$ ) but not boys, considered separately. The age finding might be due to methodological factors, such as a small sample and ceiling effects in 5-year-olds on some of our measures, although as shown in Fig. 1, the *nature* of the relation in 5-year-olds mimicked that of 4-year-olds despite their higher overall level of ER. In any case, it will be fruitful to include 3-year-olds in future research of this kind to examine the earlier emergence of IC and ER skills. The gender finding is consistent with some previous research on ER suggesting that poorly regulated emotions are more rare in girls due to socialization and/or greater emotion awareness, but when girls *are* dysregulated, it is usually indicative of even more severe problems of effortful control and social competence than is the case for boys (e.g., Denham et al., 2003; Eisenberg et al., 1996; McDowell et al., 2000).

Lastly, when we compared linear and nonlinear models regressing IC onto ER Composite scores, the linear function was significant, as anticipated given the zero-order correlations. In addition, however, there was evidence for a significant quadratic relation between the variables (over and above the linear relation), such that intermediate scores on IC were associated with the highest scores on ER in an inverted U pattern. To interpret these overall results, we next consider three basic ways of conceptualizing the potential interplay between EF and emotion regulation.

#### 4.2. *Inter-relation between executive function and emotion regulation*

*EF*  $\rightarrow$  *ER*. The first possibility is that domain-general inhibitory processes underlie and are indeed necessary for successful emotion regulation. Working memory (holding a goal in mind) plus inhibition may enable the suppression of unwanted emotional experience, inappropriate emotional displays, and possibly even the physiological markers of emotional arousal (e.g., Gross, 1998). On this account we would expect emotion regulation to depend functionally on the development of inhibitory control and maturation of PFC (e.g., Harnishfeger & Bjorklund, 1993). The link between inhibitory control and emotion regulation lies in the fact that they both have the same underlying requirements: (1) preventing an impulsive response, and (2) carrying out the opposite act. For example, to regulate an emotion expression in the Disappointing Gift task, one must resist an impulsive response (e.g., blurting out “I don’t want this!”), and ideally behave in a way that does not correspond to how one is actually feeling (e.g., smiling and saying thank you). If a deficiency of inhibitory control prevents either of these steps, then emotion regulation has failed and more than likely, the audience will not be convinced by the act. Furthermore, on this account, the more intense the experience of our *true* internal emotions, the harder it will be to control its expression and hence increase the need for inhibitory control. This hypothesis could be tested by manipulating the emotion-arousal levels within a paradigm to see whether individual differences in inhibitory control predict emotion regulation performance incrementally as a function of emotional intensity.

*ER*  $\Rightarrow$  *EF*. The second possibility is that emotion regulation plays an essential role in successful inhibitory control. On this account, better emotion-coping (via self-regulation) frees up cognitive resources for more effective problem-solving, that is, it frees up resources for the suppression of thought processes or actions that interfere with the goal or task at hand. When all is well, emotions are not so much *regulated* as they are *regulating* of ongoing goal-directed behavior. However, unchecked emotions can impair reasoning and planning ability by placing additional burdens on an already-taxed information processing system.

From this perspective, emotion is seen as fundamental to individual differences between children in temperament and coping style (e.g., Eisenberg et al., 1996; Lengua, 2002, 2006; Rothbart & Bates, 1998). Rothbart and Bates (1998) defined temperament as, “individual differences in basic psychological processes constituting the affective, activational, and attentional core of personality” (p. 108). Furthermore, emotion expressions are seen as reflecting children’s evaluation of the extent to which their *goals* are met by ongoing events (Campos, Campos, & Barrett, 1989). Thus, individual differences or predispositions in emotional functioning (conceptualized as temperament and thought to be relatively stable) can contribute to underlying processes of adaptation (or maladaptation) in all manner of goal-oriented problem-solving situations, whether they are intrapersonal and “cognitive” or more dynamic, interpersonal and “social.” As discussed in the Introduction, negative emotionality, in particular, may directly impair problem-solving ability.

*EF*  $\Leftrightarrow$  *ER*. The third possibility incorporates aspects of both directional hypotheses into an integrative model, such as that proposed by Zelazo and Cunningham (2007). They referred to deliberate self-regulation of emotion via conscious cognitive processing as the aspect of emotion regulation that is most relevant to EF, although more automatic processes of self-regulation also are clearly involved. When the primary goal, the “problem” at hand, is to regulate an emotional expression, EF and ER are indistinguishable. However, when modulation of emotion is secondary and occurs in the service of solving another problem (e.g., not peeking on Gift Delay), then EF is said to *involve* ER, but in this case other non-affective, higher-order infor-



mation processes associated with psychological distancing are likely to be active (e.g., strategies such as talking and singing). In this manner, both hot EF (control of an approach/avoidance focus) and cool EF (higher order processing of abstract information) may be associated with ER.

Correlational designs do not permit us to sort out these different possibilities but they do enable us to examine the nature and magnitude of the relation between IC and ER. Our finding of a quadratic relation points to the complexity of this interplay, and the need to consider what *more* inhibitory control means in different theoretical orientations. Strictly speaking from an EF perspective, more inhibitory control over interfering thought processes or actions is seen as adaptive and ought to be monotonically related to numerous cognitive skills (e.g., as it is to theory of mind, Carlson & Moses, 2001). From a temperament perspective, however, more inhibited tendencies in children (e.g., extreme shyness and fearfulness) can be associated with a host of developmental difficulties, as in Kagan's construct of behavioral inhibition (Kagan, Reznick, & Gibbons, 1989). In the developmental psychopathology literature, several investigators such as Fox (1994) and Nigg (2000) make the distinction between under-control that can result in externalizing problems (e.g., ADHD, oppositional behavior) and over-control that can result in internalizing problems (e.g., depression and anxiety).

It is possible that children who scored in the upper third on our IC Composite measure were relatively over-controlled and, while this trait can be helpful in some more cognitively oriented problem-solving situations, it could be less helpful (and maybe even harmful) in motivationally significant situations due to blunting of affect or increased anxiety. This interpretation fits with Eisenberg and Fabes' (1992) tripartite model of temperament and self-regulation, in which optimally controlled children would be expected to perform best on measures of emotion regulation relative to both under-controlled and highly inhibited children. Although we did not administer a full-scale temperament assessment in the present study, we know from Beck et al.'s (2007) large-scale study that preschool children who performed best on EF tasks were more highly introverted (a reactivity trait) as well as higher in effortful control (a regulatory trait). Furthermore, Liew et al. (2004) found that effortful control (both parent and teacher report) was associated with fewer *negative* reactions in the Disappointing Gift paradigm, similar to our finding of a significant zero-order correlation between IC and ER. Interestingly, however, in their study effortful control also was associated with fewer *positive* reactions during disappointment, which might suggest some emotion blunting in the most highly controlled children. This finding is consistent with our results showing an inverted U function in the IC-ER intercepts. The quadratic relation also is consistent with a report from Bell and Wolfe (2004) of relatively *poor* emotion regulation (measured as distress to limitations) in infants with *better* working memory. Their interpretation was that less emotionally well-regulated children elicit more parental interaction and support, which may in turn lead to enhanced cognitive skills including working memory. Thus, the caregiving environment might play an essential role in helping to explain these seemingly paradoxical effects. Our finding of a nonlinear relation clearly supports an interactive model of cognition and emotion and indicates that future research and theory will call for more nuanced conceptualizations of EF-ER relations.

#### 4.3. Limitations and future directions

Although EF is often depicted as a unitary construct (e.g., a central executive; Baddeley, 1986; Shallice, 1988), there is some support for at least partially dissociable EF processes involving working memory and different types of inhibition (Friedman & Miyake, 2004;

Miyake et al., 2000). We did not examine multiple divisions within the EF construct and their relation to emotion regulation, but this is a potentially fruitful direction for further research.

Similarly, multiple levels of analysis remain to be explored in addition to the behavioral assessments we used. For example, electrophysiological (EEG/ERP) techniques hold promise for evaluating the role of PFC in cognitive control in both emotive and non-emotive contexts (Lewis & Stieben, 2004). Neuroscience approaches might help to address the thorny problem in the ER literature of sorting out emotional *experience* from *regulation*, neither of which is observed but inferred from low intensity of emotional *expression*. It is possible that the individual differences we observed were more a matter of emotional intensity – and therefore in the province of temperament – than a matter of more or less effective regulation of a steady state (Cole et al., 2004; Fox, 1994; Kagan et al., 1989). However, in the disappointment paradigm at least, children do appear to intentionally modulate their emotion expressions in accordance with display rules (Cole, Zahn-Waxler, & Smith, 1994). Even so, it is difficult to standardize the extent to which different children will feel disappointed in this situation.

We also do not know the extent to which our new Secret Keeping task, designed to elicit regulation of positive excitement, was testing regulation per se versus individual differences in the emotional experience itself. It is possible that some children were very excited to share the secret whereas others were astonished and fearful of the talking fish. Further research is needed to validate this measure by demonstrating a *change* in emotion expression over time and across different social conditions. Nevertheless, this task is potentially useful for extending our understanding of emotion regulation to include positive emotions. It is important to keep in mind that highly exuberant children's inability to keep a lid on a secret, inappropriate laughter, speaking in an overly loud voice, surgency (e.g., excessive tickling), and generally not knowing when to put the brakes on their activities, are likely to put them at risk for peer rejection and poor adjustment, even though most prior research on emotion regulation has concentrated on the outcomes of negative emotions such as anger (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001).

Lastly, our research using diverse tasks helps to illustrate how similar executive control processes can be used in the service of controlling action and emotional expression. Future research, however, might include more controlled attempts to examine development and individual differences in highly similar tasks infused with cool (non-affective) and hot (affective) overtones.

The present study raises several issues that remain to be explored in cognition-emotion interactions, but it provides some answers as well. First, it demonstrated a significant correlation between individual differences in inhibitory control and emotion regulation in preschool children, using behavioral and parent-report measures of both constructs, and controlling for age and verbal ability. Second, the study uncovered a nonlinear relation between these constructs, in which both low and high levels of inhibition can be deleterious for the regulation of emotion in a social context. This research highlights that both cognitive control and temperament are important interactive contributors to socio-emotional development.

### **Acknowledgement**

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## Appendix A. Scoring sheet for reactions to the Disappointing Gift

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### Positive dimensions (1 each)

- \_\_\_Broad smile with teeth showing
- \_\_\_Broad, closed lip smile
- \_\_\_Enthusiastic “thank you”
- \_\_\_Arched brows as in positive surprise
- \_\_\_Smiling eye contact with experimenter
- \_\_\_Eye crinkle while smiling

Positive dimensions score: \_\_\_\_\_

### Transitional response dimensions (0)

- \_\_\_Slight smile – open or closed lips
- \_\_\_Faint or mumbled “thank you”
- \_\_\_Knit brows while smiling slightly, or as in distress
- \_\_\_Tongue movements visible outside mouth
- \_\_\_Two or more gaze shifts between gift and experimenter
- \_\_\_Biting or teeth visible on lips
- \_\_\_Hands to face, head
- \_\_\_Head tilt, turn
- \_\_\_Questioning vocalization
- \_\_\_Laughing, giggling
- \_\_\_Mouthing (opening, shutting)
- \_\_\_Abrupt loss of smile

### Negative dimensions (1 each)

- \_\_\_Nose wrinkling
- \_\_\_Lowered brows as in a frown or as in annoyance, disappointment
- \_\_\_Omitted “thank you”
- \_\_\_Puckered or pursed mouth
- \_\_\_Tight, straight-line mouth
- \_\_\_Avoids eye contact with experimenter
- \_\_\_Negative noise emitted (e.g., snort, “ugh”)
- \_\_\_Makes a negative comment (e.g., “This is *just* a woodchip!” or “I don’t want this”)
- \_\_\_Shoulder shrug

Negative dimensions score: \_\_\_\_\_

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