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Emergent self regulation skills among very young ethnic minority children: A confirmatory factor model

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Abstract

Emerging self regulation skills were assessed in 407 low income, African American and Latino (primarily Mexican origin) preschoolers. A battery of self regulation tasks was administered when children were 2½ years old and again approximately one year later. Confirmatory factor analyses supported four components of self regulation: inhibitory control, complex response inhibition, set shifting and working memory. Complex response inhibition was too rare a skill in this sample to be detected reliably from measures collected at age 2½ but emerged from measures collected at age 3½. In addition, significant ethnic differences were found in that African American children scored better on measures of complex response inhibition and set shifting while Latino children scored better on measures of inhibitory control and working memory. Implications of study findings for measuring self regulation in low income, ethnic diverse populations of young children as well as for the development of interventions to enhance self regulation development are discussed.

The early childhood literature has witnessed a veritable explosion of research focused on the development of self regulation among young children. As evidence of this, the number of research publications identified with the keywords “self regulation” and “preschool” in the PsycInfo database increased ten-fold between 2000 and 2011. One reason for this increased interest is evidence that self regulation is positively associated with better academic performance and behavioral adjustment in kindergarten and early elementary school (Bierman, Nix, Greenberg, Blair, & Domitrovich, 2008; Brock, Rimm-Kaufman, Nathanson, & Grimm, 2009; Dilworth-Bart, 2012; Eiden, Edwards, & Leonard, 2007; Evans & Rosenbaum, 2008; Graziano, Reavis, Keane, & Calkins, 2007; McClelland et al., 2007; Miech, Essex, & Goldsmith, 2001; Mistry, Brenner, Biesanz, Clark, & Howes, 2010; Sektnan, McClelland, Acock, & Morrison, 2010). Self regulation skills are important because they are reflected in a wide range of activities in which children must engage in order to be successful in the classroom including the ability to sit still, the ability to follow

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directions, and the ability to control impulsive behaviors. These findings have led to the development of several interventions targeted at improving self regulation as a way of improving early academic achievement (Bierman, et al., 2008; Diamond, Barnett, Thomas, & Munro, 2007; Diamond & Lee, 2011; Raver et al., 2011).

Ethnic minority children are more likely to experience early academic failure than are non-minority children (Cicchetti & Toth, 1998; Garcia & Gonzales, 2006; Kraatz Keiley, Bates, Dodge, & Pettit, 2000; Lee & Burkham, 2002; U.S. Department of Education, 2004). Poor self regulation skills have been identified as a mediator of the effects of poverty-related risk factors that disproportionately affect ethnic minority children (Evans & Rosenbaum, 2008; Mistry, et al., 2010), and improving self regulation skills is an important approach for reducing ethnic disparities in early academic achievement. However, effective intervention development requires a firm understanding of the emergence and developmental course of self regulation among ethnic minority children specifically.

Despite the need for developmental data on the emergence of self regulation among ethnic minority children, research on self regulation in ethnically diverse young children is still sparse, and psychometric analyses of self regulation measures collected on ethnically diverse children is rare. A systematic review of the studies reported by Garon et al. (2008) in their review of the literature on the emergence of executive functions during early childhood found that either researchers did not report the race/ethnicity of their samples or reported samples comprised of 80–95% White, non-Latino children. The only longitudinal studies of executive function/self regulation initiated before age 4 included virtually no ethnic minority children (Carlson, 2005; Kochanska, Coy, & Murray, 2001; Lengua, Honorado, & Bush, 2007), included a very limited measure of self regulation (Spinrad et al., 2007), did not conduct psychometric analyses of self regulation measures (Li-Grining, 2007), or relied only upon parent report (Raikes, Robinson, Bradley, Raikes, & Ayoub, 2007). The Family Life Project (FLP) is an exception with longitudinal data that includes individual child assessments starting at age 3, but the sample is 75% White, non-Latino, 25% African American and differs from most in its focus on rural children. More data on the emergence of self regulation in ethnic minority children is critical for the development of effective interventions to reduce disparities in school readiness and early academic achievement.

Bassett, Denham, Wyatt, and Warren-Knot (2012) summarized the commonly accepted definition of self regulation as “a broad construct representing the cognitive, motivational-affective, social and physiological processes that modulate attention, emotion, and behavior to a given situation/stimulus, for the purpose of pursuing a goal” (p. 597). The cognitive skills fundamental to self regulation are referred to as *executive functions* and encompass the interrelated skills of working memory, inhibitory control, and cognitive flexibility (Bassett, et al., 2012; Blair & Ursache, 2011; Denham, Warren-Khot, Bassett, Wyatt, & Perna, 2012; Diamond, 2006; Garon, Bryson, & Smith, 2008). Self regulation tasks often require the utilization of more than one executive function skill (Denham, et al., 2012).

Working memory is described as the ability to maintain and manipulate information in mind for short periods of time. It is the executive function that develops earliest and begins to develop before the age of 6 months (Garon, et al., 2008). At the youngest ages, working memory is often assessed with tasks requiring the child to find hidden objects. In preschool-aged and older children, working memory is assessed with downward extensions of memory span tasks, such as having to remember items or find hidden objects in increasingly longer sequences (e.g., one item, two items, three items, etc.).

Inhibitory control is defined as the ability to inhibit a habitual or reactive response in favor of a subdominant response (Bassett, et al., 2012; Blair & Ursache, 2011; Denham, et al.,

2012; Diamond, 2006; Garon, et al., 2008). Although inhibitory control first emerges during the latter part of the first year, levels of compliance vary greatly between children and increase significantly from infancy through early childhood. Some tasks that assess inhibitory control require a child to wait before engaging in a desired activity such as opening a gift (“wrapped gift” task), eating a candy (“snack delay” task), or touching an attractive toy (“forbidden toy” task). The amount of time a child can wait increases rapidly between the ages of 3 and 5 (Carlson, 2005; Garon, et al., 2008). The “walk-a-line slowly” and “whisper” tasks developed by Kochanska (1996) also assess inhibitory control. In the “walk-a-line slowly” task, also referred to as “balance beam”, the child is required to walk down a 6 foot line at normal speed and then again as slowly as possible. In the “whisper” task, the child is asked to whisper the names of favorite cartoon characters when shown their picture. As with the wrapped gift, snack delay, and forbidden toy tasks, compliance with these inhibitory control tasks increases significantly over the period of early childhood (Kochanska, et al., 2001; Kochanska, Murray, & Coy, 1997).

Inhibitory control tasks such as snack delay and wrapped gift are sometimes referred to as simple response inhibition tasks. In *complex response inhibition* tasks, the child must hold an arbitrary rule in mind and suppress an automatic response in favor of a less potent response. For example, in the “silly sounds” task (Willoughby, Blair, Wirth, Greenberg, & The Family Life Project Investigators, 2010), children are asked to meow when they are shown pictures of dogs but bark when shown pictures of cats. Children must suppress their natural tendency to make the sound of the animal in the picture and make a different sound. Other complex response inhibition tasks capitalize on the child’s tendency to mimic others. For example, in the “pencil tap” task (Bassett, et al., 2012; Smith-Donald, Raver, Hayes, & Richardson, 2007), the child must tap a pencil once when the experimenter taps twice and vice versa, and in the Heads/Toes/Knees/Shoulders task (Ponitz, McClelland, Matthews, & Morrison, 2009), the child must touch his head when the experimenter touches his toes and vice versa. Although most children under the age of 3 fail these tasks, success rates increase between ages 3 and 5 (Carlson, 2005; Garon, et al., 2008). In addition, between ages 3 and 7, children are able to follow increasingly complex rules regarding the response required.

Cognitive flexibility is defined as the ability to shift attention or cognitive set and appears to develop later than other executive function skills, likely because it relies upon both working memory and inhibitory control (Carlson, 2005; Diamond, 2006; Garon, et al., 2008). The most well known example of a set shifting task is the Dimensional Card Change Sort (DCCS) (Diamond, 2006). In the DCCS, the child is given cards with pictures of different shapes in different colors and is taught to sort them by one dimension (shape or color). After the child has achieved this, he is asked to sort them by the other dimension. Set shifting tasks differ from complex response inhibition tasks in that the rule the child follows in the task is completely arbitrary and does not reflect any sort of “built in” response on the part of the child. Most researchers find that 3 year old children cannot switch rules whereas 4 year olds can (Carlson, 2005; Diamond, 2006; Garon, et al., 2008; Zelazo, Frye, & Rapus, 1996; Zelazo, Müller, Frye, & Marcovitch, 2003). Diamond (2006) proposes that 3-year olds fail set shifting tasks due to “attentional inertia”, e.g., an inability to disengage their attention from the previous criteria, such as shape, to focus on the new criteria, such as color.

The differentiation between “hot” and “cool” executive function has been suggested as an important distinction in understanding the scope of a child’s self regulation skills. Some inhibitory control tasks are considered to tap “hot” executive function because the tasks are assumed to trigger an emotional response of some sort in the child, such as a desire to play with an attractive toy. In contrast, “cool” executive function tasks, such as working memory, many complex response inhibition tasks, and cognitive flexibility tasks, are affectively neutral. Bassett et al. (2012) delineates how these two aspects of self regulation may support

different aspects of adjustment in the transition to formal schooling. Specifically, “cool” executive function skills are needed by children to flexibly respond to conflicting stimuli in the classroom and to follow complex rules, while “hot” executive function skills are important in classroom situations requiring regulation of emotion such as not taking classmates’ things or waiting for a turn to participate in activities. Researchers who have examined the distinction between hot and cool executive function have reported these aspects of self regulation are differentially related to child outcomes (Brock, et al., 2009; Dennis, Brotman, Huang, & Gouley, 2007).

An accurate delineation of the developmental course of executive function skills is critical for our understanding of emerging self regulation abilities of young children as well as for the development of effective interventions to improve self regulation and enhance school readiness. However, as articulated by Denham et al. (2012), “[o]ne of the greatest challenges for contemporary investigations of self-regulation involves the definition and measurement of these skills, particularly in young populations” (p. 398). There are numerous challenges inherent in assessing emergent self regulation skills in early childhood. For one, although tasks used to assess executive functions in adults have been used with school-age children, their use with preschool-aged children is problematic because of limitations of young children’s language, motor and attention skills (Isquith, Crawford, Espy, & Gioia, 2005; Wiebe et al., 2011). Furthermore, although tasks used with older children can be adapted for use with younger children, it is often not clear if those aspects of the task critical for assessing executive function remain intact.

Another challenge in assessing emergent self regulation skills is the wide variety of tasks and assessment batteries that have been used in the published literature. Despite recent attempts to standardize assessments of self regulation and executive function for young children (Smith-Donald, et al., 2007; Willoughby, Wirth, & Blair, 2011), there are significant differences in the scope of skills assessed as well as conclusions regarding the dimensionality of the construct itself. The Preschool Self Regulation Assessment (PSRA) battery was developed by Raver and colleagues for use in the evaluation of CSRP, an intervention specifically focused on enhancing school readiness via improved self regulation skills (Raver, et al., 2011; Smith-Donald, et al., 2007). Denham et al. (2012) and Bassett et al. (2012) used confirmatory factor analysis to support a two factor structure of self regulation as assessed by the PSRA test battery. The first factor tapped inhibitory control (labeled by the researchers as “hot executive control”) and reflected performance on a wrapped gift task, a snack delay, and a “tongue” task (a task in which the child must hold a chocolate candy on his tongue but not swallow until told to do so). The second factor tapped complex response inhibition (labeled by the researchers as “cool executive control”) and included performance on the balance beam task, the pencil tap task, and the “tower” task (a task in which the child is asked to build a tower of blocks taking turns with the assessor). The PSRA does not include any working memory or set shifting tasks.

Another recently developed battery of executive function tasks developed for preschoolers is the one used as part of the Family Life Project (FLP), a longitudinal study of children growing up in rural areas of Pennsylvania and North Carolina. Willoughby and colleagues examined the psychometric properties of the battery of tasks developed for that project both cross-sectionally (when target children were 3 and 5 years of age) as well as longitudinally from age 3 to 5 (Willoughby, Blair, Wirth, & Greenberg, 2012; Willoughby, et al., 2010; Willoughby, et al., 2011; Willoughby, Wirth, & Blair, 2012). In the extensive set of psychometric analyses of the FLP data, only a single factor model has emerged. However, an examination of the specific tasks comprising the FLP battery reveal that all of them likely tap into “cool” executive function (e.g., complex response inhibition and set shifting tasks

that are affectively neutral), so it is not surprising a single factor solution would be identified.

Wiebe and colleagues (2011) conducted a confirmatory factor analysis of a battery of tasks administered to a sample of three year olds that included working memory, inhibitory control, and complex response inhibition tasks, and their results also indicated that a single factor model best fit the data. Finally, Sulik et al. (2010) found that a single factor could explain performance on a battery of direct and teacher-reported self-regulation assessments. The battery of tasks used by Sulik et al. included inhibitory control tasks as well as a perseverance task (untangling yarn). Although Sulik et al. (2010) reported comparable fit for a two factor solution, they ultimately rejected the two factor solution on grounds of parsimony.

The existing research regarding the structure of emerging self regulation in young children is limited in a number of important ways that we will address in this paper. First, confirmatory analyses of the factor structure of self regulation skills among young children are still relatively rare. Other than the studies reviewed above, most investigators created composite indices without psychometric support of any sort. These studies report conflicting findings regarding whether self regulation among preschoolers is best represented by one or multiple factors, suggesting the need for additional study of this issue. In addition, more research is needed to examine the consistency of factor structures across child gender, ethnicity, and age. There is also a need for more data on emerging self regulation among ethnic minority children, particularly Latino children, as well as among low income children. Of the studies reported above that examined the factor structure of self regulation among young children, only Sulik et al. (2010) included a significant proportion of Latino children (24%). Likewise, more psychometric analyses are needed of self regulation measures collected with low income populations, as this group is especially at risk for deficits in self regulation and later school failure.

In this paper, we contribute to the growing literature on self regulation assessment in young children by examining emerging self regulation skills in a population of children at significant risk for early academic failure, that is, low income African American and Latino children. This large sample of children, including more than half that are Latino (primarily Mexican-origin), was first assessed when they were 2½ years old, when self regulation skills are just emerging, and reassessed approximately one year later. We address two research questions. First, what levels of self regulation are observed in these children across these ages? Second, do the observed measures of self regulation represent a single or multidimensional construct in this population, and do their measurement properties differ by child ethnicity or gender?

Method

Participants and Procedure

Participants in this study included 407 2½ year-old old children (188 girls). The sample consisted of 183 (45%) African American and 224 (55%) Latino children. Of the Latino families, 75.0% preferred to communicate in Spanish, and 73.2% were foreign born (95.7% of Mexican origin). The sample was predominantly low income, with 71.6% of families having an average family income-to-needs ratio over the course of the study below 100% of the federal poverty line. Families were recruited from the community in local WIC offices, local health and community events, and through word of mouth. Children were visited in their homes and tested individually by one home visitor while mothers completed an interview with a second data collector. Sample characteristics are outlined in Table 1. The average age of children at the time of first home visit was 29.79 months (sd = .63, range 28–

31 months). African American children were significantly more likely to live in households below 50% of the federal poverty level and in households without a father present. Latino caregivers were significantly more likely than African American caregivers to have less than a high school education

Of the 407 families who completed the first home visit, 366 (90%) completed the follow-up visit one year later. Although there were no differences by family poverty status or child gender, the follow-up rate was significantly higher among Latino families (93%) compared with African American families (86%), $\chi^2(1) = 6.27, p < .05$.

Measures

Child self regulation/executive function skills—The battery of tasks used at each time point was derived from published accounts of tasks used with similarly aged children as well as information published by Carlson (2005) documenting the discriminatory potential of a range of different tasks. The tasks included in the batteries at each time point are displayed in Table 2. Three tasks (Heads & Toes, Dimensional Card Change Sort, and Memory Span) were not included at Time 1 based on published data suggesting that 2½ year olds would not be able to succeed at these tasks. In addition, three tasks that were included at Time 1 (Forbidden Toy, Shape Stroop, and Walk-a-Line Slowly) were dropped from the Time 2 visit to maintain a home visit length that averaged no more than 90 minutes. Administration of six of the eight tasks described below was videotaped and the children's behavior scored from the videotaped records, allowing determination of interrater reliability of scoring. Interrater reliability was assessed using an intraclass correlation coefficient (ICC) (Shrout & Fleiss, 1979). Three tasks were relatively easy to score and were therefore scored live by the home visitor.

In the **Snack Delay task** (Kochanska, Murray, & Harlan, 2000), children were asked to wait until a bell was rung before eating a chocolate candy. The task consisted of 4 trials lasting 10s, 20s, 30s, and 15s, respectively. Each trial was coded for the latency (seconds) from the start of the trial until the child touched the candy. Interrater reliability [intraclass correlation (ICC)] for the snack delay task coding was .99 based on 15% of cases.

In the **Wrapped Gift task** (Kochanska, et al., 2000), the visitor instructed the child not to peek while a gift was wrapped directly behind them (60s). During the **Wait for Bow** phase, the visitor instructed the child not to touch the gift while she left the room to get a bow (90s). Scoring included latency to peek during the wrap phase, and latency to touch, lift, and open the gift during the wait for bow phase. Interrater reliability (ICC) for the wrapped gift task ranged from .90–.99 based on 21% of cases.

The **Forbidden Toy task** was adapted from the NICHD Study of Early Child Care and Youth Development (NICHD ECCRN, 1998). In this task, the child and visitor played with an attractive toy car that moves on its own after shaking it. After 60 seconds of back and forth play with the visitor, the child was asked not to touch or play with the car until the visitor returned to the room (150s). Type of engagement (e.g., touched car, played with car) and latency to touch were scored. Interrater reliability of coding (ICC) for the forbidden toy task averaged .95 based on 16% of cases.

The **Shape Stroop task** is a stroop-like task adapted for children (Kochanska, et al., 2000). The child is shown small pictures of fruit embedded inside larger pictures of fruit. When asked to point to the small pictures of fruit, the child must inhibit the dominant response to point to the large fruit, and activate the subdominant response to point to the correct small picture of fruit. The child was scored on his/her ability to name each fruit (2 trials), to point to the correct small picture of fruit in practice trials with reinstruction for incorrect responses

(2 trials), and to point to the correct small picture in test trials (4 trials). Children who responded correctly to at least one naming trial moved on to the practice trials. During the practice trials, the visitor corrected children for incorrect answers. Children who responded correctly to at least one practice trial moved on to the test trials. All trials were coded on a 3-point scale (0 = incorrect, 1 = self correct, 2 = correct). Children who began to point to the incorrect picture but then stopped themselves and pointed to the correct picture were coded as 'self-correct'. In the **Mommy and Me task** (Bell & Wolfe, 2007), children were presented with pictures of both themselves and their mother. Children are instructed to point to the picture of their self when the visitor says "point to Mommy" and to point to the picture of their mother when the visitor says "point to [child]". Similar to the score for the Shape Stroop task, children were scored on their ability to name each picture (4 trials), correctly respond in practice trials with reinstruction for incorrect responses (2 trials), and respond correctly in test trials (4 trials). Children who responded correctly to at least one naming trial moved on to the practice trials. During the two practice trials, the visitor corrected children for incorrect answers. Children who answered correctly on at least one practice trial moved on to the test trials. All trials (naming, practice, test) were coded on a 3-point scale (0 = incorrect, 1 = self correct, 2 = correct). With regard to criteria for moving past the naming and practice trials, self-correct counted as a correct answer.

In the **Walk-A-Line Slowly task** (Kochanska, et al., 2000), a six-foot laminated strip with pictures of animals "marching" down the strip was taped to the floor. The task consisted of 3 trials (a baseline trial plus two test trials). In the baseline trial, the child was asked to walk down the strip or beside it but given no additional instructions. In the test trials, the child was asked to walk down the strip again, but to do so as slowly as possible. The time it took to travel the length of the strip for each test trial was subtracted from the baseline time and divided by the baseline rate to calculate the proportion of reduction.

The **Heads and Toes (H&T) task** is the first portion of the Heads-Toes-Knees-Shoulder (HTKS) task, a test of complex response inhibition developed by McClelland and colleagues (McClelland, et al., 2007; Ponitz, et al., 2009; Ponitz et al., 2008). In each trial, the child is asked to touch his/her head when the experimenter touches her toes and vice versa. The task consists of 6 practice trials and 10 test trials, each coded on a three point scale: incorrect (0), self-correct (1), and correct (2). Children who responded correctly to at least 3 practice trials moved on to test trials. Interrater reliability (ICC) based on 16% of cases was .89.

The **Dimensional Card Change Sort (DCCS)** task is a "gold standard" measure of a child's ability to shift attention (e.g., "set shifting") (Diamond, 2006; Diamond, Carlson, & Beck, 2005). The child is given a set of cards that includes pictures of fish or cars in red or blue as well as a pair of sorting boxes, each labeled with a red fish or blue car. During the warm up and priming trials, the child is instructed to sort the cards into the boxes based on one criteria (either color or shape). Children who respond correctly to at least 3 trials in a set move on to the next set. Each set (warm-up, priming, and test) has 6 trials. During the test trials, the child is asked to switch rules and sort the cards by the other dimension than the dimension used in priming trials. Of the six post-switch trials, four are conflict trials in that if the child has successfully switched rules, s/he will sort the cards correctly. The dimension used for priming trials versus test trials (color or shape) was counterbalanced across children. Performance on the conflict trials were scored as either incorrect (0) or correct (1). Interrater reliability (ICC) based on 24% double coded was .92.

A **Memory Span** task was created for the study using a toy called "Smart Snacks Hide 'n' Peek Chocolates" by Learning Resources (<http://www.learningresources.com>), a heart-shaped plastic box with removable lid and spaces for twelve differently shaped "chocolates". Only six chocolates were used for the task. Each chocolate has a removable top, underneath

which was affixed a sticker of an animal with clear adhesive. During the six naming trials, the covers were removed, and the child was asked to name each of the animals. The naming trials were followed by three practice trials in which the child was asked to find a single animal. If the child passed at least two practice trials, s/he continued to the test trials. Three test trials assessed a memory span of 2, and a second set of test trials assessed a memory span of 3.

Other measures—Other demographic characteristics included child gender, child ethnicity (African American or Latino), household composition, and family income-to-needs ratio. Income-to-needs ratio at each time point was computed as the total household income divided by the published federal poverty level for the family's household size. The income-to-needs ratios of the two time points were averaged to obtain a measure of average family income-to-needs.

RESULTS

Description of Self-Regulation Task Performance

In Table 3, we report the average performance on each task at both Time 1 (age 30 months) and Time 2 (age 42 months). Although 366 children participated in follow up data collection at Time 2, assessment data were only available for 360 children. The remaining 6 children did not complete child assessments at Time 2 because they had moved, and the follow up interview was conducted by telephone ($n = 2$), or the child had a diagnosed disability or illness that prevented them from completing the assessments ($n = 4$). For tasks that required children to pass a certain number of naming and practice trials in order to proceed to test trials (Shape Stroop, Mommy & Me, Heads & Toes, and DCCS), we report the number of children who made it to the test trials. For all tasks, a certain proportion of children refused to participate. In addition, a small number of videos (averaging 3% per task) could not be scored because of administration error or video failure. In the narrative that follows, we describe more fully the performance of children on each task.

As noted above, one source of missing data on self regulation tasks resulted from refusal to participate. Child compliance with tasks that involved waiting for something desirable (Snack Delay, Gift Wrap, Wait for Bow, and Forbidden Toy) was very high at both ages. Refusal rates were slightly higher at 30 months, ranging from 1.5% for Forbidden Toy to 5.7% for Snack Delay. At 42 months, refusal rates for these tasks ranged from .2% for Gift Wrap to .7% for Snack Delay. Refusal rates were higher for the other 30 month tasks, ranging from 13% for Mommy & Me to 18% for the Shape Stroop. At 42 months, the refusal rates were 1.5%, 6.6%, 17%, and 1.6% for Mommy & Me, DCCS, Heads & Toes, and Memory Span respectively.

Failure to pass naming and teaching/practice trials was a significant source of missing data on tasks that included such trials. At 30 months, only 127 children (38%) of children who complied with participation in the Shape Stroop task made it to the test trials. The proportion of test trials completed at 30 months on Mommy & Me was even lower; only 14% of the children who participated in Mommy & Me made it to the test trials. At 42 months, the corresponding percentage was only 25%. At 42-months, on the Heads & Toes task, 86% of children who participated in the task made it to the test trials, and on the DCCS, 90% of participating children completed the test trials. On the Memory Span task, 95% of children who complied with participation made it to the test trials.

It is important to note that children who failed to make it to the test trials on one task may have made it to the test trials on other tasks. Similarly, children who refused one task did not necessarily refuse other tasks, but all children were introduced to each task. The lower rate

of children who made it to the test trials for the Shape Stroop and Mommy and Me tasks might be a reflection the difficulty level of these tasks compared to the other tasks (e.g., walking down a line), the relatively lengthy verbal instructions compared to some of the other tasks (e.g., “Don’t touch the car until I come back,” “This time walk slowly.”), or a combination of these factors.

As can be seen in Table 3, the proportion of time the child could wait on the Snack Delay, Gift Wrap, and Wait for Bow tasks increased from 30 months to 42 months. Paired t-tests indicated that the increased waiting time was significant for all three tasks, $t(320) = -19.88$, $t(315) = -11.61$, and $t(310) = -8.84$, all p 's < .001 for Snack Delay, Gift Wrap, and Wait for Bow, respectively.

Differences in task performance by child gender, ethnicity, and family poverty status are displayed in Table 4. There was no consistent pattern of gender differences across tasks. Girls waited longer on the Snack Delay at 30 months and on the Gift Wrap task at 42 months, but none of the other tasks differed by gender. With regards to ethnicity, Latino children were better able to wait on the Snack Delay task, while African American children waited longer on the Gift Wrap task. African American children also performed better on two of the cognitive flexibility tasks at 42 months (Heads & Toes and DCCS). Latino children performed better on the Memory Span task compared with African American children. There was also a significant negative association between living below poverty and performance on Snack Delay at age 42 months, on Gift Wrap at 42 months, Wait for Bow at both ages, Walk-the-line, and Working Memory.

Factor Structure of Self Regulation Measures

First, based on findings in the literature reviewed above, confirmatory factor models were estimated to confirm the dimensional structure underlying correlations between items for four domains of executive control (inhibitory control, complex response inhibition, set shifting, and working memory). To account for any shared variation due to common times of assessment (as opposed to self-regulatory dimensions of substantive interest), a bifactor modeling strategy was used where each item loaded on two factors: one dimension of self-regulation, and one of two method factors corresponding to time (child age) of assessment. All models maximized the use of available data using a weighted least squares estimation algorithm as described in Asparouhov and Muthén (2010). All models were based on test trial level data. For tasks that required the child to pass a certain number of naming trials and practice trials before proceeding to test trials, children who complied with participation but failed to advance to test trials were coded as a 0 on all test trials.

First, we estimated separate models assuming one to four executive control/self-regulation dimensions. In solutions with more than one of these substantive dimensions, indicators were constrained to load on domains that mapped onto common distinctions proposed in the literature (Bassett, et al., 2012; Denham, et al., 2012; Garon, et al., 2008). For the model with two executive control dimensions, *inhibitory control (IC)* was comprised of items with an affective component and included Snack Delay, Wrapped Gift, and Forbidden Toy. The other dimension was comprised of items without an affective component and included the cognitive flexibility tasks of Mommy & Me, Heads & Toes, Fruit Stroop, Walk-a-Line, and the DCCS test trials, as well as the working memory task. For three dimensions, we further distinguished working memory from the cognitive flexibility component. Finally, the model with four substantive executive function dimensions further distinguished complex response inhibition from set shifting. *Complex response inhibition* was comprised of Mommy & Me, Heads & Toes, Fruit Stroop, and Walk-a-Line, whereas *set shifting* was comprised of the DCCS test trials.

Fit statistics for these models are reported in the upper half of Table 5 (Models 2–5). As a comparison, fit for a model ignoring time of assessment is also provided (Model 1) and as can be seen, was very poor. Among models that adjusted for time of assessment, a four factor structure (Model 5) fit the data best. A five factor model was also estimated but failed to converge.

Although overall fit indices were acceptable and supported a model with four substantive dimensions of executive control, assessment of local fit and model parameter estimates revealed several problems with this model at a finer scale. In particular, standard errors for complex response inhibition items (Fruit Stroop, Mommy & Me, Walk-a-Line) at the Time 1 assessment (age 30 months) were extreme; therefore, these items were dropped, and the model was refitted (Model 6). As such, we were unable to confirm a complex response inhibition factor at the younger age for the children in our sample.

Next, we addressed three more targeted questions about the configuration of subcomponents of this general model. Several nested models were compared to address three *a priori* questions: whether one or two factors could best account for items reflecting (1) inhibitory control and complex response inhibition, (2) complex response inhibition and set shifting, and (3) set shifting and working memory. Results of these nested model comparisons appear in the lower half of Table 5. To conduct these tests, the correlation between the corresponding factors was constrained to 1. Comparing these three-factor structures with the four-factor structure in Model 6 explicitly tests whether items from these pairs of tasks were better represented by a single factor or by separate factors. Specifically, comparing Models 7 and 6 tests whether Inhibitory Control (IC) and Complex Response Inhibition (CRI) items reflect a common factor. Similarly, comparing Models 8 and 6 tests whether CRI and Set Shifting (SS) items reflect a single factor, and comparing Models 9 and 6 tests whether Set Shifting and Working Memory (WM) items reflect a single factor. While these constraints produced models with acceptable (albeit lower) overall fit, each constraint significantly degraded fit relative to Model 6 (as indicated by changes in the model chi square). These results suggest that a four factor model provided a significantly better explanation of the data than solutions with fewer dimensions.

Finally, we fit two different Multiple Indicators and Multiple Causes (MIMIC) models to examine the question of measurement non-invariance by ethnicity and gender. In separate model runs, effects of ethnicity and gender on the latent variables were added to the model. Modification indices for direct effects of these covariates on factor indicators – which represent the covariate’s “biasing” effect on the indicator, above and beyond the influence of the latent variable – were inspected for extreme values (equal to or greater than 10). In these analyses, no modification index exceeded the threshold, indicating the measurement properties of factor indicators did not differ across ethnicity or gender.

As stated above, we were unable to confirm a complex response inhibition factor at 30 months, likely due to the high proportion of children at the floor of these tasks. On Fruit Stroop, 75% of children either failed the practice trials or scored a 0; on Mommy & Me, this percentage at age 30 months was 95%. On Walk-a-Line, the average reduction in speed was only 7%, with almost half going faster rather than slower on test trials. This suggests complex response inhibition skills in our sample were still too rare at age 30 months to detect reliably.

Although a complex response inhibition factor could be identified at age 42 months in our sample, these skills were still relatively rare, with 71% of children scoring at the floor of the complex response inhibition composite. However, there was a significant association between inhibitory control performance at age 30 months and complex response inhibition

at age 42 months. Children with higher scores in inhibitory control at the younger age were significantly more likely to score above the floor in complex response inhibition at 42 months, $t(335) = 2.25, p < .05$. Inhibitory control at 30 months was unrelated to set shifting at 42 months.

Relations Between Self Regulation Measures and Child and Family Characteristics

Composite indices for inhibitory control at 30m and 42m, complex response inhibition at 42m, set shifting at 42m, and working memory at 42m were created based on CFA results, and associations between these composite self regulation indices and child gender, child ethnicity, and family poverty status were examined. Because the CFA analytic methods maximized the use of available data, missing data for the composite indices were minimized. Composite indices for inhibitory control could be computed for 397 (97.5%) children at 30 months and 354 (98.3%) children at 42 months. The composite index for complex response inhibition at 42 months was available for 342 (95%) children, set shifting was available for 318 (88.3%), and working memory was available for 329 (91.4%).

Self regulation composite indices did not differ by gender. Despite no ethnic differences at 30m, Latino children displayed better inhibitory control at 42m, $t(352) = 2.04, p < .05$. African American children displayed better complex response inhibition and set shifting at 42m, $t(340) = 3.26, p < .01$ and $t(316) = 2.39, p < .05$, effect size (ES) = .35, while Latino children had better working memory at 42m, $t(327) = 3.07, p < .01, ES = .34$.

Discussion

In this study, we examined the emergence of self regulation abilities in a sample of low income African American and Latino (primarily Mexican-origin) preschoolers. Despite evidence that self regulation is a critical component of school readiness, there are very little published data regarding the emergence of self regulation in this population, one that is at significant risk for academic failure. The results indicate that the experience of administering self regulation tasks to very young, low income, ethnic minority children is very different from that reported in the literature with children this young, much based on predominantly white, middle-class samples (Carlson, Davis, & Leach, 2005; Carlson & Moses, 2001; Kochanska, et al., 2000). Particularly striking was the completion rate, which was very low in our sample of children, especially for cognitive flexibility tasks. For example, on the Shape Stroop task at 30 months, less than a third of the children in our sample were able to make it to the test trials, compared to almost all of the 24 month olds tested by Carlson et al. (2004). Furthermore, the 24 month olds in the Carlson study were correct on more than twice the number of items on the Shape Stroop compared with the 30 month olds in our study. A comparison of the self regulation task performance of the children in our sample with other published studies of preschool-aged children indicated that the children in our sample were significantly behind in both inhibitory control and cognitive flexibility skill development (Carlson & Moses, 2001; Denham, et al., 2012; Kochanska, et al., 2000; Li-Grining, 2007). It is notable that both the Carlson & Moses (2001) and Kochanska et al. (2000) samples were comprised of predominantly white, non-Hispanic middle class/upper middle class families. The Denham et al. (2012) sample was more ethnically diverse than the Kochanska and Carlson samples albeit less economically at risk than our sample and displayed higher levels of self regulation on the Wrapped Gift task relative to our sample at both ages. The Li-Grining (2007) sample was drawn from the Three Cities Study, a study of the effects of welfare reform on the children, and was both ethnically diverse as well as economically at risk. Although the Li-Grining (2007) sample displayed longer latencies to peek compared to our sample at 30 months (but not 42 months), it is difficult to make an exact comparison because of the broad age range of the Li-Grining sample (2–4 years).

Systematic examinations of the configural structure of self regulation among young children are still relatively rare; we only identified eight published studies based on five different samples of young children. Our results supported a four factor model: inhibitory control, complex response inhibition, set shifting and working memory. These results are both consistent and inconsistent with previous studies. Similar to the findings of Bassett et al. (2012) and Denham et al. (2012), we found inhibitory control tasks that had an affective component clustered on a separate factor from tasks that required cognitive flexibility but were affectively neutral. Furthermore, we found that these inhibitory control skills were discernible at a younger age in our sample of low income, ethnic minority preschoolers than were complex response inhibition and set shifting skills.

We also found that complex response inhibition represented a separate domain of executive function from tasks that assessed the child's ability to shift attention. Likewise, our data from a span-like working memory task were also represented by a separate factor. These findings are different from those reported by Willoughby and colleagues (Carlson & Moses, 2001; Denham, et al., 2012; Kochanska, et al., 2000; Li-Grining, 2007; Willoughby, Blair, et al., 2012; Willoughby, et al., 2010; Willoughby, Wirth, et al., 2012) as well as those of Wiebe et al. (2011), whose confirmatory analyses supported a single construct representing these types of executive function skills. It is possible that task specific differences between these explain the differences in findings. Furthermore, our sample is significantly different from the Family Life Project sample used in the Willoughby study, which is a little less than half African American and includes no Latinos, as well as that reported by Wiebe et al., which was more than three-quarters white, non-Hispanic. Our sample is more than half Latino, most of which were Spanish-speaking. Yet another possibility is that the dimensional structure of executive function changes over the course of development, with these components becoming more integrated as children age. Clearly, more longitudinal research is needed to address this question. In addition, greater standardization of assessment batteries across studies would facilitate the ability to compare findings.

We could only find one other study that utilized the DCCS along with a full battery of both complex response inhibition tasks and inhibitory control tasks. Carlson and Moses (2001) found the DCCS loaded on the same factor as other complex response inhibition tasks, but they conducted a principal components analysis only and did not subject their identified structural configuration to confirmatory analyses as we did. Furthermore, the Carlson and Moses (2001) sample was predominantly white and middle-class (as reported elsewhere by Carlson). If cognitive flexibility skills among the children in the Carlson and Moses sample were more developed than these skills of the children in the present study, this could be one explanation as to why they were more correlated with set shifting skills measured by the DCCS.

We could not confirm a complex response inhibition factor in our sample at age 2½, likely due to the high proportion of children at the floor of these tasks at that age. Even by age 3½, these skills were relatively rare. More than 70% of our sample scored at the floor of the complex response inhibition composite at age 3½, and more than half scored at the floor of set shifting. Interestingly, there was a relation between performance on inhibitory control tasks at age 2½ and complex response inhibition performance at age 3½. Children who displayed better inhibitory control at age 2½ were more likely to display complex response inhibition at age 3½, although inhibitory control skill at the younger age was unrelated to set shifting performance at the later age. This suggests inhibitory control may be a leading developmental marker for the development of complex response inhibition skills. This is consistent with the developmental sequence of executive function skills as proposed by Garon et al. (2008), although, as noted by Wiebe et al. (2011), there are no empirical data to support this sequence.

We also examined how self regulation skills differed by child and family characteristics in our low income, ethnic minority sample. Although we found gender differences in individual task performance, there were no gender differences identified in composite indices of inhibitory control, complex response inhibition, set shifting or working memory. This contrasts with other studies that have reported gender differences in self regulation indices. In a meta-analysis, Else-Quest, Hyde, Goldsmith, and Van Hulle (2006) found significant gender differences favoring girls in broad indices of inhibitory control and effortful control based on parent report measures. Kochanska et al. (2000) reported girls performed better than boys on specific inhibitory control and complex response inhibition tasks at 22 and 33 months of age, and Ponitz et al. (2008) found that girls performed significantly better on a complex response inhibition task in kindergarten. The lack of gender differences on our composite indices argues for the importance of using test batteries rather than individual tasks before making conclusions regarding gender differences. Gender differences on a specific task may reflect task-specific characteristics rather than differences in the underlying self regulation skill that may be more accurately assessed with multiple tasks. However, because utilization of composite indices of self regulation is still relatively rare, more research is needed regarding the question of gender differences in self regulation development.

We found robust ethnic differences in self regulation skills, with the Latino children in our sample excelling at inhibitory control and working memory tasks at age 3½, and African American children excelling in complex response inhibition and set shifting tasks at age 3½. Because of the lack of extant self regulation data on low income Latino preschoolers, any hypotheses regarding the reasons for these ethnic differences are purely speculative. The confirmation of measurement invariance of our four factor structure for both ethnic groups suggests that these ethnic differences represent actual differences in self regulation abilities and are not just an artifact of measurement differences between the two groups. Further research is necessary to determine if these ethnic differences are generalizable or unique to this particular sample of children.

Growing evidence of the links between children's emerging executive function skills and school achievement suggests that individual differences in these skills are important for processing and integrating information and regulating behavior in social interactions (Blair, 2002) and may be an important source of race/ethnic disparities in school readiness and early academic achievement. Unfortunately, the bulk of what is known about the development of behavioral regulation and executive function among very young children comes from middle income European American children, rather than from children at greatest risk for poor school achievement and health. A major purpose of launching the present longitudinal study is to help remedy this general dearth of data among low income African American and Latino preschoolers, children at risk for poor academic achievement.

Our findings indicate that substantial deficits in self regulation/executive function start early in these low income African American and Mexican American children. These deficits suggest greater emphasis on targeting and supporting the development of these skills in low income children at an early age may advance the effectiveness of early childhood interventions to improve school readiness and eliminate school achievement disparities. Relevant to such efforts are conclusions of Pianta, Barnett, Burchinal and Thornberg (2009) in their scholarly review of what is known about the substantial benefits drawn from early childhood education to improve the competencies fundamental to children's success in school and closing achievement gaps, competencies that include self regulation. The success shown by the Chicago School Readiness Project (CSRP) is a notable example of benefits that can be achieved in addressing these important competencies self regulation for school readiness (Raver, et al., 2011). Findings from the present study indicate that efforts should

be made to extend such interventions to even younger ages for low income, ethnic minority children.

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HIGHLIGHTS

We assessed self regulation skills in 407 African American and Latino preschoolers.

Confirmatory analyses identified four components of self regulation in this sample.

African American children performed better on cognitive flexibility tasks.

Latino children performed better on inhibitory control and working memory tasks.

Table 1

Characteristic of study sample (N=407)

	African American (N = 183)	Latino (N = 224)	
	N (%)	N (%)	²
<u>Child gender</u>			
Boy	101 (55.2)	118 (52.7)	.26
Girl	82 (44.8)	106 (47.3)	
<u>Caregiver's relationship to child</u>			
Mother	162 (88.5)	218 (97.3)	13.06**
Father/father-figure in household	11 (6.0)	2 (.9)	
Grandmother/aunt	10 (5.5)	4 (1.7)	
<u>Family Income</u>			
< 50% federal poverty level	96 (54.5)	33 (14.8)	74.14***
50–99% federal poverty level	40 (22.7)	117 (52.5)	
100–149% federal poverty level	23 (13.1)	47 (21.2)	
150%+ federal poverty level	17 (9.7)	26 (11.7)	
<u>Caregiver's level of education</u>			
Less than high school	27 (14.8)	96 (42.8)	39.80***
High school/GED	83 (45.4)	79 (35.3)	
More than high school	73 (39.9)	49 (21.9)	
<u>Father/father-figure in household</u>			
No	74 (40.4)	22 (9.8)	52.38***
Yes	109 (59.6)	202 (90.2)	
<i>Latino families only</i>			
<u>Preferred language (caregiver)</u>			
English		56 (25.0)	
Spanish		168 (75.0)	
<u>Preferred language (child)</u>			
English		47 (21.0)	
Spanish		177 (79.0)	
<u>Nativity (caregiver)</u>			
U.S. born		60 (26.8)	
Foreign born		164 (73.2)	
<u>Country of origin (foreign-born caregivers)</u>			
Mexico		157 (95.7)	
Central America		6 (3.7)	
South America		1 (0.6)	

**
p < .01;***
p < .001

Note. Balance of cases are missing.

Table 2

Measures of child self regulation/executive function at two time points

30 months (Time 1)	42 months (Time 2)
Snack delay	Snack delay
Wrapped gift/Wait for bow	Wrapped gift/Wait for bow
Forbidden toy	Mommy & me
Shape stroop	Heads & Toes
Mommy & me	Dimensional card change sort
Walk-a-line slowly	Memory span task

Table 3

Performance of participating children on self regulation tasks at two time points

Task	T1: 30 months (n = 407)				T2: 42 months (n = 360)			
	No. proceeding to test phase	Mean	SD	Range	No. proceeding to test phase	Mean	SD	Range
Snack delay								
Avg proportion time waited	n/a	.32	.33	.00–1.00	n/a	.74	.31	.06–1.00
Gift wrap								
Avg proportion time waited	n/a	.09	.23	.00–1.00	n/a	.34	.39	.00–1.00
Wait for bow								
Avg proportion time waited	n/a	.66	.36	.00–1.00	n/a	.84	.22	.00–1.00
Forbidden toy								
Avg proportion time waited	n/a	.23	.34	.00–1.00	---	---	---	---
Shape stroop								
Avg score (possible range 0–2)	127	.76	.46	0–2	---	---	---	---
Mommy & me								
Avg score (possible range 0–2)	48	.42	.49	0–2	88	.55	.70	0–2
Walk-a-line slowly								
Avg reduction in time to walk line	342	.13	.52	–0.75–3.89	---	---	---	---
Heads & Toes								
Avg total score (0–20)	243	---	---	---	243	1.67	3.63	0–20
Dimensional Card Change Sort								
Avg # conflict trials correct	287	---	---	---	287	1.27	1.47	0–4
Memory span task								
Highest span size across trials	297	---	---	---	297	1.84	.78	0–3

Table 4

Differences in self regulation task performance by child demographic characteristics

	Child Gender				Child Ethnicity				Family Poverty Status			
	Boy		Girl		African American		Latino		<100% FPL		100+% FPL	
	Mean (sd)	Mean (sd)	t	t	Mean (sd)	Mean (sd)	Mean (sd)	t	Mean (sd)	Mean (sd)	t	t
Snack delay (30m)	.27 (.31)	.38 (.35)	-3.08**		.29 (.30)	.35 (.35)		-1.67 ⁺	.32 (.33)	.34 (.35)		.56
Snack delay (42m)	.72 (.31)	.77 (.30)	-1.64		.70 (.32)	.78 (.30)		-2.49*	.71 (.33)	.83 (.26)		3.27**
Snack delay (change)	.46 (.38)	.42 (.41)	1.03		.42 (.39)	.46 (.40)		-.92	.41 (.42)	.49 (.36)		1.49
Gift wrap (30m)	.09 (.21)	.10 (.24)	-.54		.13 (.26)	.06 (.18)		2.81**	.07 (.20)	.07 (.20)		-.88
Gift wrap (42m)	.30 (.38)	.40 (.40)	-2.27*		.40 (.42)	.30 (.37)		2.27*	.32 (.39)	.38 (.39)		2.25*
Gift wrap (change)	.23 (.38)	.31 (.43)	-1.75 ⁺		.28 (.43)	.25 (.39)		.61	.22 (.35)	.35 (.40)		2.41*
Wait bow (30m)	.68 (.36)	.64 (.36)	1.19		.67 (.35)	.65 (.37)		.62	.62 (.37)	.73 (.35)		2.16*
Wait bow (42m)	.85 (.22)	.83 (.21)	.86		.84 (.20)	.84 (.23)		-.30	.83 (.23)	.89 (.18)		2.26*
Wait bow (change)	.17 (.38)	.20 (.37)	-.76		.18 (.36)	.19 (.38)		-.15	.21 (.37)	.16 (.40)		-.84
Forbidden toy (30m)	.21 (.32)	.26 (.36)	-1.37		.24 (.34)	.22 (.34)		.55	.23 (.35)	.28 (.37)		.93
Shape stroop (30m)	.68 (.41)	.83 (.50)	1.80 ⁺		.79 (.47)	.72 (.45)		.80	.74 (.47)	.78 (.46)		.47
Mommy & me (30m)	.40 (.51)	.43 (.48)	-.19		.50 (.51)	.35 (.48)		1.04	.43 (.53)	.44 (.39)		.06
Mommy & me (42m)	.56 (.73)	.53 (.67)	.26		.52 (.72)	.57 (.68)		-.33	.52 (.67)	.57 (.75)		.29
Walk-a-line slowly (30m)	.13 (.49)	.12 (.55)	.10		.10 (.50)	.15 (.53)		-1.02	.09 (.52)	.24 (.51)		2.36*
Heads & toes (42m)	1.66 (3.70)	1.68 (3.55)	-.05		2.22 (4.14)	1.08 (2.88)		2.52*	1.54 (3.44)	1.99 (4.20)		.67
DCCS (42m)	1.26 (1.52)	1.28 (1.41)	-.12		1.49 (1.52)	1.08 (1.40)		2.33*	1.21 (1.36)	.93 (1.39)		-1.41
Memory span (42m)	1.85 (.80)	1.83 (.76)	0.84		1.67 (.82)	1.97 (.72)		-3.32**	1.79 (.78)	1.99 (.74)		2.06*

⁺ p < .10;

* p < .05;

** p < .01

Table 5

Fit indices from confirmatory factor analyses

Model	Substantive Dimensions	χ^2	df	p	CFI	TLI	RMSEA	WRMR	2	df	p
1	SR (excluding TOA method factors)	3348.18	1080	.00	.69	.67	.07	2.55	---	---	---
2	SR	1844.29	1031	.00	.89	.88	.04	1.58	---	---	---
3	IC, CF	1597.60	1030	.00	.92	.91	.04	1.40	---	---	---
4	IC, CF, WM	1558.60	1028	.00	.93	.92	.04	1.34	---	---	---
5	IC, CRI, SS, WM	1393.17	1025	.00	.95	.94	.03	1.18	---	---	---
6	IC, CRI, SS, WM (respecified)	624.97	553	.02	.99	.99	.02	.90	---	---	---
7	IC/CRI, SS, WM	779.31	554	.00	.97	.96	.03	1.07	68.40	1	<.0001
8	IC, CRI/SS, WM	725.57	554	.00	.97	.97	.03	1.06	49.51	1	<.0001
9	IC, CRI, SS/WM	731.29	554	.00	.97	.97	.03	1.07	83.68	1	<.0001

Note 1. SR = General self regulation factor, TOA = time of assessment; IC = Inhibitory control, CF = Cognitive flexibility; WM = working memory; BRI = Complex response inhibition; SS = set shifting.

Note 2. Models 7, 8, and 9 were compared with Model 6.