Establishing Predictors of Insight Problem Solving In Children: Age, Not Cognitive Control or Socioeconomic Status, Determines Immunity to Functional Fixedness

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Cognitive control, the ability to limit attention to goal-relevant information, subserves higher-order cognitive functions such as reasoning, attention, planning and organization. Counterintuitively, deficits in these functions have proven advantageous in certain contexts: low cognitive control means less filtering of attention, and such unfiltered attention leads to novel solutions in insight problem solving contexts. Insight is the clear and often sudden discernment of a solution to a problem by means that are not obvious, and it plays an indispensable role in creative thinking. This study examined whether insight problem solving is a compensatory advantage for children of low socioeconomic status *because of* their known deficits in cognitive control.

One hundred and forty-eight children ages 4 to 11 years old, each completed two insight problem solving tasks (the Box Problem and the Pencil Problem) and a cognitive control task (the Flanker/Reverse Flanker). In addition, their parents completed a sociodemographic questionnaire, which was used as a measure of their socioeconomic status and child rearing values of obedience versus independence. No association was found between children's socioeconomic status and their ability to use insight to solve a problem. Results did show that older children exhibited less cognitive flexibility than did to younger children, and that diminished cognitive flexibility correlated with older children's ability to solve the Box Problem; however, this effect did not hold when age, sex, race, socioeconomic status, and parental report of obedience versus independence, were accounted for. Ultimately, age was the only significant predictor of children's insight problem solving ability, such that older children were significantly more likely to solve the Box Problem and to arrive at a solution more quickly for the Pencil Problem compared to younger children. Findings from this study are explained using evidence from research on children's tool innovation showing that young children are poor at inventing tools, and that older children's ability to use objects for atypical functions may be the result of their greater exposure to and experience with tools.

Keywords: cognitive control, executive functions, functional fixedness, insight problem solving, socioeconomic status

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I dedicate this accomplishment to my mother, Minoo Razavi-Ebrahimi.

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Introduction

Insight problem solving is one type of proxy measure for creativity (Dominowski & Dallob, 1995) that calls on the ability to overlook prepotent (obvious) features of a situation and reconceptualize the problem in a novel way in order to arrive at a solution (Dow & Mayer, 2004). Such restructuring can result in the "aha!" experience characteristic of suddenly overcoming an impasse (Metcalfe & Wiebe, 1987; Weisberg, 1995; Schooler & Melcher, 1995). Consider, for example, Karl Duncker's (1945) candle problem. He asked participants to figure out how to attach a lighted candle to a corkboard wall using only a box full of tacks and a book of matches. Participants who tried to stick the candle to the wall with a tack or melted wax failed. The solution was to stop thinking of the box of tacks as a container (i.e. its typical function) and instead to empty the box and tack it to the wall, thus turning the box into a platform on which to balance the candle. Arriving at this solution requires relaxing the constraints imposed by automatically activated – and seemingly relevant, but actually unhelpful – prior knowledge about the function of a box as a container (Knoblich, Ohlsson, Haider, & Rhenius, 1999). Overcoming functional fixedness was seen by Duncker to be the key to solving this kind of task.

Functional fixedness refers to a hindrance in problem solving capability that restricts a person's representation of how an object can be used exclusively to its typical function. In other words, functional fixedness makes it so that person perceives an object as being meant for only a specific purpose, not realizing that there could be potential for other uses. The concept of functional fixedness was first introduced by Norman Maier in 1931 when he presented the two string problem. Maier presented participants with two strings hanging from the ceiling at opposite ends of a room, a pair of pliers and a chair, and he asked participants to tie the two strings together. Although the strings were long enough to be tied together, they were too short for participants to be able to grasp the end of one string, walk to the opposite side of the room, and reach the other string. Thus, to solve the problem, participants had to attach the pliers to one of the strings using the pliers as a weight to make the string swing like a pendulum. Once the string was swinging with the weight of the attached pliers, participants could grasp the stationary string and catch the moving string in its upswing in order to tie the two strings together. This task requires that participants restructure the previously intractable problem such that a new understanding of what needs to be done becomes clear (i.e. using the pliers for an unintended purpose), thus demonstrating an immunity to functional fixedness and insight (Ansburg, 2000; Thomas & Lleras, 2009).

The Neural Correlates of Insight Problem Solving

Using electrophysiological and neuroimaging measures, research on the neural correlates of the cognitive processes that underlie insight have revealed that insight is accomplished not by a single brain region but rather by the widespread neural connections between distributed brain regions such as such as the cingulate cortex, hippocampus, superior temporal gyrus, fusiform gyrus, precuneus, cuneus, insula, cerebellum, and prefrontal cortex (PFC; for review see Shen et al., 2013). On insight problems solving tasks, findings show that the cingulate cortex is responsible for task-related goal directing and resolving cognitive conflict between old and new ideas (Luo, Niki, & Philips, 2004; Mai et al., 2004); the hippocampus (Luo & Nicki, 2013; Wagner et al., 2004), superior temporal gyrus (Jung-Beeman et al., 2004) and fusiform gyrus (Qiu et al., 2010; Zhang et al., 2011) form an integrated network involved in the formation of novel connections and remote associations based on knowledge in memory, auditory and semantic elements, and visual imagery; the precuneus (Luo & Niki, 2003) and cuneus (Luo, Niki, & Knoblich, 2006) facilitate non-verbal visuospatial information-processing; the insula is engaged in cognitive flexibility and the emotion experience associated with insight (Luo, Niki, & Philips, 2004; Wagner & Feldman, 2004); and the cerebellum controls fine motor movements (Darsaud et al., 2011).

Studies have also found that the PFC plays a significant role in insight problem solving (Goel & Vartanian, 2005). However, unlike other brain regions involved in insight problem solving, insight solutions are not always associated with *increased* activity in the PFC; in fact, findings from a number of studies show that reduced PFC activity are associated with superior insight problem solving ability. This is likely because the PFC is responsible for cognitive control – our ability to override prepotent responses, ignore distractions, obey rules, and shift attention between cognitively demanding tasks (Chrysikou, Weber, & Thompson-Schill, 2014; Miller, 2000) – and diminished PFC activity results in limited cognitive control.

The Role of the PFC in Cognitive Control

The PFC coordinates goal-directed actions by exerting top-down control to bias competing bottom-up input (Chrysikou et al., 2014; Miller & Cohen, 2001; Thompson-Schill, Bedny, & Goldberg, 2005); our sensory and motor systems provide detailed information about our external environment and internal states, which is then filtered by the PFC so that only task-relevant information is prioritized and perceived (Shimamura, 2000). Prefrontal lesions in adults and nonhuman primates result in impaired cognitive control (Luria, 1966; Stuss and Benson, 1986; Miller and Cohen, 2001), providing evidence that cognitive control depends on the maturation of the PFC (Dempster, 1992). Cognitive control develops gradually throughout childhood, and improvements in control are important for giving rise to reasoning, planning, self-control, and analytical problem solving (Diamond, 2013). Fundamental components of cognitive control, also called executive functions (EFs), include inhibition, working memory, and cognitive flexibility (Davidson, Amos, Anderson, & Diamond, 2006; Diamond, 2013). Inhibition refers to the ability to override attention to irrelevant stimuli in order to focus on just what is relevant to one's goal (Diamond, 2013); working memory refers to the ability to hold in mind and manipulate information that is no longer perceptually present (Baddeley & Hitch, 1994); and cognitive flexibility refers to the ability to shift tasks or roles and adapt to changing demands (Scott, 1962). Thus, paradigms used to evaluate cognitive control include tasks like the Eriksen Flanker (Eriksen and Eriksen, 1974) in which participants must ignore irrelevant and distracting stimuli, inhibit preponent response tendencies and strategies, recall and apply specific information only when appropriate, and adjust behavior and shift attention between competing demands (Bunge, Dudukovic, Thomason, Vaidya, & Gabrieli, 2002).

Given that cognitive control reflects our ability to constrain and coordinate our thoughts, emotions, and actions in the service of achieving internally represented intentions or goals (Tomlin, Rand, Ludvig, & Cohen, 2015), it is unsurprising that developing and exerting cognitive control predicts a range of important life outcomes (Moffitt et al., 2011) such as school readiness (Blair & Razza, 2007; Davis, Marra, Najafzadeh, & Liu-Ambrose, 2010), academic achievement (Borella, Carretti, & Pelegrina, 2010; Gathercole, Pickering, Knight, & Stegmann, 2004), social functioning (Broidy et al., 2003; Denson, Pedersen, Friese, Hahm, & Roberts, 2011), physical health (Crescioni et al., 2011; Miller et al., 2011; Riggs, Spruijt-Metz, Sakuma, Chou, & Pentz, 2010), income (Bailey, 2007) and overall quality of life (Brown & Landgraf, 2010; Davis et al., 2010). While the advantages of enhanced cognitive control extend across a wide range of tasks that depend on a narrow focus of attention and interference resolution (e.g. studying instead of procrastinating; sticking with a diet; suppressing impulsive emotional outbursts), several lines of evidence indicate that insight problem solving tasks benefit from diffuse attention (Amer et al., 2016). According to the Matched Filter Hypothesis, reduced PFC activation (and thus limited cognitive control) facilitates the noticing of features that allow optimal performance on certain creative tasks (Chrysikou et al., 2014).

It has been argued that overcoming functional fixedness is made possible by failure to filter low-level perceptual data – that is, failure to rule out information as irrelevant (Chrysikou et al., 2014). The ability to access 'raw' environmental data is hindered by too much filtering. In other words, a reduction in PFC-guided thought may make it possible to notice alternative possibilities for solving problems requiring creative insight (Chrysikou et al., 2014). Although the exact neural networks that underlie creative thinking remain unclear, researchers agree that creative insights are characterized by sudden realizations that occur during mental states marked by lowered inhibition and defocused attention (Eysenck, 1995; Martindale, 1999).

Findings from a number of studies show that limited cognitive control is associated with superior creative thinking and insight problem solving ability, as discussed below.

The Benefits of Low Cognitive Control for Insight Problem Solving

PFC disruption. Chrysikou et al. (2013) used transcranial direct current stimulation on neurotypical adults to temporarily disrupt lateral prefrontal cortex (LPCF) activity, and they found that this disruption appeared to facilitate generation of novel associations resulting in heightened performance on the Alternative Uses Task (AUT) – a measure of creative thinking in which participants are given an object (e.g. a brick) and must come up with as many uses for that object as possible under a time limit (e.g. a step, a paperweight, a dumbbell; Guilford, 1967). Similar findings come from a study that used transcranial alternating current stimulation to elicit transient hypofrontality, which in turn caused significant improvements in creative ideation and divergent thinking – the ability to combine and transform information in unexpected ways to come up with novel ideas (Cropley, 2006) – on the Torrance Test of Creative Thinking (TTCT, the most widely used assessment of creativity) in adults (Lustenberger, Boyle, Foulser, Mellin, & Fröhlich, 2015).

PFC lesions. Patients with PFC lesions, have been shown to outperform their non-brain-damaged counterparts on the matchstick arithmetic task (Knoblich, Ohlsson, Haider, & Rhenius, 1999; Reverberi, Toraldo, D'Agostini, & Skrap, 2005). This task consists of an array of false arithmetic statements written in roman numerals (e.g., I, II, IV), an operation (e.g. + or -) and an equal sign (=) – all composed of matchsticks. The goal is to transform the false statement into a true statement by transposing a single matchstick from one position to another. To solve these problems, the participant must overcome the constraint that operators (+, -, and =) in the equations must remain constant (e.g. that a matchstick from a plus sign cannot be removed turning it into a minus sign). Non-brain-damaged participants find this task especially challenging when the solution demands that they rotate a matchstick that is part of an operator (e.g. turning VI = VI + VI into VI = VI = VI).

Age. While it is almost always the case in developmental studies that older children out-perform younger ones, there is some evidence of more rapid solution of creative solving problems analogous to Duncker's (1945) candle problem by younger than older children. Children were shown an object being used according to its ordinary function (e.g. a box as a container, a pencil as a writing instrument) and were given a problem to solve using these objects. The problems could be solved only by avoiding the conventional function of these objects and using them in an unconventional way (Defeyter & German, 2003; German & Defeyter, 2000). These tasks were solved more quickly by 5- than 6- and 7-year olds. It is reasonable to conclude that lower cognitive control in 5-year olds due to their less developed PFC led to their superior performance (Chrysikou et al., 2014).

There is also evidence of better creative performance in older adults (65+ years old) than in younger adults (18-30 years old). Older adults typically show a decline in cognitive control (Glisky, 2007), and thus an increase in distractibility. Consistent with the argument being developed here, older adults outperform young adults on the Remote Associates Test (RAT; Kim, Hasher, & Zacks, 2007) – a measure of convergent thinking in which participants are presented with three words (e.g. pie, luck, belly), and asked to come up with a fourth word that forms a sensible two-word phrase with each of the three target words (e.g. in this case, pot; Mednick, 1962).

Attention Deficit/Hyperactivity Disorder. Individuals with Attention Deficit/Hyperactivity Disorder (ADHD; who are unmedicated) perform significantly better on the AUT than do individuals without attentional problems (White & Shah, 2006). The superior performance of individuals with attentional problems is likely due to their reduced inhibitory control and thus reduced filtering of 'irrelevant' stimuli (White & Shah, 2006). Allowing these irrelevant stimuli to come to attention may then facilitate the noticing of more – and more unusual – uses of common objects. Individuals with attentional deficits were also shown to score higher on real-world creative achievement compared to individuals without attentional problems (White & Shah, 2011).

Fatigue. Participants who completed a battery of insight problems during their 'non-optimal time of the day' (as measured by self-report ratings of sleep habits, peak performance and other circadian functions on the Morningness Eveningness Questionnaire) outperformed their ‘optimal time of the day’ counterparts. Presumably, the more tired participants benefited from their state of diminished inhibitory control and diffuse attention (Wieth & Zacks, 2011).

Intoxication. In comparison to sober participants, moderately intoxicated participants (.07 blood alcohol content) exhibited diminished working memory capacity yet still outperformed sober individuals in response speed and accuracy on the RAT (Jarosz, Colflesh, & Wiley, 2012). Because acute alcohol intoxication has been shown to produce changes in cognitive functioning similar to that exhibited by adults who have sustained prefrontal lobe damage (Peterson, Rothfleisch, Zelazo, & Pihl, 1990), the suspected underlying mechanism for enhanced creativity when inebriated is a reduction of attentional control, thus allowing for more divergent, associational or discontinuous solution processes (Jarosz et al., 2012).

The Effects of Socioeconomic Status on the Prefrontal Cortex

Existing research relating insight problem solving to cognitive control focuses predominately on adult populations, but given the evidence that impaired cognitive control can result in enhanced insight problem solving ability, it stands to reason that children of low socioeconomic status (LSES) should, *because of* their known deficits in cognitive control, outperform children of higher socioeconomic status (HSES) on insight problem solving tasks.

Poverty has profound, cascading, and lasting effects on all aspects of child development. Grade failure, school disengagement, and drop-out rates are all higher for LSES children, and the subsequent consequences sustain the cycle of poverty (Duncan, Yeung, Brooks-Gunn, & Smith, 1998). Cognitive deficits in LSES children emerge in early childhood and lead to disparities in achievement that widen throughout elementary school years (Noble, 2014). Behavioral studies have reported that childhood poverty has specific neurocognitive correlates such that LSES children show worse performance on assessments of attention (Mezzacappa, 2004) language, long-term memory, and cognitive control than do HSES children (Farah et al. 2006).

The PFC develops postnatally, and slower than any other brain region, as does its functional connectivity with other brain regions (Málková, Bachevalier, Webster, & Mishkin, 2000). Measures of myelination (i.e. the formation of the sheath surrounding nerve cells required for efficient electrical transmission of action potentials and neuronal communication; Pfefferbaum et al., 1993; Giedd et al., 1999), gray matter reduction (i.e. the process by which extra neurons and the connections between neurons are eliminated to increase neuronal efficiency; Jernigan et al., 1991; Sowell, Delis, Stiles, & Jernigan, 2001), and synaptogenesis (i.e. the formation of connections between neurons; Huttenlocher, 1979) indicate that the PFC only reaches maturation in late adolescence. Because of this extended developmental trajectory, the PFC is especially vulnerable to environmental impacts such as stress, nutrition, and cognitively enriching and stimulating experiences (Noble, Norman, & Farah, 2005).

Research involving animal models and children have found that environmental deprivation impairs the functional development of the PFC. In rodents, chronic stress hinders synaptic plasticity and induces atrophy of the PFC, which in turn severely disrupts working memory and cognitive flexibility (Cerquerira, Mailliet, Almedida, Jay, Sousa, 2007). Similarly, in children, exposure to stress hormones such as cortisol appear to impair PFC development via dendritic atrophy (Sheridan, Sarsour, Jutte, D'Esposito, & Boyce, 2012). In fact, when comparing prefrontal-dependent neurophysiological measures of attention between LSES and HSES children, results show that LSES children have reduced attention similar to the patterns observed in patients with PFC damage (Kishiyama, Boyce, Jimenez, Perry, & Knight, 2008).

Thus, insight problem solving may be a compensatory advantage of LSES because of lowered cognitive control.

The Development of Creative Thinking across Childhood

Though findings suggest that diminished cognitive control may improve insight problem solving, research shows that other factors such as age and traits like obedience may also have a significant impact of the developmental trajectory of children's creativity and thus possibly their ability to solve insight problems.

It is commonly argued that children are more creative than adults are. In fact, researchers have proposed that artistic development in children follows a U-shaped curve such that preschool children demonstrate creativity that most resembles the processes and products of adult artists. While young children's drawings tend to be unconcerned with the conventions of realism, by middle childhood, drawings become more stereotyped as children follow the rules of realistic representation. Then by late adolescence, creative works – at least for those who ultimately become artists – tend to revert to less conventional representations. Most typical adults, however, remain in the literal stage. In addition to drawing, this three-stage model has also been shown to fit the developmental trajectory of non-literal language use (Winner & Gardner, 1981).

Numerous empirical studies have found evidence showing a decline in creativity with age. For example, children's divergent thinking was assessed using a test by the National Aeronautics and Space Administration for selecting innovative engineers and scientists. Findings showed that 98% of kindergarteners tested at the genius level in divergent thinking, while only 32% and 12% of the same children re-tested at 10- and15-years old scored as high, respectively. Moreover, only two percent of adults over the age of 25 generally qualify at the genius level of creativity, as did the 5-year-olds in the study (Land & Jarman, 1992). Kim (2011) found a similar trend in diminishing creativity after analyzing the scores of 272, 599 people from kindergarten through adulthood between 1974 and 2008 on the TTCT. Results indicated that since 1990, even though IQ scores increased, creative thinking scores have significantly declined, especially across kindergarten through third grade. This reflects Torrance's (1967) finding of a fourth grade slump in children's fluency (i.e. the ability to generate a large number of ideas), flexibility (i.e. the ability to generate a variety of ideas across different categories), originality (i.e. the ability to generate novel ideas compared to others' responses), and elaboration (i.e. the ability to enhance an idea through detail) scores on the TTCT.

Cognitive factors like heightened inhibition and focused attention with age may, as previously described, result in children's decline of creative potential. In addition, external factors such as the pressure to conform to conventions as well as having less opportunity for play may also impede children's creativity. For example, research has shown that children who participate in free play score significantly higher on the TTCT than children who participate in highly structured play (Berretta & Privette, 1990). In fact, Garaigordobil (2006) found that a weekly 2-hour play session throughout the academic year significantly improved verbal and graphic-figural creativity of 10- and 11-year-olds. Despite findings of the benefits of play for improving creativity, schools increasingly emphasize rote learning and obedience with each passing grade. Using objects in imaginative ways explains part of why play has a positive effect on creative thinking and insight problem solving. Because of limited resources, LSES children may have more practice than HSES children with using objects for atypical purposes (e.g. using a wooden stick as a bat and a plastic bottle as a baseball). In fact, Dahlman, Bäckström, Bohlin, and Frans (2013) found that street children in Bolivia scored significantly higher on the AUT compared to LSES children living with their parents; the authors concluded that this was likely because the street children had more ‘training’ with this type of task given the nature of their lives.

Certain child rearing practices have also been shown to influence children’s creativity. Dai et al. (2012) found that parental support of children’s creativity – which was assessed via questionnaire – positively correlated to children’s performance on divergent thinking tests of creativity. Consistent with this finding are results from Niu (2007)’s study of ninth grade Chinese students that demonstrated that parent’s beliefs of child autonomy positively predicts creativity, and Fearon, Copeland, and Saxon’s (2013) study of first through sixth grade Jamaican students showed that children with authoritative parents scored significantly lower on the TTCT than did children whose parents subscribed to a less authoritarian style.

Taken together, the evidence shows that impaired cognitive control is associated with heightened creative thinking and insight problem solving ability. Whether this inverse association between cognitive control and insight problem solving exists in LSES children is the focus of the present study. Using two nonverbal insight problem solving tasks and a cognitive control task, the present study tested the hypotheses that: 1) LSES children have an inverse relationship between weak EF and strong insight problem solving ability; 2) HSES children have an inverse relationship between strong EF and low insight problem solving ability; and 3) younger children have poorer EF than older children, and thus will outperform older children on insight problem solving.

In addition to examining the relationship between cognitive control and insight problem solving, the present study also used parent report to investigate the potential mediating role of child obedience versus independence on insight problem solving.

Methods

Participants

A total of 148 children (89 girls, 59 boys) between the ages of 4 years 7 days and 11 years 6 days, with a mean age of 7 years 7 days, were recruited from schools, childcare centers, afterschool programs, and an affordable housing community across Massachusetts. Children with a history of severe head injury, low birth weight (i.e. <1,500 grams or less than 3.31 pounds), prenatal exposure to drugs, Fetal Alcohol Syndrome (FAS), mild or severe intellectual disability, or Autism Spectrum Disorder (ASD) were not eligible to participate. This decision was made because the focus of this study was on the relationship between insight problem solving and cognitive control in children who are *typically developing.*

To minimize the potentially confounding training effect from education curricula focused on promoting creative thinking and executive functioning, children were not recruited from research sites such as music, visual and performing arts-centric programs, or Science, Technology, Engineering, Arts, and Mathematics (STEAM) dedicated programs claiming to offer special creativity or executive functioning programming in their mission statements. Furthermore, to avoid self-selection bias and the possibility of overrepresentation of children whose parents specifically value creativity – and who are thus potentially raising their children to behave creatively – there was no reference to creativity made in the consent form. Instead, parents received a consent form inviting their child to participate in a study examining how children solve problems; they were informed that their children would work on two fantasy scenarios in which a toy character is having trouble solving two problems and needs help to find a solution, and that following these two tasks, children would complete a short computer task to assess their memory and attention.

Though all parents received a $10 Amazon gift for their participation, the burden of the sociodemographic questionnaire may have deterred some parents from participating, resulting in a low average response rate of only about 7% per research site. Therefore, to attain the target sample size for the study, children were recruited from 11 research sites. Table 1 provides demographic information for each research site, and Figures B1, B2, and B3 in Appendix B show the distribution of the primary caregivers' (i.e. defined on the consent form as "the adult who assumes the most responsibility in caring for the health and well-being of the child") highest education attainment, occupational prestige, and household income for each research site, respectively. Table 2 provides demographic information for the children who participated in this study, and Table 3 provides demographic information for the children's primary caregiver.

Table 1

Research Site Demographic Information

Site	*n* (Female)	Mean age and SD in Years (y) and Months (m)	Site Description
1	4 (0)	8y8m (2y1m)	Affordable housing community (i.e. tenants must have incomes within 30% to 80% of the area median income, which is between $24,800 to $66,150, respectively, for a family of four in Boston; "A Guide to Obtaining Housing," n.d.)
2	9 (3)	7y0m (1y5m)	After school program (tuition-free)
3	38 (24)	7y8m (1y9m)	Charter school (i.e. tuition-free publicly-funded independent schools in the US established by teachers,

			parents, or community groups that are not subject to the same curricular requirements as non-charter public schools; *What is a Charter School?*, n.d.)
4	18 (12)	6y2m (0y7m)	Charter school
5	13 (6)	9y2m (1y6m)	Charter school
6	8 (8)	10y4m (0y3m)	Charter school
7	4 (2)	5y4m (0y8m)	Daycare center ($299 per week)
8	1 (1)	5y8m (0y0m)	Daycare center ($633 per week)
9	45 (28)	6y11m (1y10m)	Private school ($8,400 per academic year)
10	7 (4)	8y3m (2y4m)	Summer camp ($1,270 per two weeks)
11	1 (1)	7y5m (0y0m)	Summer camp ($456 per month)

Notes: Units of age are years (y) and months (m). All monetary values are presented in USD currency.

Table 2

Children's Demographic Information

	%	*n* (Female)	Mean (SD)	Range
Age ……………………………………..	---	148 (89)	7y7m (1y11m)	4y7m - 11y6m
Single-parent household ……………….	36			
Speaks a language other than English ….	43			
Preferred language is English …………..	100			
Race/Ethnicity:				
African American / Black …………...	45			

American Indian / Alaskan Native …..	1
Asian ………………………………...	3
Caucasian / White …………………...	20
Hispanic / Latino …………………….	9
Mixed Race ………………………….	21
Native Hawaiian / Pacific Islander …..	1
Other ………………………………....	1

Notes: Units of age are years (y) and months (m). Correlation analyses revealed no significant relationship between the children's sex and age ($r(146)= .08$, $p= .32$), single-parent household status ($r(143)= .14$, $p= .09$), race/ethnicity ($r(146)= .01$, $p= .90$) or whether the child speaks a language other than English ($r(145)= .01$, $p= .92$). There were also no correlations found between children's age and single-parent household status ($r(143)= .10$, $p= .23$), race/ethnicity, ($r(146)= -.14$, $p= .10$), or whether the child speaks a language other than English ($r(145)= .01$, $p= .24$). However, there were correlations found between children's race/ethnicity and single-parent household status ($r(143)= .17$, $p= .05$), and whether the child speaks a language other than English ($r(145)= -.19$, $p= .02$). Table C1 in Appendix C shows the distribution of single-parent household status by child's race/ethnicity.

Table 3

Primary Caregiver's Demographic Information

	%
Relation to child:	
Mother ……………………………………..	89
Father ……………………………………...	9

Legal guardian	2
Highest education attained:	
Less than high school	3
High school diploma or equivalency	26
Associate degree	17
Bachelor's degree	18
Master's degree	24
Doctorate	6
Professional (e.g., MD, JD, DDS)	4
No response	2
Occupation:	
Farm Laborers/Menial Service Workers	2
Unskilled Workers	5
Machine Operators and Semiskilled Workers	14
Smaller Business Owners, Skilled Manual Workers, Craftsmen, and Tenant Farmers	3
Clerical and Sales Workers, Small Farm and Business Owners	3
Technicians, Semiprofessionals, Small Business Owners	12
Smaller Business Owners, Farm Owners, Managers, Minor Professionals	28
Administrators, Lesser Professionals, Proprietors of Medium Sized Businesses	16
Higher Executives, Proprietors of Large Businesses, and Major Professionals	12
No response	5
Gross annual household income:	
< $5,000	1

\$5,000 - \$11,999	8
\$12,000 - \$15,999	7
\$16,000 - \$24,999	7
\$25,000 - \$34,999	7
\$35,000 - \$49,999	11
\$50,000 - \$74,999	10
\$75,000 - \$99,999	7
> \$100,000	30
No response	12

Notes: Correlation analyses revealed no significant relationship between the children's ages and caregivers' highest education attained ($r(142)= -.05$, $p= .52$), occupation ($r(140)= .02$, $p= .79$), or gross annual household income ($r(128)= -.11$, $p= .20$). There were also no correlations found between children's sex and caregivers' highest education attained ($r(142)= -.01$, $p= .91$), occupation ($r(140)= .12$, $p= .15$), or gross annual household income ($r(128)= -.16$, $p= .08$), or children's race/ethnicity and caregivers' highest degree earned ($r(142)= -.14$, $p= .09$), occupation ($r(140)= -.13$, $p= .12$), or gross annual household income ($r(128)= -.10$, $p= .28$).

Procedure

All primary caregivers signed a consent form, and completed a sociodemographic questionnaire and a self-report measure rating both how much they value obedience versus independence in their child rearing practices as well as how obedient or independent they consider their children to actually be (see Appendix A). Obedience and independence were assessed so that their influence on creativity could be later determined. All of these forms were made available in English, Spanish, and Haitian Creole, and approved by the Boston College Institutional Review Board.

During testing, children met individually with the experimenter in a quiet area for a single session lasting approximately 20 minutes. All children were English speaking, and the session was conducted in English. Children were seated next to the experimenter at a table, and worked independently on two insight problem solving tasks, first the Box Problem (German & Defeyter, 2000), followed by the Pencil Problem (Bíró, 2001; Defeyter & German, 2003). Children were given a maximum of five minutes to complete each insight problem solving task, but they were unaware of this limit or the fact that they were being timed.

Of the 148 children who participated, 144 (i.e. all children except for those four who were recruited from the affordable housing community) were removed from their class, after school, daycare or summer camp program to participate in this study. Thus, to minimize lengthy interruptions to class time, a five-minute limit was imposed for each insight problem solving task. This time limit was justified by the fact that the longest time any of the 5- to 7-year old participants in German and Defeyter (2000)'s study took to solve the Box Problem was three minutes, and that the median latency for the 5- to 7-year old participants in Defeyter & German's (2003) study to select the target object for the Pencil Problem was less than 25 seconds. Once children completed the insight problem solving tasks, they were given a computerized cognitive control task, the Flanker/Reverse Flanker task (Schonert-Reichl et al., 2015), which lasted approximately ten minutes.

Measures

Insight Problem Solving Tasks

The Box Problem (German & Defeyter, 2000) and the Pencil Problem (Bíró, 2001; Defeyter & German, 2003) are nonverbal hands-on insight problem solving tasks that require overcoming functional fixedness in order to arrive at the respective solutions; both tasks have been previously used to investigate functional fixedness in children ages 5 to 7 years old.

Box Problem. Children were presented with an unmarked shoebox (28.5cm high x 19.5cm wide x 11cm deep) without a lid, which was positioned vertically and described as a room belonging to 'Bobo the Tiger,' a plush toy 8cm tall. On the 'back wall' of the room was a shelf 20cm from the 'floor,' on which there was a small toy airplane. Inside Bobo's room was also his 'toy box' (i.e. the target object) – a small cardboard box (4.5cm high x 9cm wide x 9cm deep) without a lid – which contained eight items ('the distractors'): two wooden blocks (each measuring 4cm high x 4cm wide x 4cm deep), a small toy car (1.5cm tall), a rubber band, an eraser (4cm long x 3cm wide x 1cm thick), a golf pencil (8cm long), a coin, and a small binder clip. The 'toy box,' which was presented to children already filled with 'the distractors' served to demonstrate the conventional function of a box as a container.

Children were introduced to Bobo, and they were told, "Bobo was playing with the toys in his toy box. Now, Bobo wants to play with his favorite toy, which is on the shelf. But, Bobo has a problem! The problem is that he is too short to reach his favorite toy and he also cannot jump high enough to reach the shelf. He does not want to throw anything at his favorite toy because he is afraid that it might break. Now, Bobo is very worried. He is saying to himself, ''How am I going to reach my favorite toy?'' Bobo has all of these things (using a gesture, the experimenter indicated the 'toy box' and its contents) that he can use to get his favorite toy down from the shelf. Using these things, help Bobo figure out how to get his favorite toy down from the shelf. You have a few minutes to solve this problem."

Children could stack the wooden blocks to make a tower 8cm high, which, combined with Bobo's height, would still not allow the tiger to reach the shelf. The only workable solution was to empty the 'toy box' of its contents and overturn it so that the wooden block tower could be stacked on top of the overturned 'toy box,' thus allowing Bobo to reach the shelf. Figure 1 shows the setup and solution for the Box Problem. No specific hints were given, but if children offered a solution by stopping their attempts and seeking approval from the experimenter without having yet used the 'toy box,' the experimenter showed them that Bobo could not reach the shelf, and prompted them for another solution (e.g. the experimenter indicated the box and its contents using the same gesture previously used to introduce children to the scenario, and the children were told: "Is there anything else Bobo could use to reach his favorite toy?"). The trial began as soon as the experimenter finished the script, and ended once the child used the emptied and overturned 'toy box' as an additional platform. Children's attempted solutions were video recorded for subsequent analysis. Performance was scored based on whether the 'toy box' was used as well as the latency from the time when the experimenter finished presenting the problem until the time when the child used the 'toy box' to solve the problem.

a) b) c) d)

Figure 1. The Box Problem's a) set-up, b) distractors, c) target object, and d) solution.

Pencil Problem. Children were presented with eight objects described as 'Bobo the Tiger's' belongings, which consisted of a transparent plastic tube (21cm long with 9cm circumference openings at each end of the tube), Bobo's pet named Tog (a plush caterpillar lodged mid-way inside of the transparent tube and measuring 7cm long x 3cm thick), a pencil (i.e. the target object; 18 cm long x 1.5cm circumference), and five 'distractor objects' including a notebook, a plastic drinking straw (6cm long x 1cm circumference openings at each end of the straw), a clear plastic cup (4cm tall x 14cm circumference at the top opening x 9.5cm circumference at the base), a rubber ball (11cm circumference), and a protractor (15cm long x 8cm wide).

Children were reintroduced to 'Bobo the Tiger,' and told, "Here are some of Bobo's things. These are the things Bobo uses for writing. Here is how Bobo writes his name (using the pencil, the experimenter wrote 'BOBO' all in capital letters on a blank page of the notebook, and then rested the pencil on the page in the notebook with Bobo's newly inscribed name). These are the things that Bobo uses for drinking. Here is how Bobo takes a drink (using the straw, the experimenter pretended to take a sip from the cup, and then left the straw inside the cup.)

Bobo has a pet named Tog (using a gesture, the experimenter indicated the transparent tube containing Tog). But, Bobo has a problem! Naughty Tog has run away and got stuck in this tube. Bobo can't leave until Tog is free. Now, Bobo is very worried. Bobo is saying to himself, ''How am I going to get Tog out of this tube?'' Bobo has all of these things that he can use to get Tog out of this tube (using a gesture, the experimenter indicated all of Bobo's belongings). Using these things, help Bobo figure out how to get his pet, Tog, out of this tube. You have a few minutes to solve this problem."

By using the pencil as a writing instrument and the straw as a drinking utensil, the experimenter demonstrated the conventional functions of these objects. Two objects were used to guard against the possibility that drawing attention to one object only would create a response bias toward (or against) the later use of that object. The only way to free Tog from the tube is to use the pencil, which was both thin enough to fit inside the tube and long enough to reach Tog. The drinking straw could not be used to solve the problem because while it was thin enough to fit inside the tube, it was too short to reach Tog. Figure 2 shows the setup and solution for the Pencil Problem. No specific hints were given, but if children offered an attempt at a solution (e.g. by trying, and failing, to reach Tog inside of the tube using their fingers or the straw) and stopped to seek approval from the experimenter without having yet used the pencil, the experimenter showed them that Bobo could not reach Tog, and prompted them for another solution (i.e. the experimenter indicated Bobo's belongings using the same gesture previously used to introduce children to the scenario, and the children were told: "Is there anything else Bobo could use to help free Tog?"). The trial began as soon as the experimenter finished the script, and ended once the child placed the pencil so that it came into contact with the opening of the tube in an attempt to push Tog free. The children's attempted solutions were video recorded for subsequent analysis. Performance was scored based on whether the pencil was used as well as the latency from the time when the experimenter finished presenting the problem until the time when the child used the pencil to solve the problem.

a) b) c) d)

Figure 2. The Pencil Problem's a) set-up, b) distractors, c) target object, and d) solution.

Cognitive Control Task

Flanker/Reverse Flanker Task. The Flanker/Reverse Flanker task (Schonert-Reichl et al., 2015) assesses the three core areas of executive functioning: working memory, inhibition, and cognitive flexibility (Diamond, 2013). This task was conducted with the child seated in front of a laptop computer with a 14-inch computer screen and an external keyboard on which the corner keys with right and left arrows were clearly marked. The test was administered using Presentation Software by Neurobehavioral Systems (Berkeley, CA). It consisted of three blocks: Standard Flanker, Reverse Flanker, and Mixed Trials – in that order. At the beginning of the session, children were given both written and verbal instructions, as well as practice trials. Block 1 (Standard Flanker with only blue fish) and block 2 (Reverse Flanker with only pink fish) were preceded by four practice trials followed by 17 test trials. Block 3 (Mixed Trials with both blue and pink fish) was preceded by eight practice trials followed by 65 test trials. For blocks 1 and 2, if participants did not respond correctly to three out of the four practice trials, the full practice round – though not necessarily with the exact same types of trials from the previous practice round – would repeat until participants achieved at least 75% accuracy before they could continue on to the test trials. For block 3, participants had to respond correctly to at least five out of the eight practice trials to avoid repeating the practice round. There was no time limit for practice trials. However, children were given a 2000ms limit to respond to each test trial before the program automatically advanced to the next trial. The only types of feedback or encouragement given from the experimenter or the computer program was when children were told 'Nice/great! Let's play again" between practice and test trials, and "Great/wonderful! Now there's going to be a new rule" between the Standard and Reverse Flanker trials.

To begin, children were told, "In this test, you have to keep your fingers on these two keys (i.e. the right and left arrows on the keyboard); you should keep your fingers elevated, don't rest your fingers on the keys. There will be instructions on the screen."

All three blocks consisted of an equal number of four kinds of trials: congruent, incongruent, neutral, and no distractors. These four kinds of trials were randomly presented within each block.

First children received the Standard Flanker block. Instructions were displayed on the computer screen, and were read aloud to the children. Children were told, "In this game, you're going to see lots of fish like these (i.e. five fish in a row, displayed on the computer screen). When the hungry fish is in the middle, feed the middle fish by pressing where the middle fish is facing. [For example] here the middle fish is facing this way (e.g. five blue fish in a row, displayed on the computer screen, with a left pointing arrow above the middle fish which was facing left whilst the flanker fish were facing right). Sometimes the middle fish will be all by himself, you should still press where he's facing. And sometimes, the middle fish will have company that's going in another direction. You should still press where the middle fish is facing. Your job is to feed the middle fish."

Congruent Trials: In the congruent trials, children were presented with five blue fish in a row all facing the same direction, displayed on the computer screen. In order to feed the middle fish, children simply had to note the direction in which *all* the fish were facing.

Incongruent Trials: In the incongruent trials, children were presented with the middle fish facing in one direction, and the blue flanker fish facing in the opposite direction. In order to feed the middle fish, children had to ignore the conflicting information presented by the flanker fish. This calls upon selective attention (attend to the correct fish) and inhibitory control (avoid pressing the key for the incorrect fish).

Neutral Trials: In the neutral trials, the distractor fish were pointing either up or down; because these were not directions corresponding with a response, they did not present conflicting information.

No Distractor Trials: In the no distractor trials, the middle fish was presented alone without any flanker fish.

Next, children received the Reverse Flanker block. This time, all five fish were pink. Children were told, "When the fish are pink, all the outside fish are hungry. So, feed the fish on the outside by pressing where they're facing. [For example] here the outside fish are facing this way (i.e. five pink fish in a row, displayed on the computer screen, with two right pointing arrows above the two sets of flanking fish which were facing right whilst the middle fish was facing left). Sometimes there won't be a middle fish, you should still press where the outside fish are facing. And sometimes, the other fish will be going somewhere else, you should still press where the outside fish are facing. Your job is to feed the outside fish." This task required children to learn a new rule and again to deploy both selective attention and inhibitory control. But, in this case children had to attend to fish they had previously tried to ignore – the fish on either side of the middle fish. This task therefore requires cognitive flexibility.

Again, children were presented with all four types of trials randomly intermixed throughout this block: congruent trials in which the flanker and middle fish were all facing the same direction, incongruent trials in which the flanker fish were facing in the opposite direction to the middle fish, neutral trials in which the middle fish was facing up or down, and no distractor trials in which there was no middle fish present.

Finally, children received the Mixed Flanker block. Here children were presented with blue target fish trials (as in the Standard Flanker block) and pink target fish trials (as in the Reverse Flanker block) intermixed such that non-switch trials were those where children saw the same type of trial back to back (i.e. a Standard Flanker trial followed by another Standard Flanker trial, or a Reverse Flanker trial followed by another Reverse Flanker trial), whereas in switch trials, children saw one trial type followed by a different trial type (i.e. a Standard Flanker trial followed by a Reverse Flanker trial, or a Reverse Flanker trial followed by a Standard Flanker trial). Children were told, "Now, you're going to play the game with both colors, so try really hard to remember the rules. Blue means feed the middle fish. Press where the middle fish is facing. Pink means feed the outside fish. Press where the outside fish are facing. Blue means middle. Pink means outside." These instructions were repeated between the practice and test trials for the Mixed Flanker block. Again, children were presented with all four types of trials (i.e. congruent, incongruent, neutral, and no distractors) randomly intermixed for each color of fish.

This block puts a heavy demand on the core executive functions; children had to switch between the rules of selectively attending to the middle fish (and ignoring the flanker fish) when the fish were blue or selectively attending to the flanker fish (and ignoring the middle fish) when the fish were pink. This block requires children to use cognitive flexibility to switch between rules, working memory to keep in mind twice as many rules, and employ selective attention and inhibitory control by focusing on the appropriate fish and pressing the appropriate key depending on the color of the fish (Diamond et al., 2007). Figure 3 shows examples of the four trial types for the Standard and Reverse Flanker blocks. The four types of trials were randomly intermixed throughout each block.

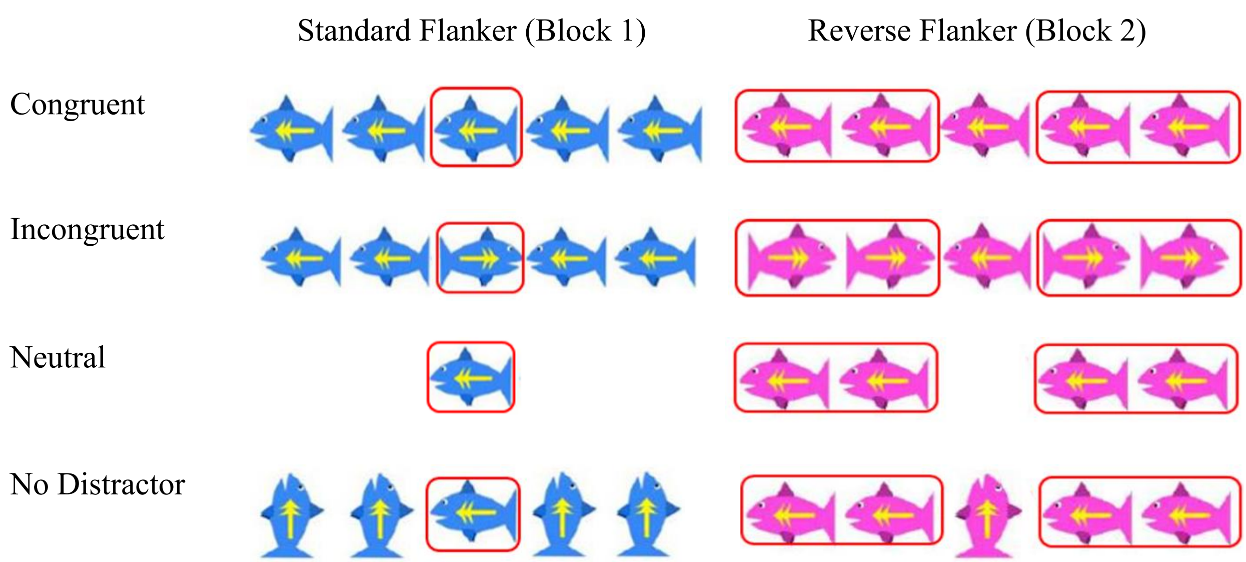

Figure 3. Examples of the four trial types (i.e. congruent, incongruent, neutral, and no distractors) in the Flanker/Reverse Flanker task. The target fish in each trial type are outlined.

Two kinds of scores were computed – global switch cost score and flanker effect score – with an accuracy and a reaction time (RT) score computed for each. RT scores were calculated only if they accompanied an accurate response.

Global switch cost accuracy and RT. The global switch cost score (for both accuracy and RT) assesses the cost of having to switch rules by determining how much worse performance is in the most difficult block (i.e. block 3: Mixed Flanker) compared to the easier blocks (i.e. block 1: Standard Flanker and block 2: Reverse Flanker). The better a participant performs on the Flanker/Reverse Flanker task, the higher their mean accuracy rate and lower their mean RT. Thus, to avoid negative number outcomes for clarity of interpretation, separate equations are used to calculate the global switch cost accuracy[1] and RT scores.

[1] Mean accuracy scores, not mean error scores, must be used to calculate global switch cost accuracy and flanker effect accuracy scores because if a participant receives a perfect accuracy score of 100% on the easier blocks, their equivalent error score would be 0%, which would result in an undefined fraction. In this study, 53% and 56% of participants received a perfect accuracy score on blocks 1 and 2, respectively.

These scores were computed as follows:

$$Global\ Switch\ Cost\ Accuarcy = \frac{Mean\ (Mean\ Standard\ Flanker\ score + Mean\ Reverse\ Flanker\ score) - \ Mean\ Mixed\ Flanker\ score}{Mean\ (Mean\ Standard\ Flanker\ score + Mean\ Reverse\ Flanker\ score)}$$

$$Global\ Switch\ Cost\ RT = \frac{Mean\ Mixed\ Flanker\ score - \ Mean\ (Mean\ Standard\ Flanker\ score + Mean\ Reverse\ Flanker\ score)}{Mean\ (Mean\ Standard\ Flanker\ score + Mean\ Reverse\ Flanker\ score)}$$

Lower global switch cost scores reflect better cognitive flexibility and working memory because they indicate the cost for switching between rules. For example, a participant with a perfect mean accuracy score of 100% on each of the three blocks would have a global switch cost accuracy score of zero, whereas a participant who performs less well by scoring 100% on the easier blocks and 50% on the more challenging block would have a global switch cost accuracy score of .5. In terms of RT, a participant with a mean RT of 250ms on each of the three blocks would have a global switch cost RT score of zero, whereas a participant who performed less well with a mean RT of 250ms on each of the easier blocks and 2000ms on the more challenging block would have a global switch cost RT score of 7.

Flanker effect accuracy and RT. The flanker effect score (for both accuracy and RT) assesses inhibition. These scores were computed by examining congruent and incongruent trial scores across all three blocks. Like for global switch cost scores, separate equations are used to calculate the flanker effect accuracy and RT scores.

These scores were computed as follows:

$$Flanker\ effect\ accuracy = \frac{Mean\ congruent\ score - Mean\ incongruent\ score}{Mean\ congruent\ score}$$

$$Flanker\ effect\ RT = \frac{Mean\ incongruent\ score - Mean\ congruent\ score}{Mean\ congruent\ score}$$

Thus, lower flanker effect scores reflect better inhibition because they indicate the fact that more attentional control is required in the incongruent trials, as opposed to the congruent trials, to inhibit responding to the non-target fish. For example, a participant with a perfect mean accuracy score of 100% on the congruent and incongruent trials would have a flanker effect accuracy score of zero, whereas a participant who performs less well by scoring 100% on the congruent trials and 50% on the incongruent trials would have a flanker effect accuracy score of .5. In terms of RT, a participant with a mean RT of 250ms on congruent and incongruent trials would have a flanker effect RT score of zero, whereas a participant who performed less well with a mean RT of 250ms on the congruent trials and 2000ms on the incongruent trials would have a flanker effect RT score of 7.

For accuracy and RT score calculations, the first non-practice trial of every block was excluded, and trials with RTs of less than 250ms were excluded (as such a score would be too fast to be considered a contemplative response to the stimulus; Davidson, Amso, Anderson, & Diamond, 2006). RT scores were calculated only if they accompanied an accurate response.

Sociodemographic Survey

Primary caregivers completed a 21-question survey consisting of items assessing parental SES, child’s history of medical conditions, and parental valuing of obedience vs. independence. Medical history was queried because this study focused on typically developing children. Appendix A shows the sociodemographic survey.

SES. The three core indicators of SES (i.e. education, occupation, and income) were assessed separately.

Education was assessed by the following question:

What is the highest degree that you have earned?

_____ *High school diploma or equivalency (GED)*

_____ *Associate degree (junior college)*

_____ *Bachelor's degree*

_____ *Master's degree*

_____ *Doctorate*

_____ *Professional (MD, JD, DDS, etc.)*

_____ *Other (please specify: ____)*

_____ *None of the above (less than high school)*

Responses were scored on a 7-point scale: 1= Less than high school; 2= High school diploma or equivalency (GED); 3= Associate’s degree; 4= Bachelor’s degree; 5= Master’s degree; 6= Doctorate; 7= Professional (MD, JD, DDS, etc.).

Occupational prestige was assessed by the following question:

With regards to your current or most recent job activity:

a. In what kind of business or industry do (did) you work?

____

(For example: hospital, newspaper publishing, mail order house, auto engine manufacturing, breakfast cereal manufacturing.)

b. What kind of work do (did) you do? (Job Title)

____

(For example: registered nurse, personnel manager, supervisor of order department, gasoline engine assembler, grinder operator.)

Occupation responses to the question about job title were scored on a 9-point scale (following Hollingshead, 1975): 1= farm laborers/menial service workers (e.g. custodial workers, amusement park attendants, baggage porters, etc.); 2= unskilled workers (e.g. crossing guards, construction laborers, bartenders, etc.); 3= machine operators and semi-skilled workers (e.g. hairdressers, roofers, taxicab or bus drivers, etc.); 4= smaller business owners (<$25,000), skilled manual laborers, craftsmen, tenant farmers (e.g. electricians, plumbers, tailors, etc.); 5= clerical and sales workers, small farm and business owners (business valued at $25,000-50,000; e.g. bank tellers, cashiers, dental assistants); 6= technicians, semi-professionals, small business owners (business valued at $50,000-70,000; e.g. air traffic controllers, sales managers, therapists, etc.); 7= smaller business owners, farm owners, managers, minor professionals (e.g. public relations persons, real estate brokers/agents, social workers, etc.); 8= administrators, lesser professionals, proprietor of medium-sized business (e.g. accountants, librarians, secondary school teachers, etc.); 9= higher executive, proprietor of large businesses, major professional (e.g. architects, lawyers, physicians, etc.).

Household income was assessed by the following question:

Which of these categories best describes your total combined family income for the past 12 months?

This should include income (before taxes) from all sources, wages, rent from properties, social security, disability and/or veteran's benefits, unemployment benefits, workman's compensation, help from relatives (including child support payments and alimony), and so on.

______*Less than $5,000*

______*$5,000 through $11,999*

______*$12,000 through $15,999*

______*$16,000 through $24,999*

______*$25,000 through $34,999*

______*$35,000 through $49,999*

______*$50,000 through $74,999*

______*$75,000 through $99,999*

______*$100,000 and greater*

______*No response*

Income responses about total combined pre-tax family income over the previous 12 months were scored on a 9-point scale: 1= less than $5,000; 2= $5,000 through $11,999; 3= $12,000 through $15,999; 4= $16,000 through $24,999; 5= $25,000 through $34,000; 6= $35,000 through $49,999; 7= $50,000 through $74,999; 8= $75,000 through $99,999; 9= $100,000 and greater.

A composite SES score was then computed by applying a *z*-transformation to the primary caregiver's highest level of education attained, occupational prestige, and gross annual household income, and then taking the average of these standardized scores. A composite SES score was justified because the caregiver's highest level of education attained correlated with occupational prestige ($r(139) = .66$, $p < .001$) and gross annual household income ($r(127) = .67$, $p < .001$), and occupational prestige correlated with gross annual household income ($r(126) = .65$, $p < .001$). The composite SES score correlated with each individual index score: highest education level ($r(125) = .88$, $p < .001$), occupational prestige ($r(125) = .83$, $p < .001$), and gross annual income ($r(125) = .88$, $p < .001$).

Obedience vs. Independence. Primary caregivers' values of obedience vs. independence in child rearing were assessed by the following two items, in the order shown below, to which they responded using a 9-point Likert scale (from 1= 'I strongly disagree' to 9= 'I strongly agree'):

a) It is very important to me that my child is obedient.
b) It is very important to me that my child is an independent thinker.

Caregivers' reports of the child's level of obedience was assessed by the following two items, in the order shown below, to which they responded using the same Likert scale as for previous two statements:

c) My child generally does everything that I tell him/her to do.
d) My child is generally well behaved.

These four items had good internal consistency (Cronbach's $\alpha = .86$), and strong inter-correlations: 'It is very important to me that my child is obedient' correlated with 'It is very important to me that my child is an independent thinker' ($r(140) = .59$, $p < .001$), as well as with 'My child generally does everything that I tell him/her to do' ($r(141) = .60$, $p < .001$), and 'My child is generally well behaved' ($r(141) = .61$, $p < .001$). 'My child generally does everything that I tell him/her to do' also correlated with 'My child is generally well behaved' ($r(143) = .75$, $p <$

.00). Given their strong correlations and conceptual relatedness, scores for items that report the child's behavior were averaged to create a composite child obedience score. This composite child obedience score correlated with each individual score reporting the child's behavior, 'My child generally does everything that I tell him/her to do' ($r(143)= .52$, $p< .001$), and 'My child is generally well behaved' ($r(144)= .56$, $p< .001$).

Results

All 148 children who participated in the study completed the cognitive control task. However, one child declined to participate in either of the insight problem solving tasks, and a videorecorder malfunction resulted in the exclusion of data from two additional children for the Box Problem. As a result, the final dataset analyzed included 148 children for the Flanker/Reverse Flanker Task[2], 145 children for the Box Problem and 147 children for the Pencil Problem. All analyses were conducted at the 5% significance level and performed using IBM SPSS Statistics 24.

Cognitive Control Task Check

On the Flanker/Reverse Flanker task, the best possible accuracy score that a participant could achieve is 100% and the worst possible accuracy score is 0%, whereas the best possible RT is 250ms and the worst possible RT is 2000ms. If the Flanker/Reverse Flanker functioned properly, results would show that children who are better able to manage the more difficult blocks (i.e. block 2: Reverse Flanker and block 3: Mixed Flanker) and trials (i.e. incongruent trials across all blocks and switch trials in block 3) and thus receive higher rates of accuracy and

[2] According to Westfall et al. (2018), to reduce the effects of outlier data points on the Flanker task, data should be discarded from children who have an overall accuracy of less than 50% (1 participant) or an overall RT greater than three standard deviations above or below the mean (0 participants). Analyses were conducted with and without this exclusion criteria, and since in both cases the statistical significance of the results did not change, no data were dropped and data from all children were included in the analyses presented here.

shorter RT should also show better performance on the easier blocks (i.e. block 1: Standard Flanker) and trials (i.e. congruent trials across all blocks and non-switch trials in block 3). Thus, to verify that the Flanker/Reverse Flanker functioned as expected[3], a two-way repeated-measures ANOVA was used to analyze blocks versus trials. In addition, a paired samples t-test was used to compare the switch and non-switch trials, which occurred only in block 3. This analysis has been used in previous studies (e.g. Hooper, Faria, Fortes, Wanner, & Albuquerque, 2020) to assess the reliability of the Flanker/Reverse Flaker task as a test of executive functions.

A repeated measures ANOVA for accuracy found a significant interaction between blocks and trials ($F(1.87, 273.66)= 26.37$, $p< .001$) with a moderate effect size ($\eta p^2= .153$). The Huyndt-Feldt correction is reported because Maulchy's test of the sphericity assumption was violated for this interaction effect ($x^2(2)= 12.11$, $p= .002$, Greenhouse-Geisser $\varepsilon= .926$, Huyndt-Feldt $\varepsilon= .937$). Pairwise comparisons with Bonferonni adjustments indicated that children performed with significantly greater accuracy on the congruent trials compared to the incongruent trials *within* each block. More specifically, in block 1, children's performance was 9% more accurate on the congruent versus incongruent trials ($p< .001$), in block 2, accuracy was higher by 4% on the congruent versus incongruent trials ($p= .021$), and in block 3, children were 22% more accurate on the congruent than incongruent trials ($p< .001$). Pairwise comparisons with Bonferonni adjustments confirmed that, as predicted, children performed with greater accuracy in blocks 1 and 2 than they did in block 3 for each trial type. For congruent trials, performance was 8% more accurate in block 1 than in block 3 ($p< .001$), and 5% more accurate

[3] The Flanker/Reverse Flanker task from Neurobehavioral Systems provided output for each participant describing the block type (i.e. blocks 1, 2, or 3), trial number (i.e. trials 1 to 17 for blocks 1 and 2, and trials 1 to 65 for block 3), trial name (e.g. practice_incongruent_blue, neutral_blue_right, congruent_pink_left, etc.), expected response (i.e. whether the target fish was/were facing right or left), participant's response (i.e. whether the participant pressed the key on the furthest right or left of the keyboard), response correct (i.e. whether the expected response and the participant's response matched for each trial), and the RT for each trial (measured in milliseconds). Due to a program malfunction, the response correct score had to be computed manually across all trials for six participants.

in block 2 than block 3 (*p*= .018). For incongruent trials, performance was 21% more accurate in block 1 than block 3 (*p*< .001), and 23% more accurate in block 2 than block 3 (*p*< .001). For blocks 1 and 2, there was no significant difference in accuracy for the congruent (*p*= .567) or incongruent (*p*= 1.00) trials. Table 4 and Figure 4a show the mean accuracy rates for the blocks and trials.

Table 4

Mean Percent Accuracy Rates Across Blocks and Trials

	Congruent		Incongruent		*p*
	n	Mean (SD)	*n*	Mean (SD)	
Block 1: Standard Flanker	147	96 (16)	148	87 (25)	<.001
Block 2: Reverse Flanker	148	93 (18)	148	89 (22)	.021
Block 3: Mixed Flanker	148	88 (16)	148	66 (18)	<.001

A repeated measures ANOVA, this time with RT as the dependent variable, was conducted. Results again showed a significant interaction between blocks and trials ($F(1, 136)= 106.82$, $p< .001$), with a large effect size ($\eta p^2= .44$). Huyndt-Feldt correction is reported because Maulchy's test of the sphericity assumption was violated for this interaction effect ($x^2(2)= 9.46$, $p= .009$, Greenhouse-Geisser $\varepsilon= .937$, Huyndt-Feldt $\varepsilon= .949$). Pairwise comparisons with Bonferonni adjustments indicated that children performed significantly faster on the congruent than incongruent trials for each block. In block 1, children performed 127.46ms faster on the congruent than incongruent trials (*p*< .001); in block 2, RT was 79.97ms faster on congruent than incongruent trials (*p*= .001); and in block 3, RT was 154.13ms faster on congruent than incongruent trials (*p*< .001). Pairwise comparisons with Bonferonni adjustments also showed that children performed significantly faster in blocks 1 and 2 than in block 3 for each trial type. For congruent trials, children performed 115.02ms faster in block 1 than in block 3 ($p< .001$), and 84.28ms faster in block 2 than in block 3 ($p= .001$). For incongruent trials, children performed 141.69ms faster in block 1 than in block 3 ($p< .001$), and 158.44ms faster in block 2 than in block 3 ($p< .001$). For blocks 1 and 2, there was no significant difference in RT for the congruent ($p= .460$) or incongruent ($p= 1.00$) trials. Table 5 and Figure 4b show the mean RT for the blocks and trials.

Table 5

Mean Reaction Time (ms) Across Blocks and Trials

	Congruent		Incongruent		*p*
	n	Mean (SD)	*n*	Mean (SD)	
Block 1: Standard Flanker	144	935.50 (273.83)	145	1062.96 (291.62)	<.001
Block 2: Reverse Flanker	146	966.24 (290.32)	144	1046.21 (335.63)	.001
Block 3: Mixed Flanker	148	1050.52 (211.21)	148	1204.65 (262.14)	<.001

A paired samples t-test for block 3 did not indicate any difference in accuracy between switch (M= 81%) and non-switch (M= 82%) trials ($t(147)= .888$, $p= .376$, $d= .073$); Figure 4c shows the mean accuracy rates for switch and non-switch trials. On the other hand, switch trials (M= 1114.38ms) had significantly longer RT than did the non-switch trials (M= 1065.89ms; $t(147)= -5.52$, $p< .001$, $d= .453$); Figure 4d shows the mean RT for switch and non-switch trials.

These findings confirm that the Flanker/Reverse Flanker task functioned properly.

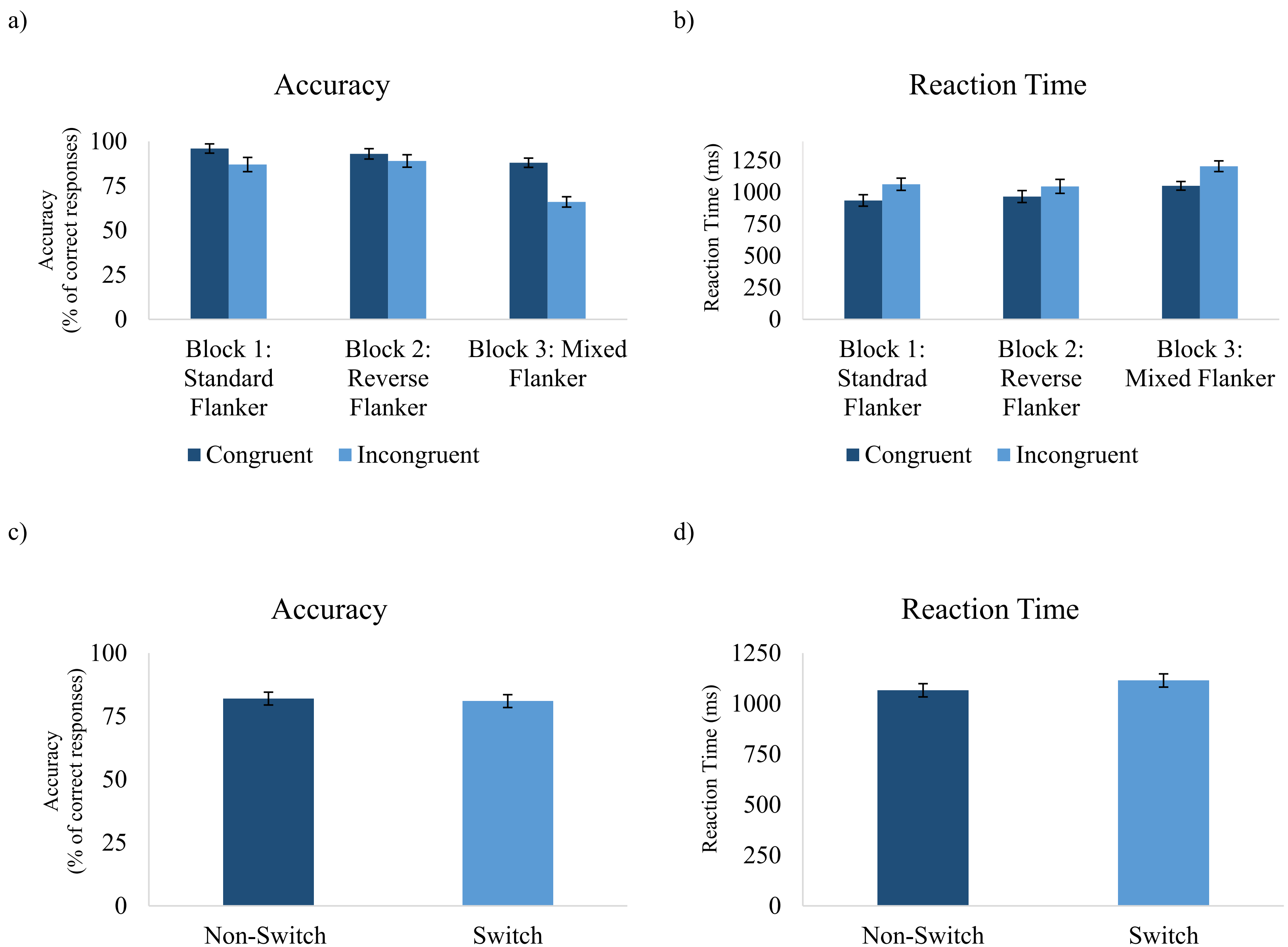
a)
Accuracy
Accuracy
(% of correct responses)
100
75
50
25
0
Block 1: Standard Flanker
Block 2: Reverse Flanker
Block 3: Mixed Flanker
Congruent
Incongruent
b)
Reaction Time
Reaction Time (ms)
1250
1000
750
500
250
0
Block 1: Standrad Flanker
Block 2: Reverse Flanker
Block 3: Mixed Flanker
Congruent
Incongruent
c)
Accuracy
Accuracy
(% of correct responses)
100
75
50
25
0
Non-Switch
Switch
d)
Reaction Time
Reaction Time (ms)
1250
1000
750
500
250
0
Non-Switch
Switch

Figure 4. Verifying that the Flanker/Reverse Flanker functioned as predicted by examining differences between blocks and trials. a) Differences in accuracy between blocks in congruent and incongruent trials; b) differences in RT between blocks in congruent and incongruent trials; c) differences in accuracy between blocks in switch and non-switch trials; d) differences in RT between blocks in switch and non-switch trials.

Scoring Children's Performance on the Insight Problem Solving Tasks

Children's performance on each of the insight problem solving tasks was scored by two independent raters from video recorded sessions. Two scores were computed for each of the insight problem solving tasks: 1) whether the child 'passed' or 'failed' the task by using the target object in their solution to the problem, and 2) the latency (in seconds) from the time when the experimenter finished presenting the problem until the time when the target object was selected to be used in a solution attempt; children who failed to select the target object before the five minute cutoff did not receive a latency score. There were no disagreements between the raters as to as whether or not a child used the respective target object before the five minute limit, and interrater reliability was high for how much time elapsed before the respective target object was chosen to solve the Box problem ($r(73)= .94$, $p< .001$) and the Pencil Problem ($r(133)= .97$, $p< .001$). Thus, latency scores from both raters were averaged for each insight problem solving task.

Because the associations between SES, age, insight problem solving ability, and cognitive control are of fundamental importance to this study, each of these relationships were first examined without the inclusion of other potential predictors or covariates.

The Association between SES and Cognitive Control

Correlation analysis did not indicate any significant association between the SES composite score (i.e. composite score of caregiver's highest level of education, occupational prestige and gross annual household income) and any of the cognitive control measures: global switch cost RT ($r(125)= -.004$, $p= .967$), global switch cost accuracy ($r(125)= .107$, $p= .233$), flanker effect RT ($r(125)= .019$, $p= .828$), or flanker effect accuracy ($r(125)= -.070$, $p= .435$).

The Association between SES and Insight Problem Solving Ability

Correlation analysis was used to examine the relationship between SES and creative solving ability. Results did not show any significant association between the SES composite score and children's ability to solve the Box Problem ($r(122) = .067$, $p = .458$) or the Pencil Problem ($r(124) = .077$, $p = .394$), or mean latency to solve to Box Problem ($r(60) = .053$, $p = .685$) or Pencil Problem ($r(114) = .020$, $p = .831$).

The Association between Age and Cognitive Control

Correlation analysis was used to examine the relationship between children's age and cognitive control. Results indicated a significant positive association between age and mean accuracy ($r(146) = .201$, $p = .014$) and a significant negative association between age and mean RT ($r(146) = -.271$, $p < .001$) across all blocks and trials. Results also showed a significant positive association between age and global switch cost RT ($r(146) = .334$, $p < .001$). No association was found between age and global switch cost accuracy ($r(146) = -.075$, $p = .363$), flanker effect RT ($r(146) = .042$, $p = .612$), or flanker effect accuracy ($r(146) = -.045$, $p = .590$).

The Association between Age and Insight Problem Solving Ability

Correlation analysis was used to examine the relationship between children's age and insight problem solving ability. Results indicated a significant positive association between children's age and ability to solve the Box Problem ($r(143) = .422$, $p < .001$) and a significant negative association between children's age and mean latency to solving the Pencil Problem ($r(133) = -.178$, $p = .039$). No association was found between children's age and mean latency to solving the Box Problem ($r(73) = -.112$, $p = .339$) or ability to solve the Pencil Problem ($r(145) = .100$, $p = .226$).

The mean times to solution for each task by age[4] for children who offered a target object solution appear in Table 6, and age trends are plotted in Figure 5 and Figure 6. As can be seen in Figure 5, there was a ceiling effect for the Pencil Problem, which proved easier than the Box Problem.

Table 6

Percentage of Children Scoring Accurately and Mean Seconds to Accurate Solutions at Each Age for Each Task

	Box Problem			Pencil Problem		
Age (years)	*n*	% Solved	Mean RT (SD)	*n*	% Solved	Mean RT (SD)
5	22	23	83.20 (74.52)	22	91	35.95 (41.93)
6	28	29	129.75 (88.49)	29	86	37.48 (66.85)
7	36	47	107.82 (89.63)	36	94	30.09 (40.27)
8	20	67	90.43 (69.51)	21	86	25.06 (50.04)
9	4	100	129.50 (76.57)	4	100	27.50 (17.79)
10	20	90	68.83 (66.63)	20	95	13.21 (18.81)
11	16	63	110.89 (81.63)	16	94	19.53 (32.09)

[4] Ages are rounded such that children with more than six months to their next birthday are included in the category representing their current whole number age (e.g. 7 years 5 months old is considered 7 years old) while children with six months or less to their next birthday are included in the category representing their next whole number age (e.g. 7 years 6 months old is considered 8 years old).

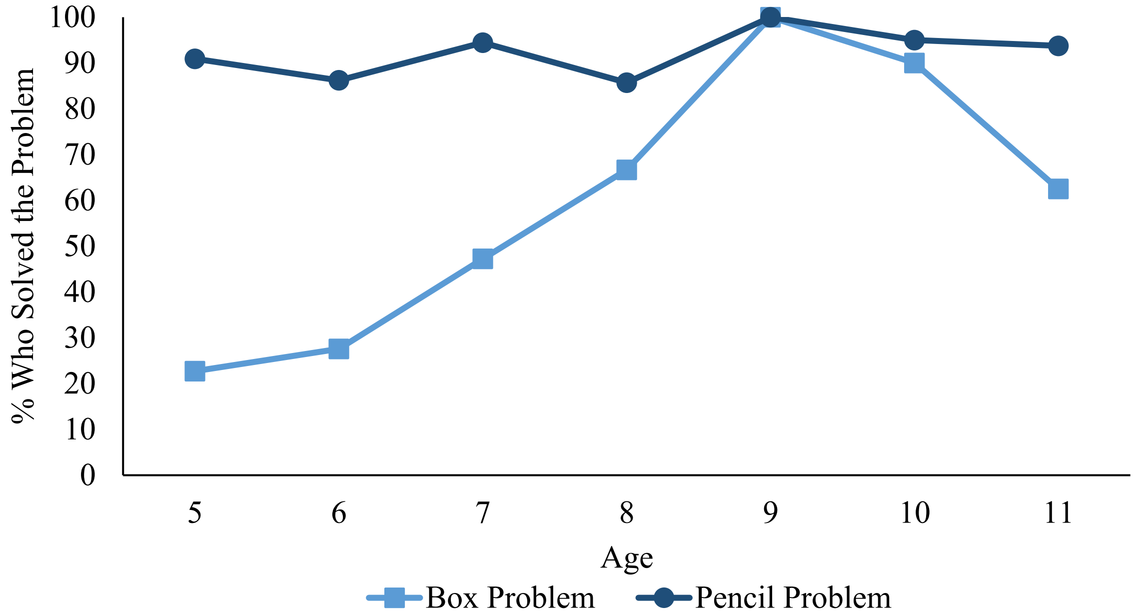

Figure 5. Graph showing percentage of children who solved the Box Problem and Pencil by selecting the target object as a function of age.

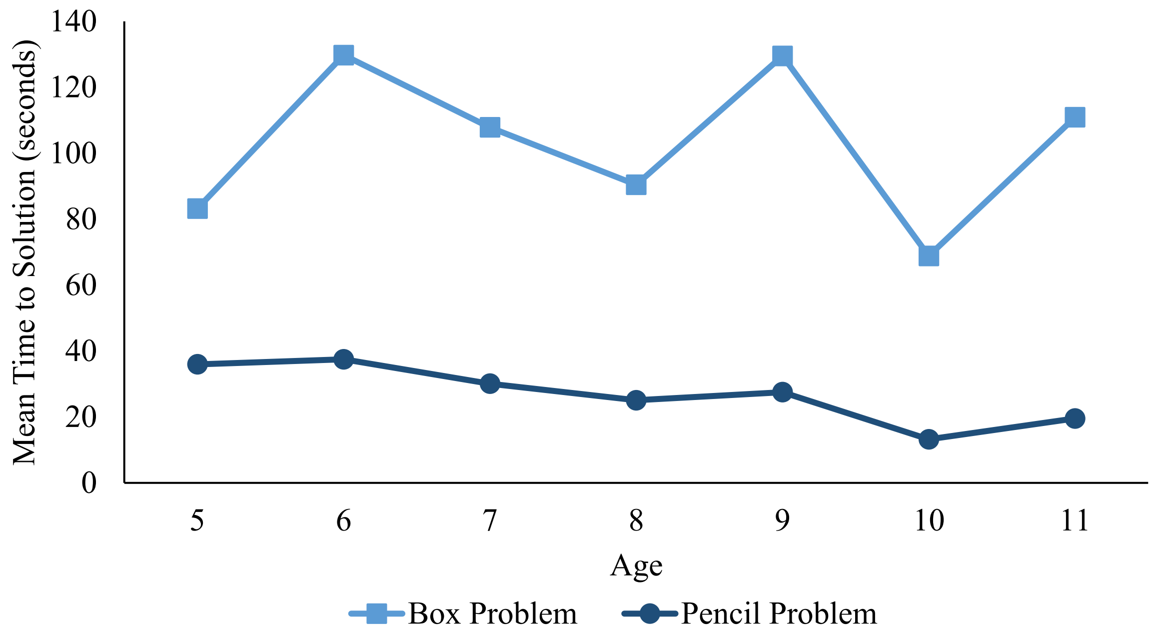

Figure 6. Graph showing mean time to solution (in seconds) as a function of age for the Box Problem and Pencil Problem.

The Association between Insight Problem Solving Ability and Cognitive Control

Correlation analysis was used to examine the relationship between insight problem solving ability and cognitive control. Results indicated a significant positive association between children's' ability to solve the Box Problem (where fail=0 and pass=1) and global switch cost RT ($r(144)= .235$, $p= .004$). No association was found between cognitive control and children's ability solve the Pencil Problem (i.e. global switch cost accuracy: $r(145)= -.052$, $p= .530$, global switch cost RT: $r(145)= .073$, $p= .382$, flanker effect accuracy: $r(145)= -.012$, $p= .890$, or flanker effect RT: $r(145)= .061$, $p= .461$), or mean latency to solve the Box Problem (i.e. global switch cost accuracy: $r(73)= -.031$, $p= .789$, global switch cost RT: $r(73)= .015$, $p= .900$, flanker effect accuracy: $r(73)= .144$, $p= .218$, or flanker effect RT: $r(73)= .068$, $p= .564$) or Pencil Problem (i.e. global switch cost accuracy: $r(133)= -.065$, $p= .457$, global switch cost RT: $r(133)= .006$, $p= .943$, flanker effect accuracy: $r(133)= .027$, $p= .758$, or flanker effect RT: $r(133)= -.055$, $p= .525$).

Predictors of Insight Problem Solving Ability

Binary logistic regression was used to examine whether age, sex, race, cognitive control, SES, and obedience (i.e. one composite score for child obedience, and two scores for values in child rearing practices based on the sociodemographic survey items 'It is very important to me that my child is obedient' and 'It is very important to me that my child is an independent thinker') predict[5] children's ability to solve the Box Problem or Pencil Problem with categorical

[5] ANOVA indicated significant differences between sites in terms of child's age ($F(10, 137)= 6.04$, $p< .001$); SES composite score ($F(10, 116)= 9.44$, $p< .001$); composite score of obedience ($F(10, 136)= 4.07$, $p< .001$); and caregivers' child rearing values, 'It is very important to me that my child is obedient' ($F(10, 132)= 11.20$, $p< .001$) and 'It is very important to me that my child is an independent thinker' ($F(10, 133)= 30.01$, $p< .001$). There were no significant differences between sites with regards to sex, race, or any of the cognitive control measures (i.e. global switch cost RT, global switch cost accuracy, flanker effect RT, and flanker effect accuracy). Site was excluded as a potential predictor or covariate in the analyses throughout because of a lack of adequate sample size across each site, but differences across sites are reflected in predictor variables of SES and obedience.

outcome variables being 'pass' or 'fail.' For the Box Problem, the logistic regression model was statistically significant ($\chi^2(16) = 37.41$, $p= .002$). The model explained 35.7% (Nagelkerke R^2) of the variance in children's ability to solve the Box Problem and correctly classified 74.2% of cases. Age was the only predictor to add significantly to the model ($\beta= .402$, SE= .132, Wald= 9.236, $p= .002$). Thus, for each additional year in age, the likelihood of solving the Box Problem increases by a factor of 1.495. Figure 7 illustrates the significant relationship between age and children's ability to solve the Box Problem. For the Pencil Problem, the model was not significant ($\chi^2(16) = 14.67$, $p= .549$), nor were any of the variables in the equation; this is most likely due to a ceiling effect given that 92% of all children who attempted the Pencil Problem were able to solve it.

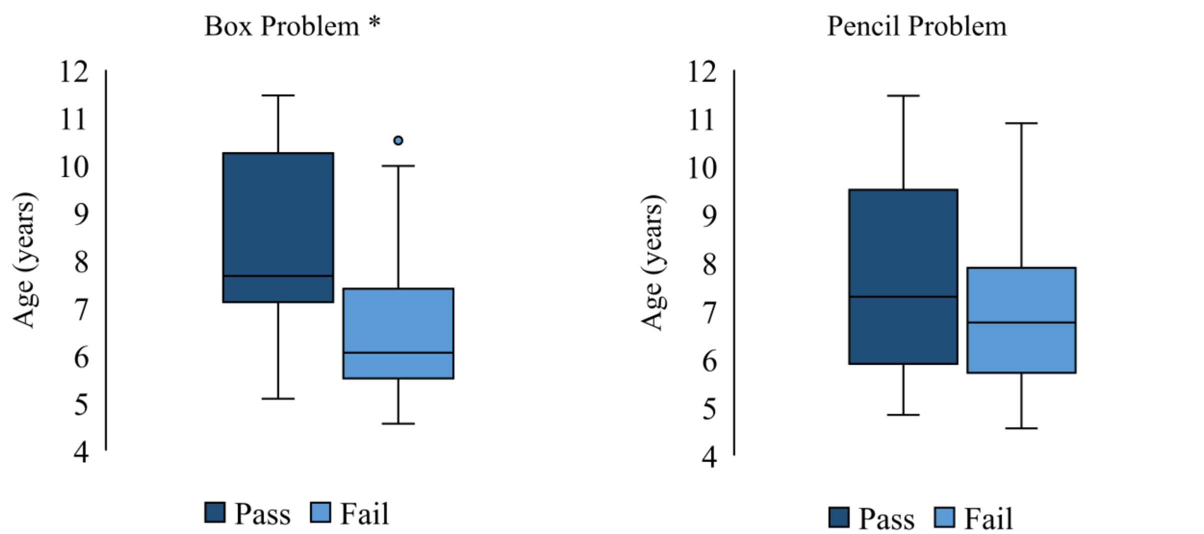

Figure 7. Boxplots showing age and children's ability to solve the Box Problem and Pencil Problem. *$p= .002$

Stepwise multiple linear regressions were performed to evaluate whether age, sex, race, cognitive control, SES, and obedience predict children's mean latency to solution for the Box Problem or Pencil Problem. Neither of the regression models nor any of the variables examined significantly predicted how long it took for a child to solve the Box Problem ($F(11, 50) = .404$, $p = .948$) or the Pencil Problem ($F(11, 104) = .705$, $p = .705$).

A sensitivity analysis for linear multiple regression was performed with the sample sizes for the insight problem solving tasks and 11 predictor variables (G*Power 3.1; Faul, Erdfelder, Buchner, & Lang, 2009). Results revealed that this study was adequately powered to detect a medium effect size ($f^2 = .125$ for $N_{\text{Box Problem}} = 145$; $f^2 = .123$ for $N_{\text{Pencil Problem}} = 147$) with power of 80%.

Discussion

The hypothesis of the present study was that LSES children, because of their documented deficits in cognitive control, would outperform children of higher SES given that studies have shown that limited cognitive control can benefit insight problem solving ability. No effect of SES on insight problem solving ability was found, which might be accounted for by the fact that no effect of SES on cognitive control was found in the present study. In this study, SES was determined by considering commonly used criteria such parental education, occupation, and income; moderate to strong intercorrelations were found between these SES indices for the parents' of the children who participate in this study. A meta-analysis conducted by Wong and Edwards (2013) found that maternal educational level is most consistently associated with cognitive outcomes such that children of mothers with less than a high school diploma tend to show a range of cognitive deficits. In the present study, 89 percent of the parents who completed the sociodemographic questionnaire identified themselves as the child's mother, and 29 percent of the parents indicated that they had a high school diploma or less (43 percent of the parents had less than a college education, while 52 percent had attained a bachelor's degree or higher). Despite the distribution in SES of the sample of children who participated in this study, no effect of SES was found on measures of children's cognitive control which may reflect the quality of education that the children were receiving from their respective schools and/or by the fact that 43 percent of the children in this study spoke more than one language other than English. Engel de Abrea et al. (2012) compared the effects of bilingualism on executive functioning in LSES and HSES 12 year olds, and found that regardless of SES, bilinguals performed significantly better than monolinguals on tests of selective attention and interference suppression. Furthermore, Brod, Bunge, and Shing (2017) compared the executive functioning of 5-year-olds born close to the cutoff date for entry into first grade; the 5-year-olds whose birthdates qualified them to enter first grade (which is more instruction oriented) outperformed the 5-year-olds who remained in kindergarten (which is more play-based) on tests of sustained attention, which illustrates the importance of formal schooling on the development of cognitive control.

Though no effect of SES on cognitive control or insight problems solving was found in the present study, an effect of age on insight problems solving was found – but in the opposite direction to what was hypothesized. The key finding from the present study is that as children grow older they are more likely to demonstrate immunity to functional fixedness. Results showed that when sex, race, SES, cognitive control, and obedience were accounted for, older children were better able than younger children to solve the Box Problem. Furthermore, even though younger and older children were equally as likely to solve the Pencil Problem, older children were still able to solve the Pencil Problem significantly faster than younger children. Despite the fact the Box Problem and Pencil Problem used in this study were adopted from German and Defeyter's (2000) and Defeyter and German's (2003) studies, respectively, the findings from the study presented here contradict their findings that younger children are better than older children at solving problems requiring insight. Though the tasks used in the present study were not exact replicas of the tasks used in German and Defeyter's (2000) and Defeyter and German's (2003) studies (i.e. some of the distractor items differed between the versions of the tasks used across studies: for the Box Problem, German and Defeyter (2000) included *four wooden blocks*, a pencil, a ball, *a small flat magnet*, a small toy car, and a coin, while the Box Problem used in the present study included only two wooden blocks, a pencil, a small toy car, a coin, *a small eraser*, *a rubber band*, and *a small binder clip*; the only difference between Defeyter and German's (2003) version of the Pencil Problem and the one used in the present study was that while they included a ruler as one of the distractor items, we included a protractor), the minor differences in some of the items used across studies does not offer a sufficient explanation for why the findings of the present study challenge previous findings. A more notable difference between studies are the sample sizes that were used to assess performance on the insight problem solving tasks; while only 30 children completed the Box Problem in German and Defeyter's (2000) study, the present study included almost five times as many participants (i.e. 145 children) for this task, and Defeyter and German's (2003) study of the Pencil Problem included 120 children, while the present study included 147 children for this task. The larger sample sizes and thus power of the present study – especially for the Box Problem – provide support for the results found here.

German and Defeyter (2000) and Defeyter and German (2003) assert that their findings support the notion that younger children's conceptions of an object's function are more fluid and flexible than that of older children thus making younger children better able to reason about an object's atypical functions (German & Johnson, 2002). However, the findings from the present study suggest the opposite – that younger children may possess a more narrow criteria for how an object can be used, and that with increasing age, experience and more opportunities to observe others use objects in inventive ways to solve problems, older children are more apt at imagining novel purposes for objects. Developmental research examining children's tool use has shown that young children are poor at tool innovation – defined as a capacity for constructing new tools, or using old tools in new ways, to solve problems (Nielsen, Tomaselli, Mushin, & Whiten, 2014). For example, Beck, Apperly, Chappell, Gutherie, and Cutting (2011) found that while only 50 percent of 8-year olds could generate a solution for how to retrieve a small bucket with a sticker inside of it from inside a plastic bottle by bending a pipecleaner to create a hook tool, the vast majority of younger children failed the task. In two other studies, children were even given the opportunity to practice bending pipecleaners to become familiar with their pliable property, but they still were unable to successfully use the pipecleaners to solve a problem in a subsequent tool-making task (Beck et al., 2011; Cutting et al., 2011). Success on this task does improve with age such that 9- and 10-years olds are able to solve the problem (Beck et al., 2011). These findings suggest that children's difficulty with tool innovation is not merely the result of their limited knowledge of the properties of materials.

Another reason for children's difficulty with tool innovation may be that younger children are less capable of managing the ill-structured nature of tool innovation problems (as well as object-based insight problem solving problem tasks). Ill-structured problems are tasks that are missing information from its start state, goal state, or information about the transformation that is needed to go from the start state to the goal state (Goel & Grafman, 2000; Wood, 1983). To investigate this alternative explanation for children's difficulty with tool innovation, Cutting, Apperly, Chappell, & Beck (2014) tested 4- to 6-year olds using the same bucket and pipecleaner set-up described above. They found that older children were able to use the pipecleaner to solve the problem only if they had a chance to manipulate the materials during a practice trial and after they were shown a ready-made pipecleaner hook (but were not shown how to make it); despite this information, younger children were still unable to solve the problem. Their findings suggest that for younger children, the main difficulty with tool innovation is in retrieving relevant information from memory (i.e. pipecleaners are pliable) and coordinating that information as a useful solution to the problem (i.e. hooked pipecleaners can be used to grasp the handle of a bucket).

In the current study, results showed that with age, children's cognitive control improved (i.e. a positive association was found between age and overall accuracy and overall RT on the Flanker/reverse Flanker task). However, older children who were able to solve the Box Problem also spent significantly more time selecting correct responses on the Mixed Flanker than did younger children who solved the Box Problem. While this appears to suggest that older children demonstrated poorer cognitive flexibility than younger children did, this finding may also indicate that as children get older, they exhibit greater interference because heightened working memory and focused attention, which in turn could make task-irrelevant rules (i.e. focusing on the middle fish, instead of the flanker fish, when pink fish are presented in the Mixed Flanker) more salient and distracting, and thus more challenging to ignore. Therefore, as suggested by Cutting et al. (2014), older children in the present study may have performed significantly better on the insight problem solving tasks because of their enhanced ability, compared to younger children, to retrieve relevant knowledge from memory and recognize the utility of that information as a solution to the problem. Though numerous studies have found that impaired cognitive control results in heightened insight problem solving ability that research has focused almost exclusively on adult populations. The findings of the current study suggest that children's successful tool innovation with age may be attributed to increased exposure to the many ways in which an object may be used as a tool to solve a problem. Thus, being in a state of diffuse attention with diminished inhibition may only help to arrive at a solution using insight if one has had sufficient prior experience (personal or via observation) using objects for atypical functions.

It is possible that the children included in the present study did not serve as an accurate representation of LSES children because of confounds previously discussed (i.e. the bilingual advantage and high quality formal schooling). Therefore, future studies should seek to replicate this paradigm with more SES divergent samples to test the hypothesis that poverty and thus low cognitive control may benefit insight problem solving in children. Given what research has shown about the effects of low cognitive control on insight problem solving – albeit mainly in adult populations, researchers should consider poverty not only in terms of deleterious effects but also in terms of its potential to lead to compensatory strengths in creative thinking. Such research would have important social implications.

Understanding potential strengths that children may develop as a result of living in poverty could lead to educational programs to foster these positive abilities, thus improving academic and consequent socioemotional outcomes for our most disenfranchised students. Such understanding could also help to keep low-income students from being assigned unjustly to special education or low academic tracks. However, there has been far more focus on strengthening deficits in children at risk than in enhancing their creativity. The Organisation for Economic Cooperation and Development (OECD, 2014), United Nations Educational, Scientific and Cultural Organization (Scott, 2015), and Partnership for 21st Century Skills (Plucker, Kaufman, & Beghetto, n.d.) have identified creativity and innovation in problem-solving as fundamental employability skills. Considering that corporate executives and public sector leaders worldwide cite creativity as the most important leadership quality for success in business (IBM

Institute for Business Value, 2016), support for the proposed theory could have far reaching effects with regards to closing equity and academic achievement gaps between the rich and poor.

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Appendix A

Sociodemographic Questionnaire

This questionnaire should be completed by the primary caregiver of the child named below (i.e., the adult who assumes the most responsibility in caring for the health and well-being of the child). The items on this questionnaire ask about the child's medical history and behavior as well as the primary caregiver's education, occupation, and household income. Your responses on this questionnaire will remain fully confidential and will not be disclosed to anyone other than the principal investigator of this study. Please respond as accurately and honestly as possible. Thank you!

Due to the nature of this study, children with a history of severe head injury, low birth-weight (<1500 grams or 3.31 lbs.), prenatal exposure to drugs, Fetal Alcohol Syndrome (FAS), mild or severe intellectual disability, or Autism Spectrum Disorder, are not eligible to participate.

Child's full name: ____

Child's date of birth (mm/dd/yyyy): __________/__________/____________

Question 1. Are you the child's primary caregiver?

____ Yes

____ No

Question 2. What is your relation to the child?

____ Mother

____ Father

____ Legal guardian

Question 3. Is the child being raised:

____ By both of his/her parents

____ In a single-parent household

Question 4. Please indicate your child's race/ethnicity.

____ White

____ African American/Black

____ Asian

____ American Indian/Alaskan Native

____ Native Hawaiian/Pacific Islander

____ Hispanic/Latino

____ Mixed race (please specify: ____)

____ Other (please specify: ____)

Question 5a. Does your child speak a language other than English at home?

______Yes (please specify: ____)

______No, only English

Question 5b. Is your child's preferred language English?

______Yes

______No

CHILD'S BEHAVIOR

Question 6. Please read the statements below, and then consider how much you agree with each statement. Indicate your rating by circling the most suitable number.

'It is very important to me that my child is obedient'

(1) (2) (3) (4) (5) (6) (7) (8) (9)

I strongly disagree	I disagree	I am undecided	I agree	I strongly agree

'It is very important to me that my child is an independent thinker'

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I strongly disagree		I disagree		I am undecided		I agree		I strongly agree

'My child generally does everything that I tell him/her to do.'

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I strongly disagree		I disagree		I am undecided		I agree		I strongly agree

'My child is generally well behaved.'

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I strongly disagree		I disagree		I am undecided		I agree		I strongly agree

CHILD'S MEDICAL HISTORY

Question 7. Has the child ever been diagnosed with any of the following?

(Please check all that apply)

______Attention Deficit Hyperactivity Disorder

______Autism Spectrum Disorder

______Learning disability (please specify: ____)

______Intellectual disability (please specify: ______________________________________)

______History of severe head injury

______Low birth-weight (<1500 grams or 3.31 lbs.)

______Prenatal exposure to drugs

______Fetal Alcohol Syndrome (FAS)

______Other neurological or psychiatric condition (please specify: ______________________)

Question 8. If your child has ever taken medication for ADHD, please indicate the name of the medication and the most recent date of consumption?

Medication:

______Ritalin / Metadate / Concerta / Adderall / Dexedrin

______'I don't remember the specific name of the ADHD medication'

______Other (please specify: ____)

Most recent date of consumption (mm/dd/yyyy): __________/__________/____________

PRIMARY CAREGIVER'S EDUCATION

Question 9. What is the highest degree that you have earned?

_____ High school diploma or equivalency (GED)

_____ Associate degree (junior college)

_____ Bachelor's degree

_____ Master's degree

_____ Doctorate

_____ Professional (MD, JD, DDS, etc.)

_____ Other (please specify: ____)

_____ None of the above (less than high school)

PRIMARY CAREGIVER’S OCCUPATION

Question 10. Which of the following best describes your current main daily activities and/or responsibilities? (Please check all that apply)

______Working full time

______Working part-time

______Unemployed or laid off

______Looking for work

______Keeping house or raising children full-time

______Retired

Question 11. With regards to your current or most recent job activity:

a. In what kind of business or industry do (did) you work?

____

(For example: hospital, newspaper publishing, mail order house, auto engine manufacturing, breakfast cereal manufacturing.)

b. What kind of work do (did) you do? (Job Title)

____

(For example: registered nurse, personnel manager, supervisor of order department, gasoline engine assembler, grinder operator.)

HOUSEHOLD INCOME

Question 12. What was your current zip code? ___________________________________

Question 13. Which of these categories best describes your total combined family income for the past 12 months?

This should include income (before taxes) from all sources, wages, rent from properties, social security, disability and/or veteran's benefits, unemployment benefits, workman's compensation, help from relatives (including child support payments and alimony), and so on.

______Less than $5,000

______$5,000 through $11,999

______$12,000 through $15,999

______$16,000 through $24,999

______$25,000 through $34,999

______$35,000 through $49,999

______$50,000 through $74,999

______$75,000 through $99,999

______$100,000 and greater

______No response

Question 14. How many people are currently living in your household, including yourself?

______Number of people

______Of these people, how many are children?

______Of these people, how many are adults?

______Of the adults, how many bring income into the household?

Appendix B

Distribution of Primary Caregiver's Highest Education Attained, Occupational Prestige, and Household Income for Each Research Site

Table B1

Research Site Key for Figures B1, B2 and B3

Research Site	Type of Site
1	Affordable housing community
2	After school program (tuition-free)
3	Charter school
4	Charter school
5	Charter school
6	Charter school
7	Daycare center ($299 per week)
8	Daycare center ($633 per week)
9	Private school ($8,400 per academic year)
10	Summer camp ($1,270 per two weeks)
11	Summer camp ($456 per month)

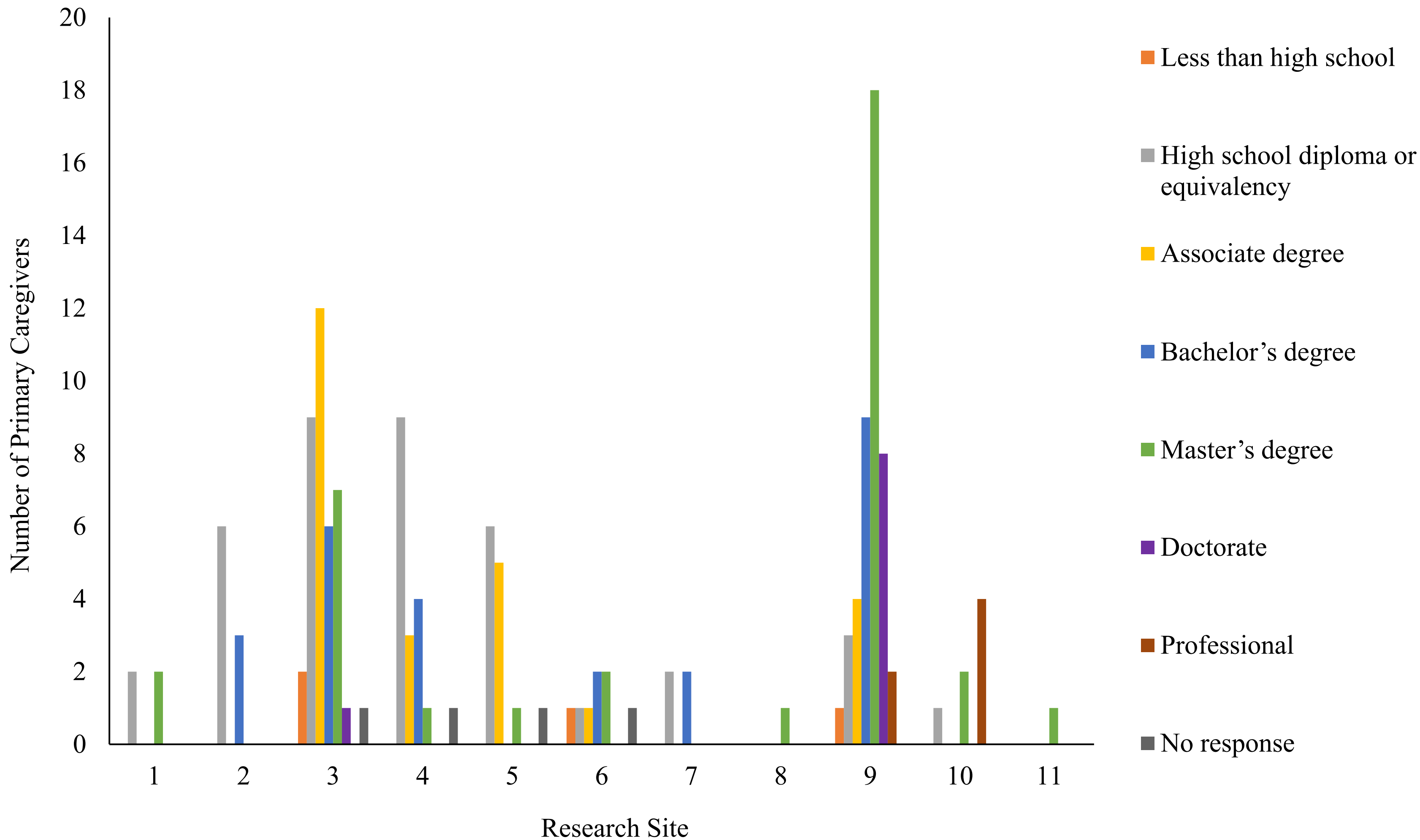

Figure B1. Distribution of primary caregivers' highest education attainment by research site.

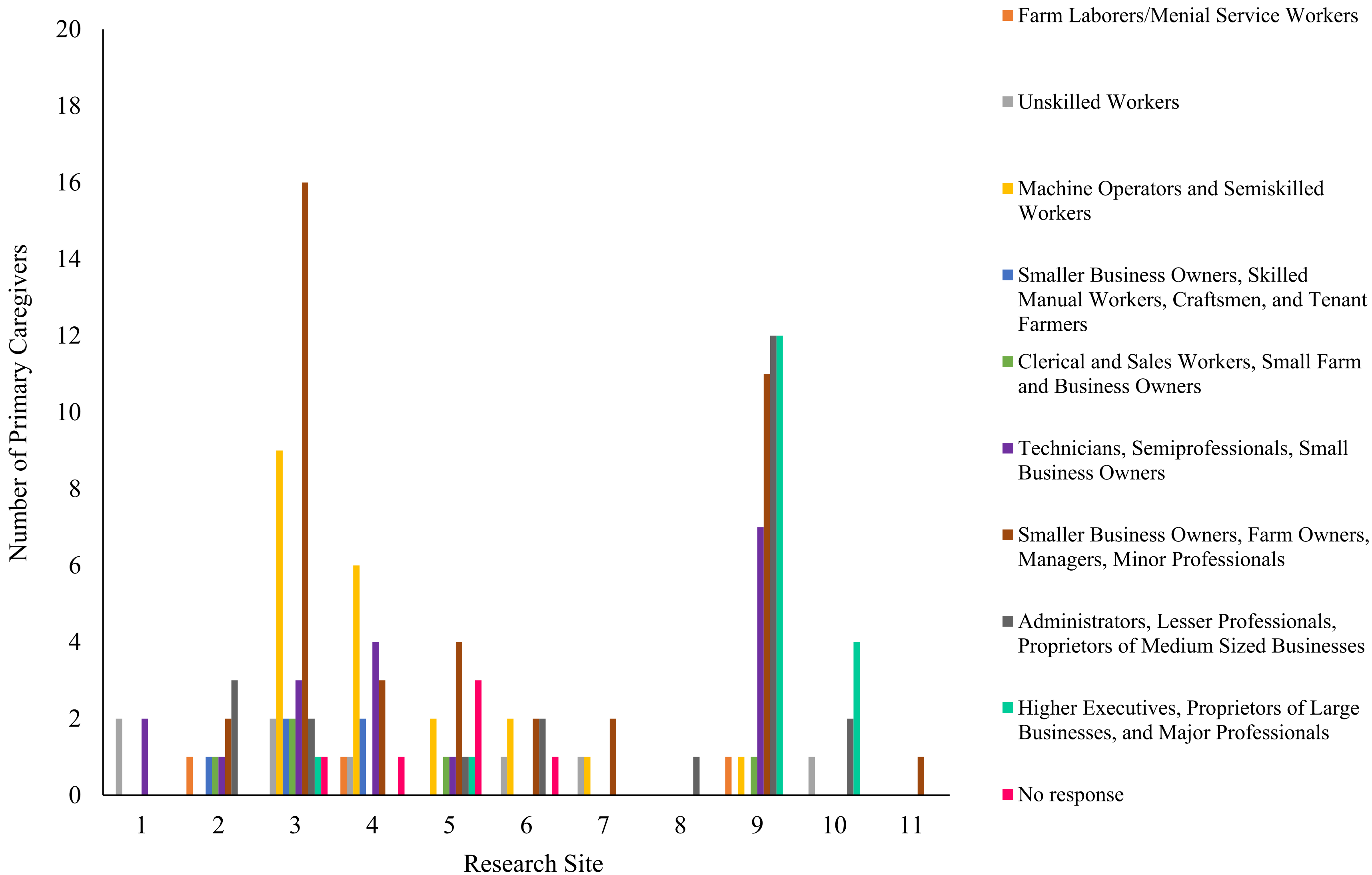

Figure B2. Distribution of primary caregivers' occupational prestige by research site.

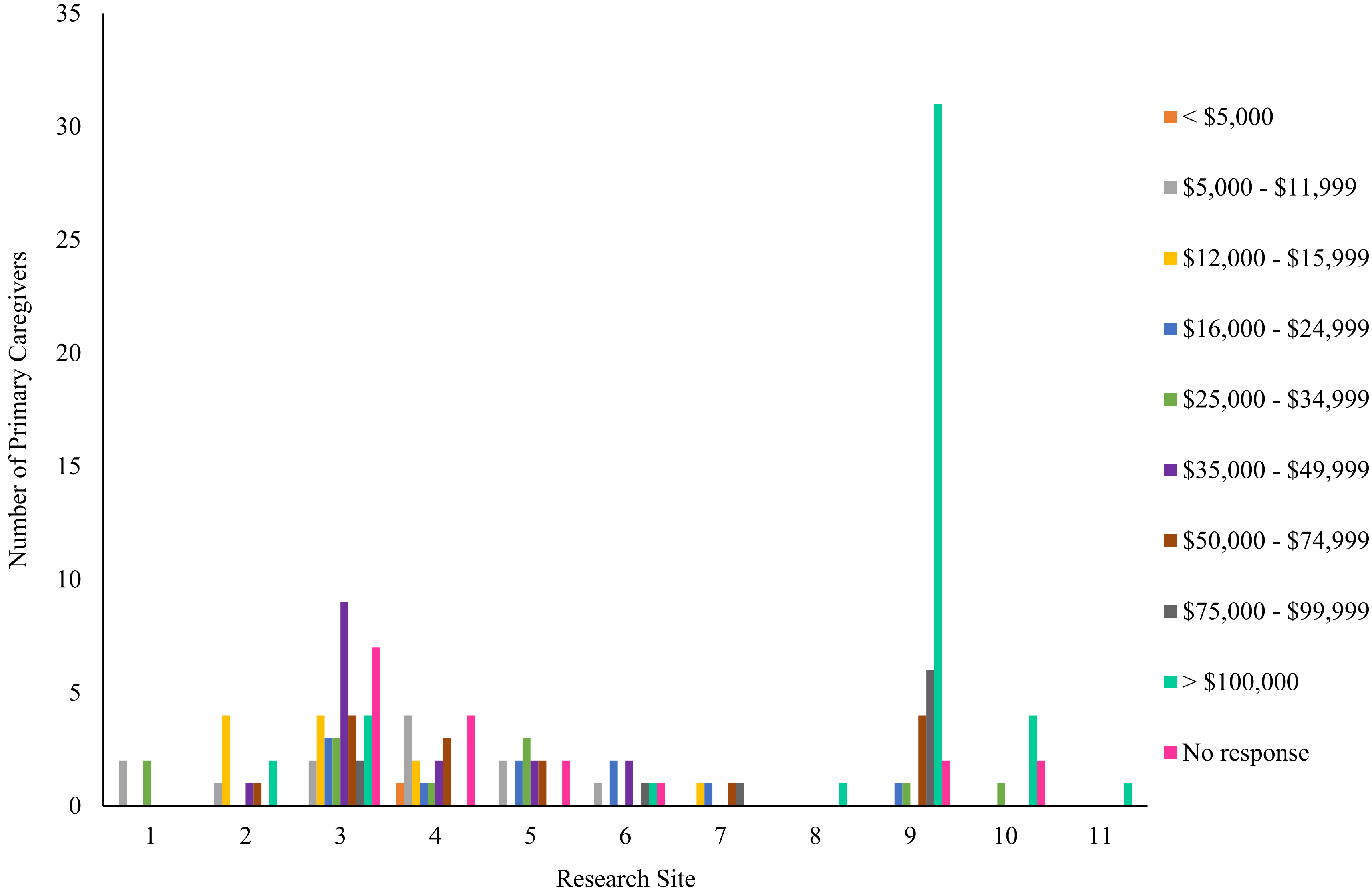

Figure B3. Distribution of primary caregivers' household income by research site.

Appendix C

Table C1

Percentage of Child Participants Being Raised by Either a Single Parent or Both Parents by the Child's Race/Ethnicity

		Percentage of Children Being Raised By:	
Child's Race/Ethnicity	*n*	Single Parent	Both Parents
African American / Black	63	51	49
American Indian / Alaskan Native	1	0	100
Asian	4	0	100
Caucasian / White	30	0	100
Hispanic / Latino	14	50	50
Mixed Race	31	42	58
Native Hawaiian / Pacific Islander	1	0	100
Other	1	100	0

Notes: N= 145. Whether the child was being raised by either a single parent or both parents was not reported on the sociodemographic questionnaire for three of the African American / Black children.