Published in final edited form as:
J Cogn Dev. 2011 ; 12(1): 103–119. doi:10.1080/15248372.2010.535229.

Motivational Influences on Cognitive Performance in Children: Focus Over Fit[a]

Darrell A. Worthy[1,2], **Caitlin C. Brez**[3,*], **Arthur B. Markman**[1], and **W. Todd Maddox**[1]

[1] The University of Texas at Austin

[2] Texas A&M University

[3] The University of Kansas

Abstract

Cognitive psychologists have begun to address how motivational factors influence adults' performance on cognitive tasks. However, little research has examined how different motivational factors interact with one another to affect behavior across the lifespan. The current study examined how children perform on a classification task when placed in a regulatory fit or mismatch. Nine-year-old children performed a classification task in which they either gained or lost points for each response. Additionally, children were given either a global promotion focus (trying to earn a gift card) or a prevention focus (trying to avoid losing a gift card). Previous work indicates that adults in this task tend to perform better when there is a match (or *fit*) between the overall incentive to earn or avoid losing the incentive and the task reward structure to maximize points gained or minimize points lost. Unlike adults, nine-year-olds perform better in the promotion condition than in the prevention condition regardless of task reward structure. Possible explanations for the differences between adults' and children's performance are discussed as well as possible applications for academic settings.

Motivation is a crucial determinant of action, and as a result it has been an important focus of psychological research (*e.g.* Higgins, 2000; Deci, 1971). Recently, cognitive psychologists have begun to investigate the impact of motivational incentives on cognitive performance (Higgins, 2000; Shah, Higgins, & Friedman, 1998; Maddox, Baldwin, & Markman, 2006; Grimm, Markman, Maddox, & Baldwin, 2008; Worthy, Maddox, & Markman, 2007; Maddox & Markman, 2010). This research has been conducted primarily using young adults as participants. In the current work we examine the effect of motivational incentives on children. A focus on children is important both for its implications for basic research as well as for its implications for academic situations. Children's cognitive performance is evaluated on a daily basis at school. Like adults, children are given incentives to perform their best in a variety of situations. Information about how children react to these motivational factors will be valuable in understanding how to structure classroom and testing environments to maximize students' performance (e.g. Grimm, Markman, Maddox, & Baldwin, 2009).

[a]This research was supported by NIMH grant MH077708 to WTM and ABM, and a supplement to NIMH grant MH077708 to DAW. We thank members of the motivation research group at the University of Texas at Austin for valuable discussions and comments, and the MaddoxLab RAs for help with data collection.

Correspondence should be addressed to: Darrell A. Worthy now at the Department of Psychology, Texas A&M, worthyda@tamu.edu or W. Todd Maddox, Department of Psychology, Institute for Neuroscience, Center for Perceptual Systems, University of Texas, maddox@psy.utexas.edu.
*The first two authors contributed equally to this work.

A core distinction in the motivational literature is the one between *approach* and *avoidance* goals (Lewin, 1935; Markman & Brendl, 2000; and Miller, 1959). Approach goals are situations in which someone is working towards a desirable end state (*e.g.* cash bonus, new car, praise from a teacher); whereas avoidance goals are situations in which someone is trying to prevent an undesirable end state (*e.g.* being fired, car accident, discipline from a teacher). Higgins' (1987 Higgins' (1997) regulatory focus theory proposes that individuals also develop psychological states of readiness, or regulatory foci, when pursuing goals. A person in a *promotion focus* is particularly sensitive to gains in the environment and will, therefore, typically approach positive end states. In contrast, a person in a *prevention focus* is particularly sensitive to losses in the environment and will work to avoid negative end states. The promotion/prevention focus distinction is orthogonal to the approach/avoidance distinction. For example, two people may share an approach goal of earning a prize for good performance. One of them may regulate toward the goal in an eager, gain-promotion manner, while the other may regulate toward earning the prize in a vigilant, loss prevention manner. Thus regulatory focus theory distinguishes between two different orientations toward goal pursuit.

Recent laboratory work has shown that regulatory focus can be situationally induced (e.g. Forster & Higgins, 2005; Maddox et al., 2006; Grimm et al., 2008; Worthy et al., 2007). Studies conducted in our labs have employed a raffle ticket manipulation to manipulate regulatory focus situationally. Participants induced into a promotion focus had the opportunity to earn a ticket into the raffle by reaching a certain performance criterion. Participants induced into a prevention focus were given a ticket before the start of the experiment and had to avoid losing the ticket by reaching the performance criterion. Thus, the overall goal is the same--to achieve an entry into the raffle--but the way in which participants regulate toward this goal is manipulated experimentally. This method offers an excellent way to examine how regulatory focus can influence behavior.

Another motivational factor to consider, in addition to the global regulatory focus, is the local manner of goal pursuit used as one is working toward achieving a goal. For example, individuals can go about attaining a goal by repeatedly gaining points and attempting to maximize cumulative gains, or by repeatedly losing points and attempting to minimize cumulative losses. The interaction between one's global regulatory focus and the manner of goal pursuit influences the degree of *regulatory fit* experienced when performing the task. When there is a fit between one's regulatory focus and the reward structure (*i.e.* promotion focus and gains reward structure *or* prevention focus and losses reward structure), people tend to experience a feeling of ease (e.g Higgins 2000). A fit can lead people to feel more confident about their choices in a task or to experience more positive feelings regarding the outcome of a decision (Aaker & Lee, 2006). A regulatory fit has also been shown to increase motivational strength and engagement (Spiegel, Grant-Pillow, & Higgins, 2004; Higgins, 2000). The increased feeling of ease, motivational strength, and engagement can lead to better performance on tasks that are cognitively demanding. For example, Shah et al. (2006) gave participants an anagram task in which they could choose anagrams that yielded points (gains) or ones that lost points. Participants in a promotion focus were more likely to choose the anagrams that gained points whereas participants in a prevention focus were more likely to choose the anagrams that lost points. Similar results have been observed in rule-based classification tasks (Maddox, et al., 2006; Grimm et al., 2008).

Motivation and Children

There is an extensive literature on children's motivation. Many of these studies focus primarily on achievement motivation and the types of goals that are most likely to motivate children's performance in school (Elliott & Dweck, 1988; Smiley & Dweck, 1994; Mueller & Dweck, 1998). One distinction that is prevalent in the literature is the distinction between mastery and performance goals. Mastery goal orientations emphasize the development of overall competence over the attainment of external rewards. In contrast, performance goals emphasize the attainment of positive outcomes and peer judgments and the avoidance of negative ones. The distinction between mastery and performance goals centers on how children approach the learning process. Often children are classified as being predisposed toward either a mastery or performance orientation. A main finding of this work is that mastery goals are more conducive to learning than performance goals (e.g. Elliot & Dweck, 1988; Mueller & Dweck, 1998). Performance goals have been found to increase the tendency for children to develop a learned helplessness response when faced with difficult problems.

The distinction between motivation and performance goals is qualitatively different than the distinction between promotion and prevention foci engaged in goal pursuit. In the raffle-ticket manipulation presented above, participants are essentially given a performance goal of earning an entry into the drawing. Elliot and colleagues make such a distinction between performance –approach and performance-avoidance goals with mastery goals being considered separately (e.g. Elliot, 1999).

Children are given performance goal situations quite often. Standardized testing has become routine in primary and secondary education. This environment is likely to induce a situational performance goal, because it is unlikely that many students view a standardized test as something that can be mastered for their own intrinsic benefit. Students likely view many testing situations as compulsory events in which they must achieve a certain criterion in order to gain positive outcomes and avoid negative ones. Further, students likely regulate toward the goal of successfully completing the test in a manner that is consistent with either a promotion or prevention regulatory focus. For this reason it is important to examine the way different regulatory foci toward achieving performance goals affect learning in children.

There is some reason to believe that elementary school children will not be affected by manipulations in the same way as adults. In adults, it is the regulatory *fit* between global regulatory foci and the local reward structure of the task that influences performance. Adults in a regulatory fit tend to perform well on tasks that require the specific application of rules and the exploration of a variety of rule-based hypotheses due to increases in task engagement that results from a regulatory fit. These same effects might be predicted for children. However, many of the brain regions associated with a regulatory fit, such as the anterior and posterior cingulate cortices, and the amygdala (Touryan et al., 2007; Cunningham, Raye, & Johnson, 2005) do not fully develop until after adolescence (Cunningham, Bhattacharyya, & Benes, 2002; Ernst, Pine, & Hardin, 2005; Eshel, Nelson, Blair, Pine, & Ernst, 2006). Nine-year-olds were selected for participation in the present study because they were old enough to follow directions in order to complete the task (Kaplan & White, 1980), but young enough that many of the structures shown to be activated by a regulatory fit have not fully developed (Cunningham et al., 2002; Casey et al., 2002; Eshel et al., 2006). The immaturity of these areas that process a regulatory fit raises the possibility that the global regulatory foci or the reward structure (rather than their interaction) may have a larger impact on performance than the interaction between these factors.

If regulatory fit (which is an interaction between regulatory focus and the reward structure of the task) does not predict children's performance, then it is likely that children will exhibit a main effect of either regulatory fit or reward structure (or both). A model of motivation in adolescence suggests that adolescents have a strong approach-based reward system, but a weak avoidant system (e.g. Ernst et al., 2005). While nine-year-old children are not yet adolescents, it is possible that they will be more responsive to and engaged by the promotion focus manipulation than the prevention focus manipulation because a promotion focus offers the opportunity to approach a positive outcome. A straightforward prediction from this view is that participants in the promotion focus condition will outperform participants in the prevention focus condition.

Alternatively, there could be a main effect of reward structure. Children probably have more experience maximizing gains than minimizing losses, so it is possible that confusion from receiving losses will hinder their ability to find the correct rule. Work from the behavioral economics literature suggests that adults are risk averse when presented with options involving potential gains, but more risk-seeking when presented with options involving potential losses (e.g., Kahneman & Tversky, 1979; Tom, Fox, Trepel, & Poldrack, 2007). Risk seeking for losses is supposed to reflect that people feel the sting of a loss of a given magnitude more strongly than the feel the joy of a gain of the same magnitude. Increased risk-seeking behavior could translate to increased use of a variety of rules, and could thus predict better performance with losses than with gains. However, previous work in young adults found no differences in performance based on reward structure (e.g. Maddox et al., 2006).[b] There is also evidence that children process gains and losses in the same way and that the tendencies toward risk-seeking or risk-aversion do not develop until adulthood (e.g. Reyna & Ellis, 1994). For this reason we predict that if there is regulatory fit interaction, then the induced regulatory focus is more likely to influence performance than the reward structure of the task.

In this study, we adopted the same classification task used to study motivation in adults in order to examine how motivation affects learning and behavior in nine-year old children. Previous research demonstrates that children successfully complete perceptual classification tasks when the stimuli are unidimensional or the rules are easily verbalizable as in the current task (Minda, Desroches, & Church, 2008). Category-learning tasks are useful for examining the influence of motivation on cognition and behavior. In a typical classification task, participants place simple stimuli into one of a small number of categories. At the start of the study, they have no prior experience with the items. An important reason for employing classification tasks is that there are mathematical models that can be fit to the data from individual participants in each block of the task to assess the strategy being used in that block. Thus, classification allows us to take a poorly understood phenomenon (like motivation) and place it in a well-understood experimental context (Markman, Beer, Grimm, Rein, & Maddox, 2009).

The same reasoning used to hypothesize that children will perform the task better in a promotion focus than in a prevention focus could also suggest that children may perform the task better with a gains reward structure than with a losses reward structure. The gains reward structure may be seen by children as a chance on each trial to approach a positive outcome. Although this is a possibility, if it is the increased engagement in the task which leads to better performance then it is likely that the global incentive manipulation of earning or keeping the gift card will have a larger impact on performance than the trial-by-trial reward structure.

[b]In the previous experiment with young adults, Maddox and colleagues (2006) analyzed the data from the gains and losses condition separately. We reanalyzed the data here to determine whether any differences based on the reward structure existed. A 2 (promotion vs. prevention) × 2 (gains vs. losses) × 12 (block) repeated measures ANOVA showed no main effect of reward structure, $F(1,115)<1$, $p>.10$. There was also no effect of regulatory focus, $F(1,115)<1$, $p>.10$. Only the regulatory focus × reward structure interaction was significant, $F(1,115)=6.55$, $p<.05$, $\eta^2=.05$.

Methods

Participants

Forty-two 9-year-olds participated in this experiment (*M* = 9;6, range = 9;2 – 9;11). An additional eight children participated, but were excluded from the analyses for the following reasons: technical problems (*n* = 6), child had a developmental delay (*n*=1), or child did not complete the task (*n* =1). Participants were randomly placed into one of four between-subjects conditions that consisted of the factorial combination of 2 Regulatory Focus (promotion vs. prevention) × 2 Reward Structure (gains vs. losses) conditions. There were 11 participants in the two losses conditions and 10 participants in each of the gains conditions. Demographic information including ethnicity and parents' education level was not collected. However, the sample was typical of most studies conducted in the Children's Research Laboratory at the University of Texas in which most children are Caucasian and most parents have at least a four-year college degree (see Tullos & Woolley, 2009). Children's and parents' names were obtained through birth records from the Texas Department of Health. Parents were sent a letter describing the study and procedure before being contacted by telephone to schedule an appointment. All children received a small toy for participating.

Stimuli

The stimuli were 576 unique lines that varied in their length, orientation, and position on the computer screen. Figure 1 shows a three-dimensional plot of the stimuli. The stimuli were evenly divided into two categories based on a conjunctive rule that separated them. The rule was: "If the line is long and steep, then it is in Category A; otherwise it is in Category B." Although using the position of the line to categorize it always led to suboptimal performance, a rule that categorized stimuli on the right side of the screen into Category A and stimuli on the left side of the screen into Category B still resulted in reasonably good accuracy (about 83%). In order to reach the bonus criterion of 90% participants had to ignore the position dimension and focus only on the length and orientation dimensions.

Procedure

Participants were tested individually in a small room with a computer. Parents were allowed to either sit in the room with their child or in a nearby waiting room. Children were informed that the task was to categorize the lines into one of two categories. Children were not provided with any additional information regarding *how* to categorize the lines, but they were told that they would learn the categories through trial-and-error. They were told to do their best to try to reach the bonus criterion (which corresponds to 90% accuracy). In the gains conditions, children received 2 points for each correct response. For each incorrect response, there was no net gain or loss (*i.e.* zero points). The point meter on the right side of the screen started at zero and slowly moved up as children accumulated points (see Figure 2a). Participants needed to accumulate 86 points in order to get the bonus criterion (corresponds to 90% accuracy). Feedback, both audio and visual, was provided after each response. For a correct response, the word "Correct" was displayed along with the sound of a cash register ("Ka-ching"). For an incorrect response, the phrase, "No, the correct category was X" was displayed along with a buzzer sound. This reward structure is identical to the experiments with adult participants.

In the losses conditions, children lost only 1 point for a correct response, but they lost 3 points for an incorrect response. These were the same reward structures used in the study that examined the effects of motivational incentives on young adults (e.g. Maddox et al., 2006). One reason for using this reward structure is that the point meter changes each time a correct response is made. If 0 points were lost for a correct response and 2 points for an incorrect response then the point meter would only change when an incorrect response was made. The point meter began at the top of the screen with 58 points and slowly moved down as participants lost points throughout the task. The goal was to minimize losses and not lose more than 58 points (bonus criterion; 90% accuracy) which would put them below the "0" mark on the point meter. Participants received the same audio and visual feedback as in gains conditions after each response. The relevant reward structure was explained in detail to each participant before the experiment began. Participants completed a total of twelve 48-trial blocks. At the end of the experiment they were given, or allowed to keep, their gift card if they reached the bonus criterion on at least one block of the experiment.

We manipulated regulatory focus by giving participants the opportunity to either earn or keep a $10 gift card. For the promotion conditions, children were told that they needed to reach the bonus on a randomly selected block in order to get a $10 gift card. They were told that they would not receive the gift card if they failed to reach the bonus. For the prevention conditions children selected which gift card they would like from a number of different options (Target, Blockbuster Video etc.) before the experiment began. The card was placed beside the computer they conducted the experiment on, and they were told that they would lose the gift card if they did not reach the bonus criterion on a randomly selected block of trials in the task. However, if they reached the bonus then they would not lose the gift card. Participants in both conditions were aware of the possibility of obtaining the gift card, including what specific gift cards were available, before the experiment began. At the end of the experiment all children were given a small toy for participating, and they were allowed to take/keep their gift card if they reached the bonus criterion.

Results

Accuracy Data

For each block of trials, participants' overall accuracy was calculated. These data are shown in Figure 3. We performed a 2 (Regulatory Focus) × 2 (Reward Structure) × 12 (Block) repeated measures ANOVA on the proportion correct in each block. There was a main effect of Block, $F(11) = 7.68$, $p < .001$, $\eta^2 = .17$, which suggests that performance improved as the task progressed. There was also a main effect of Regulatory Focus, $F(1,38) = 7.32$, $p < .01$, $\eta^2 = .16$ reflecting that participants with a promotion focus (M=.84, SD=.04) were more accurate overall than participants with a prevention focus (M=.79, SD=.06). However, there was no effect of Reward Structure, $F(1,38) < 1$, $p > .10$. Unlike what we see with adults, the interaction between Regulatory Focus and Reward Structure was not significant, $F(1,38) < 1$, $p > .10$.

Thus, the accuracy results suggest that participants in a promotion focus perform better than participants in a prevention focus. These results contrast with those found in adults performing the same task who show an interaction between regulatory focus and the reward structure of the task that led to better performance for participants in a regulatory fit (either promotion-gains, or prevention-losses conditions) compared to those performing the task in a regulatory mismatch (either promotion-losses or prevention-gains conditions).

Model-Based Analysis

Modeling Methods—While the accuracy results are informative, they tell us little about the types of strategies that participants used to solve the task. In the current task, it is important to determine which participants were using the optimal conjunctive rule, and which participants were using some other rule that led to poorer performance. To answer this question, we fit a series of decision bound models to the data (*e.g.* Maddox & Ashby, 1993). These models set a "decision-bound" along one or more of the spatial dimensions of the stimuli and classify the stimulus based on which side of the bound they fall on. A number of models are fit to the data with each model employing a different type of decision bound. For example, a “position model” can be fit that places a bound so that stimuli with positions to one side of the bound are placed in one category and those on the other side of the bound are in the other category.

We fit models to each participant’s data on a block-by-block basis. We fit unidimensional models that placed decision-bounds along the length, orientation, and position dimensions. These models had a free parameter along their relevant dimension and a parameter representing the criterial and perceptual noise. We also fit an optimal and sub-optimal version of the conjunctive model along the length and orientation dimensions. For the optimal model, the length and orientation coordinates were set so that the decision bound optimally distinguished the members of each category. This model had one free parameter that measured criterial and perceptual noise. For the sub-optimal model the length and orientation coordinates of the decision-bound were free parameters. Finally, we fit a “random-responder” model that assumed that participants were responding randomly. This model had one free parameter that represented the probability of responding “A” on any given trial.

Because the conjunctive models have more parameters than the unidimensional models, we used the AIC criterion (Akaike, 1974) to determine which model fit best during each block. The AIC criterion penalizes models for having extra parameters.

Modeling Results—We first examined the proportion of participants in each condition whose data were best fit by a conjunctive rule model in at least one block of the experiment. A total of 18 of the 21 participants performing the task in a promotion focus (8 in the gains condition and 10 in the losses condition) were best fit by the conjunctive model in at least one block ($p<.05$ by sign test), compared to only 13 of the 21 participants performing the task in a prevention focus (5 in the gains conditions and 8 in the losses condition, $p>.10$ by sign test).

We next examined the average number of blocks that were best fit by a conjunctive model for participants in each condition. This is displayed in Figure 4. A 2 (Regulatory Focus) × 2 (Reward Structure) ANOVA revealed a significant main effect of regulatory focus,, $F(1,38) = 4.87$, $p <.05$, $\eta^2=.11$. Participants who performed the task in a promotion focus (*M*=6.00, *SD*=4.34) were best fit by a conjunctive model in more blocks than participants who performed the task in a prevention focus (*M*=3.33, *SD*=3.38). The effect of reward structure (F=2.19) and the interaction between regulatory focus and reward structure (F=1.22) were not significant.

These results suggest that a promotion focus caused a higher proportion of participants to implement a conjunctive rule to solve the category-learning task. It was necessary to abandon good, but sub-optimal, unidimensional rules in order to reach the bonus criterion. Participants who performed the task in a promotion focus were more likely to use a conjunctive rule, and this led to better performance in the task.

Discussion

In these studies, we were interested in whether 9-year-olds (like adults) would be better able to learn a complex classification task when they experience a regulatory fit than when they experienced a regulatory mismatch. Unlike adults, 9-year-olds do not show an effect of regulatory fit in this classification task. Instead, 9-year-olds generally perform better in a promotion focus than in a prevention focus. Children in one of the promotion focus conditions were more accurate and their data were more likely to be best fit by a conjunctive rule-based model. This suggests that, if given a promotion focus incentive, children were more likely to explore a greater variety of rules. Previous work has similarly found that a promotion focus is associated with generating more hypotheses than a prevention focus (e.g. Liberman, Molden, Idson, & Higgins, 2001). The increased rule-use allowed them to avoid consistently using a sub-optimal unidimensional rule, and to eventually use a conjunctive rule that led to the best performance on the task.

There are neurobiological reasons why regulatory focus had a bigger impact on performance than the regulatory fit between the regulatory focus and the reward structure. Studies with adults have shown that the amygdala and cingulate cortex may be important components for processing emotional words associated with one's regulatory focus (Touryan et al, 2007 and Cunningham et al., 2005a; 2005b). These areas may be important for integrating different types of motivational factors (like global incentive foci and local reward structures) to determine if there is a regulatory fit. These areas do not fully develop until late adolescence or early adulthood (Cunningham et al., 2002, Casey et al, 2002; Eshel et al., 2006). If these regions are not fully developed, then it may not be surprising that children are only affected by regulatory focus and not a fit between regulatory focus and reward structure.

There are several possible reasons why children performed better when given a promotion focus incentive than when given a prevention focus incentive. Children who are approaching adolescence have shown a tendency to give greater weight to potential positive outcomes than potential negative outcomes (Ernst et al., 2005). This would explain the improved performance for children given a promotion focus incentive. Additionally, children may not have as much experience with prevention-type situations and therefore, may not be motivated by that manipulation. It can be argued that children's environments (school and home) are largely goal-oriented from a promotion perspective. For example, children in school are encouraged to perform well to achieve good grades, to receive praise from teachers and parents, or to get special prizes for good behavior and grades. While children clearly are presented with situations in which they attempt to avoid a negative consequence (e.g. time-out, elimination of privileges, etc), they probably experience more promotion situations. Furthermore, children's games and activities are very approach-oriented (e.g. be the fastest, get the most points).

Another reason for the promotion-focus advantage is that the prevention focus seemed to create more anxiety. Children in the prevention focus conditions knew that they would have to return the gift card if they did not reach the bonus criterion and that pressure seemed to be greater than the promotion manipulation in which children started with nothing and were trying to earn the gift card. It is certainly possible that children are not used to being in that type of situation (avoidance orientation) and that may affect children's performance in this task. While it is possible that increased anxiety is a reason for our results, it is important to note that we did not manipulate anxiety or stress; we manipulated participants' situational regulatory focus. We also did not explicitly measure anxiety or stress levels so it is difficult to tell whether participants in a prevention focus had higher levels of anxiety than participants in a promotion focus. Participants in the promotion focus condition were also in jeopardy of leaving the experiment without a gift card, so the only reason why they should be less anxious is because they prefer to regulate toward goals in a promotion focus rather than a prevention focus.

Finally, one possible reason for the difference between our results and those with young adults is the difference in the global incentive manipulation. We used a gift card as an incentive because it is possible that children do not understand the concept of a raffle. Adults had a chance to earn an entry where they had at least a 10% chance of winning $50.

Thus the expected value of the raffle ticket could be as low as $5 whereas the expected value of the gift card was $10. This could be a potential reason why we found a main effect of the global incentive focus in children and not in adults. However, the expected values for both the raffle and the gift cards were both relatively low compared to prospects that have been shown to cause loss aversion in adults. Many of the prospects given to participants in behavioral economics experiments have expected values of hundreds of dollars (e.g. Kahneman & Tversky, 1979). It is unlikely that the small difference in incentives led to the divergent findings between children and adults. This investigation is the first to address how children perform on a classification task in which they are placed in a regulatory fit. This is also the first investigation of motivational factors to apply computational models to children's data. Our approach allowed us to quantitatively specify the types of strategies children used to solve the task. While research is accumulating on how adults perform in these situations, no one has addressed the development of these motivational factors. Clearly children show a different pattern of results from adults; they perform better in a promotion focus than a prevention focus whereas adults perform best when there is a match between their regulatory focus and the reward structure of the task. While it is possible that children's academic and home environments may account for these differences, it is likely that the neurobiological systems responsible for these effects with adults are simply not fully developed in children of this age as brain development is still occurring in elementary school and throughout adolescence. We are closer to understanding what neurological systems are responsible for adults' performance in these tasks (Cunningham et al, 2005a; 2005b; Berkman & Lieberman, 2009; Touryan et al, 2007). It is equally important to investigate how these systems develop in children.

References

Aaker JL, Lee AY. Understanding regulatory fit. Journal of Marketing Research. 2006; 43:15–19.

Akaike H. A new look at the statistical model identification. IEEE Transactions on Automatic Control. 1974; 19:716–723.

Avnet T, Higgins ET. Locomotion, assessment, and regulatory fit: Value transfer from "how" to "what. Journal of Experimental Social Psychology. 2003; 39:525–530.

Avnet T, Higgins ET. How regulatory fit affects value in consumer choices and opinions. Journal of Marketing Research. 2006; 43:1–10.

Berkman ET, Lieberman MD. Approaching the bad and avoiding the good: Lateral prefrontal cortical asymmetry distinguishes between action and valence. Journal of Cognitive Neuroscience. in press.

Crowe E, Higgins ET. Regulatory focus and strategic inclinations: Promotion and prevention in decision-making. Organizational Behavior and Human Decision Processes. 1997; 69:117–132.

Cunningham MG, Bhattacharya S, Benes FM. Amygdalo-cortical sprouting continues into early adulthood: Implications for the development of normal and abnormal function during adolescence. The Journal of Comparative Neurology. 2002; 435:116–130. [PubMed: 12373778]

Cunningham WA, Espinet SD, DeYoung CG, Zelazo PD. Attitudes to the right- and left: Frontal ERP asymmetries associated with stimulus valence and processing goals. NeuroImage. 2005a; 28:827–834. [PubMed: 16039143]

Cunningham WA, Raye CL, Johnson MK. Neural correlates of evaluation associated with promotion and prevention regulatory focus. Cognitive, Affective, and Behavioral Neuroscience. 2005b; 5:202–211.

Deci EL. Effects of externally mediated rewards on intrinsic motivation. Journal of Personality and Social Psychology. 1971; 18:105–115.

Elliott ES, Dweck CS. Goals: An approach to motivation and achievement. Journal of Personality and Social Psychology. 1988; 54:5–12. [PubMed: 3346808]

Elliot AJ. Approach and avoidance motivation and achievement goals. Educational Psychologist. 1999; 34:169–189.

Eshel N, Nelson EE, Blair RJ, Pine DS, Ernst M. Neural substrates of choice selection in adults and adolescents: Development of the ventrolateral prefrontal and anterior cingulate cortices. Neuropsychologia. 2007; 45:1270–1279. [PubMed: 17118409]

Ernst M, Pine DS, Hardin M. Triadic model of the neurobiology of motivated behavior in adolescence. Psychological Medicine. 2006; 36:299–312. [PubMed: 16472412]

Förster J, Higgins ET. How global versus local perception fits regulatory focus. Psychological Science. 2005; 16:631–636. [PubMed: 16102066]

Grimm LR, Markman AB, Maddox WT, Baldwin GC. Differential effects of regulatory fit on category learning. Journal of Experimental Social Psychology. 2008; 44:920–927. [PubMed: 19412324]

Grimm LR, Markman AB, Maddox WT, Baldwin GC. Stereotype threat reinterpreted as a regulatory mismatch. Journal of Personality and Social Psychology. 2009; 96:288–304. [PubMed: 19159133]

Higgins ET. Self-discrepancy: A theory relating self and affect. Psychological Review. 1987; 94:319–340. [PubMed: 3615707]

Higgins ET. Beyond pleasure and pain. American Psychologist. 1997; 52:1280–1300. [PubMed: 9414606]

Higgins ET. Making a good decision: Value from fit. American Psychologist. 2000; 55:1217–1230. [PubMed: 11280936]

Huizenga HM, Crone EA, Jansen BJ. Decision-making in healthy children, adolescents, and adults explained by the use of increasingly complex proportional reasoning rules. Developmental Science. 2007; 10:814–825. [PubMed: 17973798]

Lewin, K. A dynamic theory of personality. New York: McGraw-Hill; 1935.

Liberman N, Molden DC, Idson LC, Higgins ET. Promotion and prevention focus on alternative hypotheses: Implications for attributional functions. Journal of Personality and Social Psychology. 2001; 80:5–18. [PubMed: 11195890]

Maddox WT, Ashby FG. Comparing decision bound and exemplar models of categorization. Perception and Psychophysics. 1993; 53:49–70. [PubMed: 8433906]

Maddox WT, Baldwin GC, Markman AB. A test of the regulatory fit hypothesis in perceptual classification learning. Memory & Cognition. 2006; 34:1377–1397.

Maddox WT, Markman AB. The motivation-cognition interface in learning and decision making. Current Directions in Psychological Science. 2010; 19:106–110. [PubMed: 20556228]

Markman AB, Beer JS, Grimm LR, Rein JR, Maddox WT. The optimal level of fuzz: Case studies in a methodology for psychological research. Journal of Experimental and Theoretical Artificial Intelligence. 2009; 21(3):197–215. [PubMed: 19756251]

Markman, AB.; Brendl, CM. The influence of goals on value and choice. In: Medin, DL., editor. The Psychology of Learning and Motivation. Vol. 39. San Diego: Academic Press; 2000. p. 97-129.

Markman AB, Maddox WT, Baldwin GC. The implications of advances in research on motivation for cognitive models. Journal of Experimental & Theoretical Artificial Intelligence. 2005; 17:371–384.

Markman AB, Maddox WT, Worthy DA. Choking and excelling under pressure. Psychological Science. 2006; 17:944–948. [PubMed: 17176424]

Miller, NE. Liberalization of basic S-R concepts: Extensions to conflict behavior, motivation, and social learning. In: Koch, S., editor. Psychology: A study of a science. General and systematic formulations, learning, and special processes. New York: McGraw-Hill; 1959. p. 196-292.

Minda JP, Desroches AS, Church BA. Learning rule-described and non- rule-described categories: A comparison of children and adults. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2008; 34:1518–1533.

Mueller CM, Dweck CS. Praise for intelligence can undermine children's motivation and performance. Journal of Personality and Social Psychology. 1998; 75:33–52. [PubMed: 9686450]

Reyna VF, Ellis SC. Fuzzy-trace theory and framing effects in children's risky decision-making. Psychological Science. 1994; 5:275–279.

Shah J, Higgins ET, Friedman RS. Performance incentives and means: How regulatory focus influences goal attainment. Journal of Personality and Social Psychology. 1998; 74:285–293. [PubMed: 9491583]

Siegler RS. Developmental sequences within and between concepts. Monographs of the Society for Research in Child Development. 1981; 46:1–84.

Smiley PA, Dweck CS. Individual differences in achievement goals among young children. Child Development. 1994; 65:1723–1743. [PubMed: 7859551]

Spiegel S, Grant-Pillow H, Higgins ET. How regulatory fit enhances motivational strength during goal pursuit. European Journal of Social Psychology. 2004; 34:39–54.

Tom SM, Fox CR, Trepel C, Poldrack RA. The neural basis of loss aversion in decision-making under risk. Science. 2007; 315:515–518. [PubMed: 17255512]

Touryan SR, Johnson MK, Mitchell KJ, Farb N, Cunningham WA, Raye CL. The influence of self-regulatory focus on encoding of, and memory for, emotional words. Social Neuroscience. 2007; 2:14–27. [PubMed: 18633804]

Tullos A, Woolley JD. The development of children's ability to use evidence to infer reality status. Child Development. 2009; 80:101–114. [PubMed: 19236395]

Worthy DA, Maddox WT, Markman AB. Regulatory fit effects in a choice task. Psychonomic Bulletin and Review. 2007; 14:1125–1132. [PubMed: 18229485]

Worthy DA, Markman AB, Maddox WT. What is pressure? Evidence for social pressure as a type of regulatory focus. Psychonomic Bulletin and Review. 2009A; 16:344–349. [PubMed: 19293105]

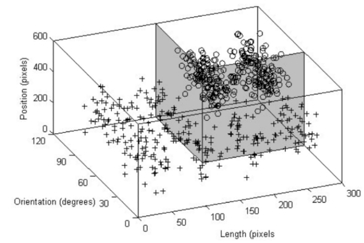


Figure 1.
Three-dimensional plot of the stimuli used in the experiment. The rule that led to the best performance was a conjunctive rule along the length and orientation dimensions.

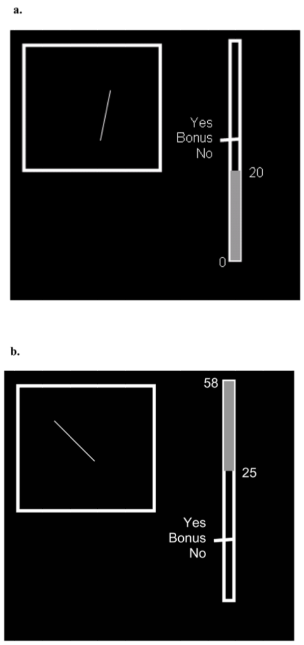
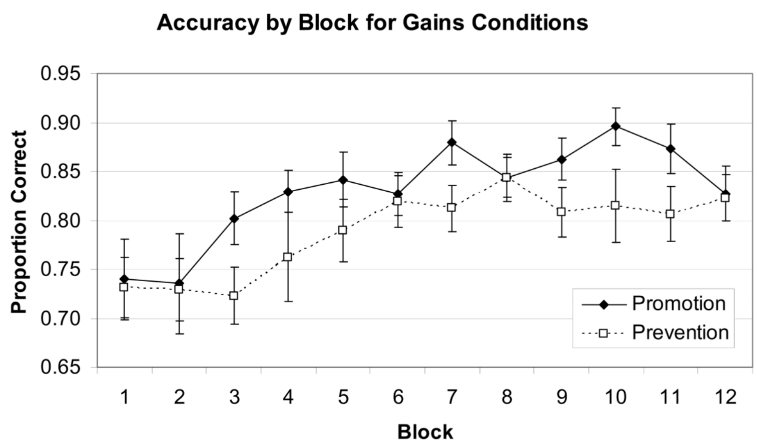


Figure 2.

(a.) Sample screen shot from the gains version of the task. Participants start with zero points and the point-meter moves the bottom up as they gain points for each correct response. (b.). Sample screen from the losses version of the task. Participants start with 58 points and the point meter moves from the top down as they lose points for each response. The bonus line corresponds to zero points.

a.



b.

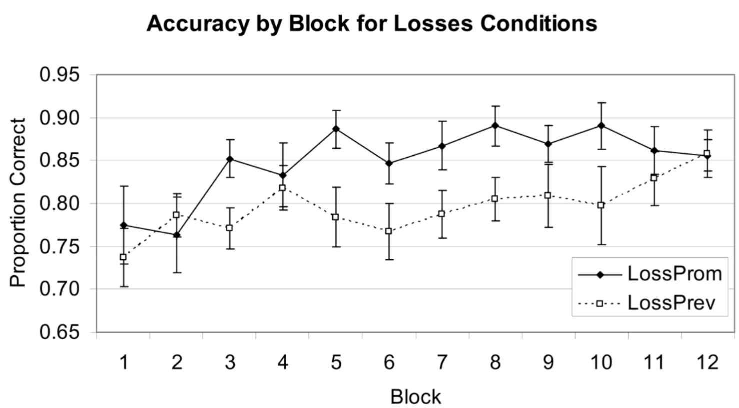


Figure 3.

Proportion of correct responses for each block for the gains version (a.) and losses version (b.). Error bars represent one standard error.

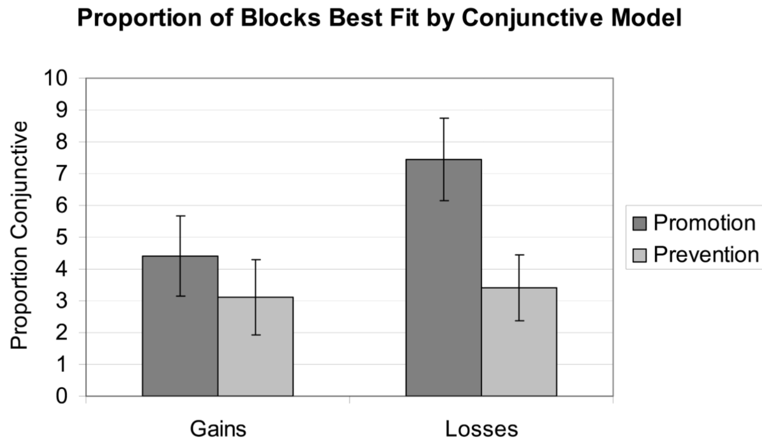


Figure 4.
Proportion of blocks best fit by a conjuctive rule model in each condition.