

INTRODUCTION

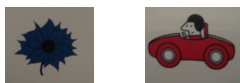
Current literature supports that individual differences in temperament and language are associated with cognitive processes and more specifically, inhibitory control (Wolfe & Bell, 2004). The ability to suppress a prepotent response is just one of many functions associated with prefrontal cortex. In the first few years of life, the prefrontal cortex undergoes substantial development. This is consistent with the fact that inhibitory control improves considerably between 3 and 4 years of age (Hongwanishkul et al., 2005).

In this study, we use the Dimensional Change Card Sort (DCCS) task to examine inhibitory control in 2-year-old children and its relations with temperament and language. The DCCS has been used with preschoolers from 2 1/2 through 4 years of age, but it's only at age 4 that the majority of children display inhibitory control during task performance (Diamond, 2005).

PARTICIPANTS

In our ongoing longitudinal study of cognitive development, we are examining performance on multiple tests of executive function, including the DCCS, throughout the first 4 years of life. Our original sample consisted of 108 healthy full-term infants. All parents had at least a high school education and the majority of the children are Caucasian. We have seen the children at 5 and 10 months (completed) and at 2 (completed), 3 (in progress), and 4 years (in progress). For this analysis, our sample included 70 children who attempted to play the DCCS, out of a total of 80 children who visited the lab age 2. All the data were gathered within 2 months after turning 2 years of age.

METHODS



1) *DCCS*: Requires children to sort pictures on 2 dimensions into 2 baskets with target cards attached (red flower, blue car). First, the child is asked to sort the pictures by color (preswitch; blue and red) and if they are successful they are asked to sort the pictures by shape (postswitch; flower and car). The sorting order was counterbalanced. Variables of interest were a) whether child understood task and if so, b) number of cards that were sorted correctly on the postswitch.

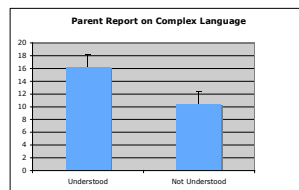
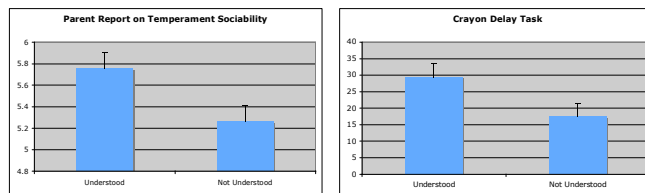
- 2) *Temperament*: Rothbart's Early Childhood Behavior Questionnaire (ECBQ) designed to assess 18 different temperament dimensions from 18-36 months of age. We looked at the temperament construct of effortful control, defined by attention, inhibitory control, low-intensity pleasure, and perceptual sensitivity.
- 3) *Language*: MacArthur-Bates Communicative Development Inventory (MCDI). The following measures were calculated: total number of spoken words (nouns, verbs, pronouns, quantifiers, etc), MLU (mean length utterance), and complex language (subject-noun agreement).
- 4) *Inhibitory Control*: Crayon Delay task. Experimenter places brand-new box of markers and piece of paper on table and tells child to wait and not touch. Experimenter leaves the room for 60 seconds.

RESULTS

Because many of our 2-year-olds had difficulty participating in the DCCS task, we looked at measures describing the children who appeared to us to understand the DCCS relative to those children who appeared to not understand the task. We defined "understood the task" as:

- willingness to play.
- attempting to sort at both preswitch and postswitch phases.
- not losing interest during postswitch or not showing bias to one basket during postswitch.

Children who understood the task ($n=37$), compared to children who did not understand the task ($n=33$), scored higher on the Crayon Delay task ($p=.04$), higher on parent report of temperament sociability ($p=.03$), and higher on parent report of complex language ($p=.04$).



We next examined performance correlates for the 37 2-year-olds who understood the task. Those with higher language scores had lower performance on the DCCS: complex language ($r = -.39$), MLU ($r = -.46$), and total number of spoken words ($r = -.37$), all $p's < .05$. In addition, children whose mothers rated them higher in attentional shifting ($r = -.42$), inhibitory control ($r = -.35$), and effortful control ($r = -.42$) had lower performance on the DCCS task, all $p's < .05$.

Given the above results, we then examined the relation between the preswitch and postswitch performance. We found that the top scoring children at the postswitch phase (> 60% correct) were the children who scored less than perfect (100%) on the preswitch trials. The lower scoring children at the post-switch phase were the children who were more like to sort perfectly at the preswitch.

DISCUSSION

About half of the 2-year-olds understood what was asked of them during the DCCS. Having better language and being more social are findings that are intuitive when taking into consideration that these children needed to interact and understand what the experimenter was asking of them. In addition, having a temperament that allows for delay of gratification (Crayon Delay task) and self-control allowed these 2-year-olds to sit through a challenging task that is, generally, above their cognitive capabilities.

Children who correctly sorted more cards during the postswitch phase scored lower in attentional shifting, inhibitory control, effortful control and language. Previous literature with 4-year-old children (Wolfe & Bell, 2004) supports positive associations between inhibitory control measures with effortful control and language performance. Our results are counterintuitive, but they are consistent, as we have negative correlations with *all* language measures and temperament traits associated with inhibitory control.

Simple sorting is a challenging task at age 2. When adding the inhibitory component required by the postswitch, the performance predictors we expect to see at ages 3 and 4 may not be valid with 2-year-olds. Is the DCCS an appropriate task for 2-year-olds or are performance predictors for 2-year-olds just very different than for older children? With our longitudinal study still in progress, we expect that DCCS performance at ages 3 and 4 to be correlated with performance at age 2, but with different predictors of performance at each of these three developmental stages.