JoVE: Science Education

Executive Function and the Dimensional Change Card Sort Task

--Manuscript Draft--

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Psychology Education Title: Executive Function and the Dimensional Change Card Sort Task

Overview:

Infants are born with amazing cognitive resources at their disposal, but they don't know how to use them effectively. In order to harness the power of their brains, humans must develop high-level cognitive processes that manage basic brain functions. These processes make up what psychologists refer to as "Executive Function." Executive function is a key factor in many self-regulatory behaviors, including forming plans to solve problems, negotiating between desires and actions, and directing attention. For example, a child must use several executive processes to stop playing with toys and start cleaning their room. These processes include inhibition (to stop what they're doing), planning (to determine what actions need to be performed to clean the room), and attentional control (to stay on task until the cleaning is done). A breakdown of executive function during any of these steps would lead to the room remaining dirty.

Developing executive function is one of the key challenges faced by children as they mature. Some elements of executive function can only be mastered with practice, and brain areas linked to executive function, specifically the prefrontal cortex, develop slowly throughout development, continuing to grow and organize until an individual reaches their twenties. Early demonstrations of executive function have been linked to self-control and behavioral outcomes in children, as well as successes later in life. Relatedly, executive function is impaired in children diagnosed with ADHD and autism spectrum disorders.

This experiment demonstrates how to assess executive function in children using the Dimensional Change Card Sort Task, developed by Dr. Philip Zelazo and colleagues.

Procedure:

1. Recruit children between the ages of 3 and 5 with no visual impairment, color blindness, or hearing impairment. For the purposes of this demonstration, only one child is tested. Larger sample sizes are recommended when conducting any experiments.

2. Data collection.

    2.1. Setup.

        2.1.1. Create a set of 16 cards, including 2 target cards and 14 test cards.

            2.1.1.1. Target cards depict a blue rabbit and a red boat on a white background.

2.1.1.2. Test cards are split evenly between pictures of red rabbits and blue boats.

2.1.2. Place two small trays on a table and affix one target card to each tray.

2.1.3. Place one blue rabbit card and one red boat card aside. Shuffle the remaining test cards.

2.1.4. Examine the cards, and reshuffle them if there is a run of more than two cards of the same type (e.g. if there are three or more blue boats in a row).

2.1.5. Once the cards are pseudo-randomized, place them face down and add the two pre-selected cards on top of the deck.

2.2. Demonstration phase.

2.2.1. Instruct the child to sit within view of the trays and target cards.

2.2.2. Label the two target cards and say, "Here is a blue rabbit and here is a red boat."

2.2.3. Introduce the pre-switch rules by saying, "Now, we're going to play a card game. In the color game, all the blue ones go here, and all the red ones go here." The experimenter points to relevant target cards.

2.2.4. The experimenter draws a test card, labels its color aloud (e.g. "This is a blue one, so it goes here"), and then narrates as they place it face down into the appropriate tray as a demonstration to the child.

2.2.5. Repeat the color game rules.

2.2.6. Draw a second card, label it, and then ask the child which tray it should go into (e.g. "Here's a red one. Where does this one go?").

2.2.7. Encourage the child to take the card and place it face down in the appropriate tray.

2.2.7.1. If the child makes an error in placing the card (e.g. puts it in the wrong tray or indicates the wrong tray), the experimenter should correct them and ensure that the card is placed face down in the correct tray.

2.3. Pre-switch phase.

2.3.1. Tell the child it is their turn and present six pre-switch trials to the child.

2.3.2. On each pre-switch trial, the experimenter states the pre-switch rules, selects a card, labels the card for the child, and then asks the child to sort the card (e.g. "Here's a red one, where does it go?").

2.4. Post-switch phase.

2.4.1. Tell the child, "Now we're going to play a new game. We're not going to play the color game anymore. We're going to play the shape game. In the shape game, all the rabbits go here, and all the boats go here. Remember, if it's a rabbit, put it here, but if it's a boat, put it here." Point to the appropriate tray while stating the instructions.

2.4.2. Draw the remaining six cards, label them by the relevant dimension (e.g. boat or rabbit), and ask, "Where does this one go?"

2.4.3. Note that the rules are not repeated in the post-switch phase.

3. Analysis.

3.1. Children 3 and older typically sort all cards correctly during the pre-switch phase.

3.2. The Dimensional Change Card Sort Task classifies children as either passing or failing.

3.3. A child must correctly sort 5 out of 6 post-switch trials to pass this task.

Representative Results:

In the pre-switch phase of the Dimensional Change Card Sort Task, children are building up patterns of thinking and attention, and those mental activities guide their physical responses. They learn to pay special attention to color, to ignore shape, and to place cards into the relevant trays. The post-switch phase requires children to shift their attention to a new dimension, which they had to actively ignore in the prior task, and to overcome their tendency to perform certain physical actions (e.g. putting the card in the box on the right when it is blue) in favor of an alternative action. Failing to inhibit either the prior focus of their attention or the learned action results in poor sorting accuracy during the post-switch phase.

After learning to complete the pre-switch color game, children's responses diverge by age. Three-year-olds typically have a very difficult time transitioning from the first game to a new game that uses the same materials but different rules. They fail to inhibit their recently learned patterns of thinking and acting. In contrast, most 4- and 5-year-olds pass the Dimensional Change Card Sort Task. This success is interpreted as evidence of their emerging development in the domain of executive function.

Applications:

The Dimensional Change Card Sort Task is a tool designed to evaluate children's executive function. The basic version described here can be used to effectively evaluate the executive function of 3- to 5-year-old children. However, there are permutations of this task that can be used to characterize executive function in children up to age 7. This task can also be used diagnostically to identify children with particularly poor executive function, which can be indicative of developmental delay, mental retardation, certain kinds of brain damage, or a clinical disorder, such as ADHD or Autism Spectrum Disorder. Generally, executive function is correlated with problem solving and self- and social-understanding.

Critically, there are many situations where important factors, such as intelligence, diverge from good decision-making. For example, choosing to go to a party instead of studying is a decision that many college students make, even though the short-term fun of a party is obviously less valuable than the long-term payoff of studying (**Figure 1**). However, the prefrontal cortex, a part of the brain related to executive function, is still developing in college-aged individuals, so it is much easier to understand why even smart young people sometimes make poor decisions.

Legend:

Figure 1: When faced with a long night of studying or a fun party, a college student is more likely to pick the latter.

References:

Zelazo, P.D. (2006). The dimensional change card sort (DCCS): A method of assessing executive function in children. *Nature Protocols, 1,* 297-301.

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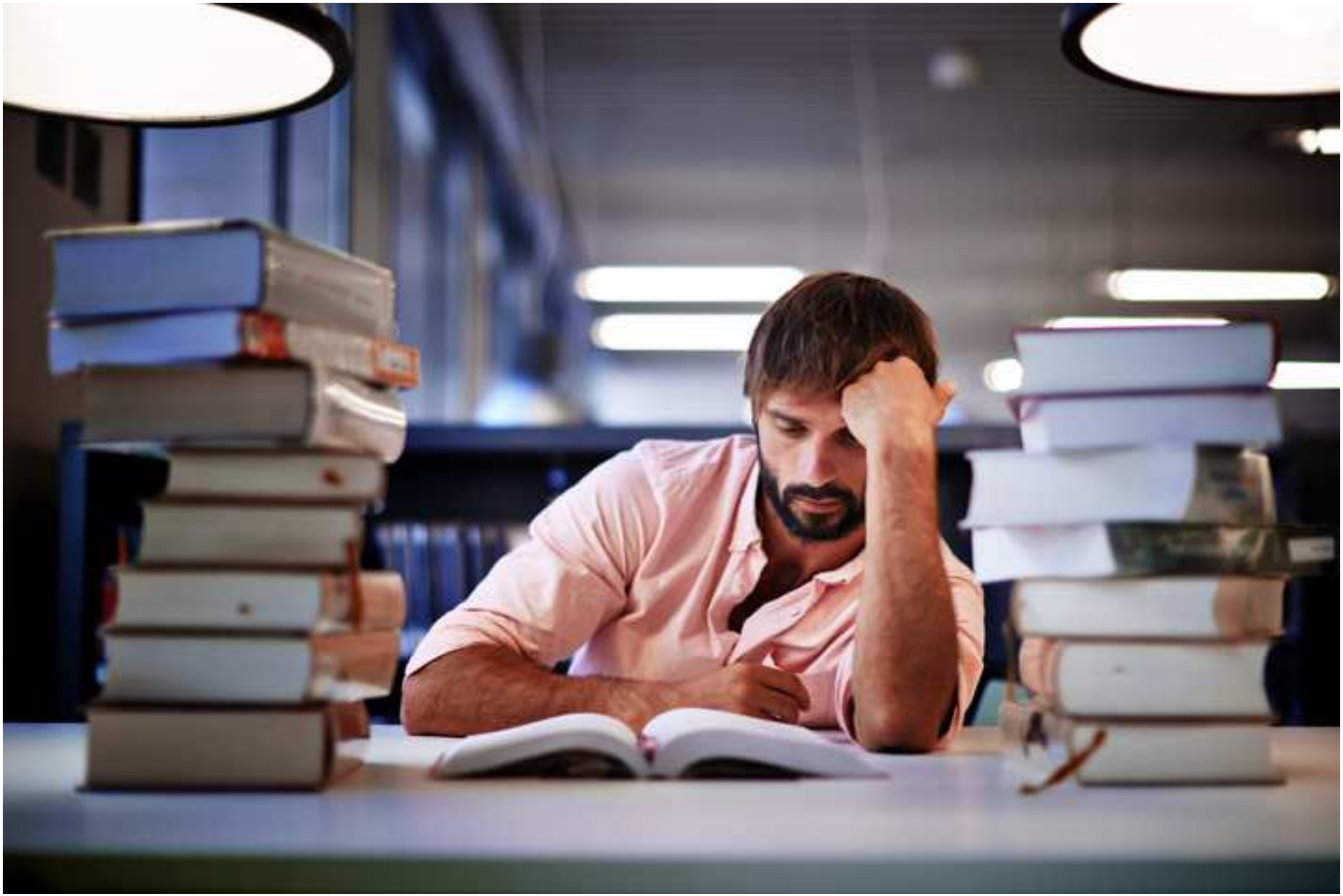

PIs: Nicholaus Noles and Judith Danovitch

Psychology Education Title: Executive Function and the Dimensional Change Card Sort Task

Comment [DR1]: JoVE comments 3/9: The manuscript is well-written but does not include a figure depicting the results of the procedure.

Comment [NN2]: A figure is attached as a separate document.

Overview:

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3.1. Children 3 and older typically sort all cards correctly during the pre-switch phase.

3.2. Use the Dimensional Change Card Sort Task to classify children as either passing or failing.

3.3. A child must correctly sort 5 out of 6 post-switch trials to pass this task. Mean average accuracy on post-switch trials may also be analyzed using an ANOVA to compare performance between age groups.

Comment [JS3]: The analysis section should be written with the experimenter in mind. How are the data analyzed? Average % correct to compare pre- against post-switch?

Comment [NN4]: Most children are at ceiling in the target age groups for the pretest, so you would see a significant drop in the 3s, but a drop in 5s is more difficult to drop as their variability would be tight (most get 5 or 6 correct), and so their mean percentage correct might drop significantly also, even though almost all of them are passing the task. The best use of the DCCS is to use the pre-test as an inclusion criteria (if they can't do that, they're not following directions), and then to make claims based on either the number of kids passing in an age group or the differences in mean accuracy.

Representative Results:

In the pre-switch phase of the Dimensional Change Card Sort Task, children are building up patterns of thinking and attention, and those mental activities guide their physical responses. They learn to pay special attention to color, to ignore shape, and to place cards into the relevant trays. The post-switch phase requires children to shift their attention to a new dimension, which they had to actively ignore in the prior task, and to overcome their tendency to perform certain physical actions (e.g. putting the card in the box on the right when it is blue) in favor of an alternative action. Failing to inhibit either the prior focus of their attention or the learned action results in poor sorting accuracy during the post-switch phase.

Comment [JS5]: The manuscript should contain a figure that represents the experiment described here.

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Comment [NN6]: One is attached as a separate file.

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Comment [JS7]: Image should not be included in manuscript; use separate file

Legend:

Figure 1: The percentage of correct test trials completed by each child on average. Children scoring 80% or more "pass" the Dimensional Change Card Sort T~~t~~ask.

~~Figure 2: When faced with a long night of studying or a fun party, a college student is more likely to pick the latter.~~

References:

Zelazo, P.D. (2006). The dimensional change card sort (DCCS): A method of assessing executive function in children. *Nature Protocols*, *1*, 297-301.

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