Psikoloji Çalışmaları
Studies in Psychology

Psikoloji Çalışmaları - Studies in Psychology Cilt/Volume: 43, Sayı/Issue: 2, 2023
DOI: 10.26650/SP2022-1138580
Review Article/*Derleme Makalesi*

Cognitive Flexibility in Early Childhood: A Contemporary View of the Development of Flexible Goal-Oriented Behavior

Erken Çocukluk Döneminde Bilişsel Esneklik: Esnek Amaç-Odaklı Davranış Gelişimine Güncel Bakış

Yeşim Yavaşlar Doğru[1,2], Daniel Carroll[3], Emma Blakey[3]

[1]Dr, University of Kent, School of Psychology, Canterbury-United Kingdom
[2]Karabuk University, Faculty of Letters, Psychology Department, Demir Celik Campus, Karabuk, Türkiye
[3]Dr, University of Sheffield, Department of Psychology, Sheffield-United Kingdom

ORCID: Y.Y.D. 0000-0002-8229-0528;
D.C. 0000-0003-2190-7253;
E.B. 0000-0003-3685-3649

Corresponding author/Sorumlu yazar:
Yeşim Yavaşlar Doğru,
Karabuk University, Faculty of Letters, Psychology Department, Demir Celik Campus, Karabuk, Türkiye
E-mail/E-posta:
yesimyavaslardogru@karabuk.edu.tr

Submitted/Başvuru: 30.06.2022
Revision Requested/Revizyon Talebi: 02.05.2023
Last Revision Received/Son Revizyon: 05.05.2023
Accepted/Kabul: 09.05.2023
Published Online/Online Yayın: 00.00.0000

Citation/Atıf: Yavaslar Dogru, Y., Carroll, D., & Blakey, E. (2023). Cognitive flexibility in early childhood: A contemporary view of the development of flexible goal-oriented behavior. *Psikoloji Çalışmaları - Studies in Psychology, 43*(2): 171–193. https://doi.org/10.26650/SP2022-1138580

ABSTRACT
Cognitive flexibility is usually described as a skill that allows us to revise our behaviors or ideas as the task objective or the environment changes. Over 20 years, in addition to inhibitory control and working memory, cognitive flexibility has been presented as one of the main executive functions and has been considered to develop at around three to four years of age when children learn to easily switch from sorting cards according to one rule (e.g., shape) to the other rule (e.g., colour). This classic view of cognitive flexibility has been highly influential in improving our knowledge about the development of cognitive flexibility. However, in recent years, the way cognitive flexibility is understood has changed remarkably that leads the way that it should be thought and studied has also changed. The present paper aims to present a contemporary view of cognitive flexibility by reviewing recent advances in methodological and analytical techniques used to study cognitive flexibility. Particularly, recent research has started to use less constrained rule-switching tasks to assess cognitive flexibility and use more advanced modelling-based statistical approaches to analyse cognitive flexibility. These recent advances suggest that cognitive flexibility is not a stand-alone skill that emerges during the preschool years. Instead, cognitive flexibility is the culmination of the development of controlled, goal-oriented behavior that happens across a broader age span and in a much more diverse range of contexts than previously thought. While the earlier developments in cognitive flexibility in the first two years of life are underpinned by attention and language, the later developments in cognitive flexibility from around three years onwards are underpinned by inhibitory control and working memory.
Keywords: Cognitive flexibility, inhibitory control, working memory

ÖZ

Bilişsel esneklik değişen hedefler ya da çevresel etkilere bağlı olarak düşünce ya da davranışlarımızı güncellememize olanak sağlayan yetenek olarak tanımlanabilir. Yirmi yılı aşkın süredir bilişsel esneklik, engelleyici kontrol ve çalışan bellek ile birlikte üç ana yürütücü işlevden biri olarak sunulmakta ve bilişsel esnekliğin çocukların belli kartları bir kuraldan (örn., şekil) diğer kurala (örn., renk) göre esnek bir şekilde sınıflandırmayı öğrendiği üç ile dört yaşları arasında geliştiği düşünülmektedir. Bilişsel esnekliğin üç ana yürütücü işlevden biri olduğunu ve üç ile dört yaşları arasında geliştiğini savunan bu klasik görüş, bilişsel esnekliğin gelişimini anlamamızda uzun yıllar etkili olmuştur. Fakat son yıllarda bilişsel esneklik konusundaki anlayışımız önemli ölçüde değişmiştir ve bu değişiklik bilişsel esnekliği daha iyi anlamamız ve daha iyi çalışmamız konusundaki değişikliklere de ön ayak olmuştur. Bu araştırma, bilişsel esnekliği çalışırken kullanılan yöntem ve analitik tekniklerdeki güncel gelişmeleri tarayarak bilişsel esneklik konusundaki güncel görüşü sunmayı amaçlamaktadır. Özellikle, son zamanlarda yapılan araştırmalar bilişsel esnekliği ölçmek için daha az sınırlandırılmış kural-değiştirme bataryaları geliştirmekte ve bilişsel esnekliği analiz etmek için daha ileri modelleme analiz yöntemlerini kullanmaktadır. Yapılan son çalışmalar, bilişsel esnekliğin okul öncesi çağda ortaya çıkan tek başına bir yürütücü işlev olmadığını göstermektedir. Aksine, son çalışmalar bilişsel esnekliğin düşünülenden daha geniş zamana yayılan ve daha farklı şekillerde ortaya çıkan kontrollü, amaç-odaklı davranış gelişiminin son basamağı olduğunu göstermektedir. Güncel veriler, uzun gelişim evresine sahip bilişsel esnekliğin yaşamın ilk iki yılındaki erken gelişim dönemlerinin dikkat ve dil yetenekleri tarafından desteklenirken, üç yaş ve sonrası ileri gelişim dönemlerinin engelleyici kontrol ve çalışan bellek yetenekleri tarafından desteklendiğini göstermektedir.

Anahtar Kelimeler: Bilişsel esneklik, engelleyici kontrol, çalışan bellek

Cognitive flexibility (CF) is a skill that enables us to revise our ideas or behaviors as the environment or task objective changes (Chevalier et al., 2012). It is an early-emerging ability and is important both because it reflects the onset of complex, systematic, goal-oriented behavior in children, and because early CF is associated with a number of significant developmental abilities. For example, CF is positively associated with an enhanced theory of mind abilities (Marcovitch et al., 2015), better comprehension of emotions (Wang et al., 2021) and increased success at school (Clark et al., 2013). This emphasizes the significance of discerning the development of CF during the early years of life.

Research into the development of CF first emerged in the 1990s and 2000s (Towse et al., 2000; Zelazo et al., 1996), and much of the foundation of what is known about dynamic goal-oriented behavior in children comes from this pioneering early work. However, in recent years, the way CF is understood has changed enormously – and as a result, the way that CF needs to be thought and studied has changed. This paper begins by briefly outlining the "classic" view of CF, a view derived from this early research, and centered on an age period that used to be thought of as the three- to four-year-old shift. It then presents a selective review of recent research covering the first six years of life that frames CF *not* as a stand-alone ability that emerges during the preschool years but rather, as the culmination of the development of a controlled, goal-oriented behavior. Within this context, it will be apparent that CF emerges across a much broader age span, and in a much more diverse range of contexts, than previously thought. The paper then highlights the domain-general processes that are shown to play a role in the development of flexible behavior in children. And finally, it presents a conclusion and outlines a number of principles for future CF research to follow.

The Classic View of Cognitive Flexibility

When research into CF first emerged, CF itself was presented as one of the main executive functions, in addition to inhibitory control and working memory (Garon et al., 2008; Garon et al., 2014; Miyake et al., 2000). These three executive functions were said to emerge during the preschool years, and while each one was independent, they could be deployed together to create flexible, goal-oriented behavior. This classic view of CF suggests that CF develops between the ages of three and four years when children learn to flexibly adjust their behavior based on a changing task goal such as a rule (Diamond et al., 2005). During this process, children learn to follow an explicit rule and following that children learn to flexibly update their behavior in response to a different rule (Muller et al., 2006). This view of how CF develops in early childhood is derived from the most commonly used tasks to measure CF during this period, such as the Shape School Task (Espy, 1997) or the Dimensional Change Card Sorting Task (DCCS; Zelazo, 2006). For example, the DCCS is a two-phase rule-switching task in which children must sort complex bidimensional cards first by one dimension (e.g., shape), and then by another dimension (e.g., color). Thus, the core demand of tasks such as this is the need to modify behavior in line with the rule change (Zelazo et al., 1996).

Findings from the DCCS are robust and consistent; when asked to sort complex stimuli, three-year-olds usually sort these stimuli by an initial rule, regardless of whether it is *shape* or *color*. However, when asked to switch to a new rule, the majority of three-year-olds are unable to do this, and instead keep sorting according to the initial rule (Zelazo, 2006). That is, when asked to switch rules, most three-year-olds *perseverate* with their initial response tendency. Conversely, by around the age of four years, children can usually sort stimuli according to the new rule. Thus, the view that developed from research with the DCCS task tended to see the most critical age period in CF development as around three to four years of age; and to see the most crucial developmental advancement being the ability to overcome perseveration (Munakata et al., 2012).

Three-year-olds' failure to switch is particularly striking, given that these children are able to verbally report what rule they should be sorting by (Yerys & Munakata, 2006). To date, different theories are offered to explain why three-year-olds fail to switch to the new rule. For example, cognitive complexity and control theory suggests that three-year-olds fail to switch to the new rule even if they know that the rule is changed because three-year-olds are unable to combine different pieces of information into complex higher-order rule structure (Zelazo, 2006; Zelazo, 2015). Alternatively, Perner and Lang (2002) suggested that three-year-olds perseverate with the old rule when the rule changed because three-year-olds were unable to exert multidimensionality of mental representations to redescribe the stimuli in a different way in line with the new rule. Other researchers suggested that three-year-olds' failure to switch to the new rule is related to the deficits in inhibiting the previous rule (Kirkham et al., 2003; Rennie et al., 2004) or deficits in maintaining the new rule in mind (Morton & Munakata, 2002). These theories offered important insights on why three-year-olds perseverate while switching rules. One important point to keep in mind is that while explaining CF development, these theories usually target one change in switching behavior from perseverating with the old rule to switching the rule successfully between the ages of three and four. However, in the contemporary view of the CF in the following sections, younger children also engage in basic forms of CF through mastering errors of inattention (Blakey et al., 2016). Even though it is outside the scope of this manuscript, CF development continues to occur in older children and adolescence (Best & Miller, 2010; Cragg & Chevalier, 2012). These existing theories do not consider the CF changes occurring in more diverse types of performance across broader age ranges (Carroll et al., 2016).

Presenting a Contemporary View of Cognitive Flexibility

The findings from the DCCS proved to be highly influential (Doebel & Zelazo, 2015). However, in recent years it is clear that CF develops in a more complicated and protracted manner than the classic view would suggest. A number of methodological innovations emerged. For example, rule-switching tasks were developed with an increased number of response options to measure more diverse kinds of switching behavior with simpler instructions and response requirements to measure CF in a wider, younger age range of children. These innovations demonstrated that the beginning of CF emerges much earlier than previously thought. The changes in how CF is conceived led to it being viewed no longer as a stand-alone executive function that emerges from nowhere during the preschool years, but rather as an integral part of children's ability to act in a systematic goal-oriented way (Ionescu, 2017; Ionescu, 2019). In particular, the contemporary view of CF sees the kind of behavior measured by the DCCS task – that is, explicit rule-based sorting of complex stimuli – as just *one example* of intentional goal-oriented behavior; this behavior emerges gradually and becomes increasingly stable and complex with time.

The paper now presents a short review of some of the key studies tracing the emergence of stable, goal-oriented behavior that led to this revised, contemporary view of CF. This behavior first starts to emerge during infancy and is developed and refined during the preschool and early school years. The most important point to make is that CF is not a stand-alone ability that emerges at around four years of age, but rather an integrated part of a child's ability to act in an intentional, planned, and systematic way. A child's ability to flexibly switch rules is founded on the ability to reliably respond according to a rule; on the ability to focus their attention on selected aspects of a situation;

and the ability to overcome distractors. As the paper will now show, these abilities emerge gradually, during the first six years of life.

Precursors to Cognitive Flexibility from Birth to Two Years

The emergence of goal-oriented behavior begins in the first year of life (Hendry et al., 2016). During this time, infants demonstrate little evidence of intentional, reflective, planned behavior. Nevertheless, they do begin to control their looking reaching behavior in response to increasing muscle maturation (Ellis & Oakes, 2006). The developments in controlling looking and reaching are treated as important precursors to CF since they reflect an infants' accumulated learning to exert attention control towards external elements, and to direct their attention towards and away from key aspects of their environment.

Assessing infants' goal-oriented behavior is not trivial because existing CF measurements require a high level of motor and language demands, which is limited in infants. Thus, researchers used different measures that are designed to capture looking and reaching control in order to assess CF in infancy. These measures are highlighted on the ability to allow infants to learn to give a response to a certain stimulus; afterwards, to update this response based on a change in the stimulus. Around four to six-months of age, infants learn to update their response to changing stimuli (Hendry et al., 2016).

Early in the first year of life is when controlled goal-oriented behavior is first observed. That is, infants start to control their gaze to focus on a single stimulus and away from another stimulus. Such controlled looking can be treated as one of the first instances of infants' showing implicit goal-oriented behavior, because whether infants are clearly thinking about a goal to achieve is not definite at this stage of development (Johnson et al., 1991). However, implicit goal-oriented behavior shows the ability to *volitionally* shift attention between different stimuli, rather than simply having one's attention involuntarily captured by the most salient stimuli in one's environment (Evans & Stanovich, 2013). For example, the Fixation-Shift tasks examine an infants' ability to shift their visual focus (Atkinson et al., 1992). These tasks involve an appealing object presented in the middle of a screen for the infant to focus on. After that, additional stimuli are shown on each side of the screen, either with or without the central primary object. The outcome variable is to test whether infants can change their focus of attention from the central to the peripheral objects on each side. It is around the age of four months when infants are able to shift their attention from a focal point on the screen to peripheral objects. Furthermore, with age infants spend less time in diverting their attention away from the main object (Hunnius et al., 2006; Kulke et al., 2015). While this simple index of directed attention might seem more basic than the kinds of complex volitional behavior associated with CF, it should be noted that infants' high scores on attentional control tasks predict higher scores on CF tasks later in life (Holmboe et al., 2008).

Another type of test for goal-oriented behavior in infancy is directed reaching tasks, typically used with children from around eight months. Controlled reaching is treated as one of the first examples of explicit goal-oriented behavior because infants are able to intentionally initiate an object-oriented motor response (e.g., urging to find a hidden toy), which is a clear antecedent of later CF (Clearfield et al., 2006). The A-not-B task, in which the infant witnessed an experimenter putting a toy in one of two boxes, is a typical illustration of this (Piaget, 1954). The infant was then permitted access to the toy. The toy was initially hidden in the first box (location A) for a number of trials, and then was moved to a second box (location B). Again, the infant was permitted access to the toy from the new place. Eight-month-old infants typically continued to look for the toy in the initial "A" location, thus making the classic Piagetian perseverative error. Errors made by eight-month-olds in the task were usually labeled as executive, indicating challenges with suppressing the infant's focus to the prior location or challenges with updating the representation of the toy's hiding location (Diamond, 1985). However, by around the age of 12 months, infants can reach the new location to retrieve the toy – thus demonstrating a robust ability to direct an action based on an updated task representation. Thus, one of the essential foundations of later CF – namely, the ability to *update* a mental representation as the basis for intentional action – starts to become apparent by the end of the first year of life (Clearfield & Niman, 2012).

The last ability that contributes to goal-oriented behavior during infancy is seen at 20 months of age when infants begin to demonstrate the ability to disregard distractions that are not important to their task. For instance, researchers looked into how well young children could mimic an experimenter's activity sequences (Wiebe et al., 2010). Infants in the experiment initially observed the experimenter carries out two distinct three-step activities. That is, the experimenter arranged a seesaw, placed a toy fish on it, and pressed one edge of the seesaw in order to see the fish jump. After that, the experimenter assembled a peg top, placed the toy dog on it, and spun the peg top in order to make the dog dance. Then, all the toys (the seesaw and the fish) that allow infants to mimic the first activity were given to them, along with just one toy that allows infants to mimic the second activity (the peg top). Infants could therefore only fully mimic the first activity, but not the second. The peg top is now a distracting toy as a result. Researchers found that by disregarding the distractor toy, infants can successfully mimic the first activity of the experimenter at the age of 20 months.

In the light of this information, it can be concluded that important antecedents of CF, such as controlling of gaze and controlling of reaching start to develop as early as infancy. The reason these behaviors can be considered as important antecedents of CF is because they reflect infants' attentional control abilities for changing external elements (Phipps et al., 2019).

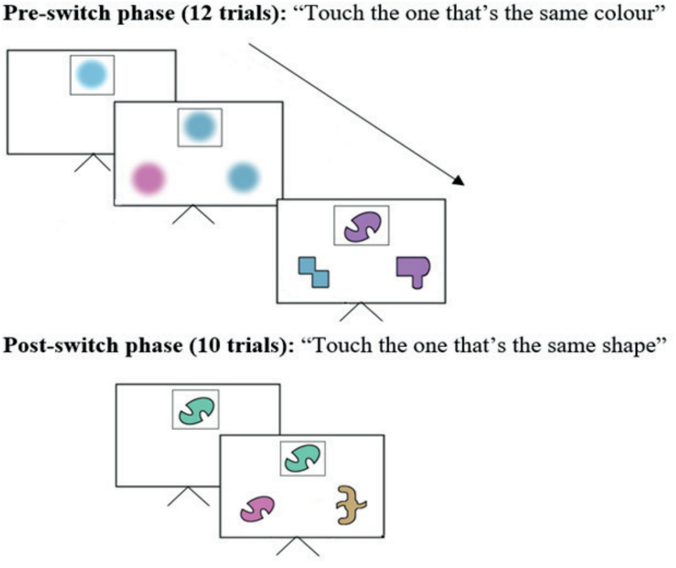
Cognitive Flexibility from Two to Three Years

From around two years of age, children begin to display early forms of deliberate and explicit goal-oriented behaviors (Wiebe & Bauer, 2005). These behaviors are relatively simple and tend to be prone to disruption at every stage whether by salient aspects of the environment around them, or simply from inattention on the part of the child (Carroll et al., 2016). Nevertheless, it is at this age that children start to demonstrate the ability to act systematically in response to instructions from someone else (Brooks et al., 2003). As it will be shown, these behaviors are important antecedents of developing CF as they establish a basis of consistent goal-oriented behavior which two-year-olds can subsequently learn to adapt (Blakey et al., 2016).

Two-year-old children are able to act reliably following simple rules that they are given (Johansson et al., 2016). This is a simple but essential landmark in the development of CF, since the ability to switch from one sorting rule to another – as seen later on tasks like the DCCS – is obviously dependent on the ability to sort reliably by a single sorting rule in the first place. Importantly in terms of CF, however, two-year-olds also start to show the ability to *update* their rule-oriented behavior, so that their initial sorting behavior can be changed (Wiebe & Bauer, 2005). To illustrate this with an example, the Reverse Categorization Task asks two-year-old children to classify cubes with different colors into boxes with different colors (Carlson et al., 2004). Specifically, children are initially asked to classify cubes according to a simple rule (e.g., "blue cubes go to the blue box and yellow cubes go to the yellow box"), and then they are asked to classify the cubes according to the reversed form of that rule (e.g., "blue cubes go to the yellow box and yellow cubes go to the blue box"). When the rule changed, two-year-olds performed well at both the first task of putting the cubes into the corresponding boxes and the subsequent task of doing the reverse. Two-year-olds' performance on this task shows that around two years of age, children become able to update their behavior – though only when the objects they are sorting are simple, and when the rule they must update is a straightforward reversal of their initial behavior.

By the end of two years of age, children's ability to update their behavior further improves in a way that when presented with distracting information, two-and-a-half-year-olds begin to demonstrate the ability to modify their behavior (Blakey et al., 2016). This is an important development, given that young children's behavior is frequently prone to disruption from distraction and inattention. So, the ability to sort systematically when there is distracting information is a significant advance. To test this, Blakey and colleagues (2016) developed a computer-based rule-switching task called the Switching, Inhibition, and Flexibility Task (SwIFT), that asks two-and-a-half-year-olds to select one of the two colorful shapes that corresponds to a prompt image according to the relevant rule on each trial. The task involved a pre-switch phase, where children sorted in accordance with one rule (e.g., colour), and a post-switch phase, where they sorted in accordance with another rule (e.g., shape; see Figure 1 for an example trial). This task was simpler than the DCCS, since the incorrect response on any given trial did *not* correspond to the prompt image according to the previous rule – thus, the stimuli to be sorted were less likely to induce the child to incorrectly sort by the old rule. Nevertheless, by sorting successfully on the task, two-and-a-half-year-olds showed that they could explicitly update their sorting behavior, through flexibly changing the rule that they use to sort different stimuli. This is a clear demonstration of explicit CF in two-year-olds and shows that the developmental trajectory of CF is longer, and starts earlier, than previously thought.

Figure 1
Distracting Version of the Switching, Inhibition, and Flexibility Task (SwIFT) (Blakey et al., 2016)

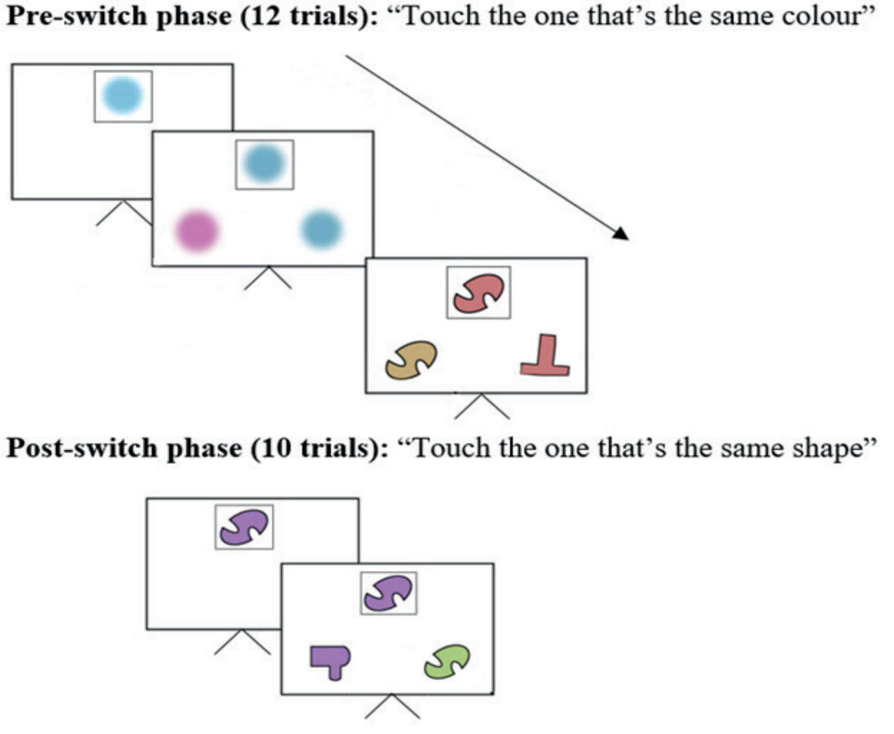


Note. In the Distracting version of the Switching, Inhibition, and Flexibility Task (SwIFT), children are prompted to select one of the colorful images presented at the bottom of the screen that corresponds to the prompt image in line with the relevant rule "Touch the one that's the same [colour/shape]". In the Distracting SwIFT, the post-switch phase does not involve a colorful image that corresponds to the prompt image according to the previous rule.

Cognitive Flexibility from Three to Four years

As preschoolers grow old, they start to cope with sorting more challenging stimuli (Espy, 1997; Zelazo, 2006). Most notably, they become able to flexibly sort stimuli that display *response conflict*. Response conflict is the term used to describe stimuli on switching tasks that could be sorted either based on the initial pre-switch rule or based on the post-switch rule (see Figure 2 for an example). Sorting stimuli with response conflict is particularly challenging for young children, since as well as requiring children to switch to another rule, it also requires them to adjust their focus within an object by initially paying attention only to one aspect of a stimuli (e.g., its colour), and then, following a change in the rule, shifting their focus to the other aspect of the stimuli (e.g., its shape). This makes it particularly hard for children to ignore the initial rule, since they will have sorted by this rule in the whole pre-switch phase. Due to the fact that the stimuli contain information related to both colour and shape, both of the rules will be activated in the post-switch phase. That is why in order to succeed on the task, children need to overcome this response conflict. Between the ages of three and four years, children become able to switch to the new rule flexibly by resolving the conflict between responses (Blakey et al., 2016; Doebel & Zelazo, 2015). Three-year-olds typically find this challenging; it is common on many switching tasks for them to fail to resolve this conflict between responses, and therefore to keep sorting based on the pre-switch rule when the rule changes. Conversely, four-year-olds have developed the ability to resolve response conflict and are able to update their basis for sorting accordingly.

Figure 2
Conflicting Version of the Switching, Inhibition, and Flexibility Task (SwIFT) (Blakey et al., 2016)



Note. In the Conflicting version of the Switching, Inhibition, and Flexibility Task (SwIFT), children are prompted to select one of the colorful images presented at the bottom of the screen that corresponds to the prompt image in line with the relevant rule "Touch the one that's the same [colour/shape]". In the Conflicting SwIFT, the post-switch phase involves a colorful image that corresponds to the prompt image according to the previous rule.

Research testing how children successfully switch the rules by resolving the response conflict between the ages of three and four-years has been enormous. Particularly, different versions of the DCCS have been designed to test how experimental variations help children resolve the response conflict better (Doebel & Zelazo, 2015). For example, children were found to switch better when they label the cards to be sorted explicitly by themselves (for "card-labelling" versions: Doebel & Zelazo, 2013; Muller et al., 2004). In addition, when the post-switch dimension is made more salient, children's switching performance increases whereas when the post-switch dimension is made less salient, children's switching performance decreases (for "perceptual salience" versions: Fisher, 2011a, 2011b; Jordan & Morton, 2008). Furthermore, physically segregating the values for different dimensions (separating the colour information and the shape information such as a yellow-filled circle presented next to an outline of a car) was related to better switching ability in a way that full degree of segregation yielded the most successful outcomes (for "dimensional separation" versions: Diamond et al., 2005; Kloo & Perner, 2005; Kloo et al., 2010). These experimental versions of the DCCS are important in helping us better eliminate the various ways through which children can avoid making perseverative errors by resolving the response conflict.

However, the contemporary view of CF suggests that in addition to making perseverative errors, children can make switching errors for different reasons. That is, children can make switching errors due to inattention or distraction (Carroll et al., 2016) and thus characterizing CF as only being able to resolve the response conflict seems to be problematic. To illustrate, Chevalier and Blaye (2008) developed the Preschool Attentional Switching Task-3 (PAST-3) which is a three-item task array that asks children to perform an intra-dimensional switch. That is, in the PAST-3, instead of switching from shape to colour, children are asked to switch within the same dimension such as switching from choosing blue items to choosing yellow items. Crucially, the task array had three different response options that reveal a different type of response: Selecting the yellow object would count as a successful switch; selecting a blue object would count as perseverating with the original rule; and selecting a green object would count as making a distraction error – in other words, neither a successful switch nor perseveration. When children were given the chance to respond to this less constrained task, the researchers found that three-year-old children committed a similar proportion of distraction errors and perseverative errors. Hence importantly, CF tasks that solely assess perseveration tend to omit a crucial aspect of CF behavior that children could display (Chevalier & Blaye, 2008; Deak & Narasimham, 2003).

When switching tasks allow for different kinds of error, the eventual data is likely to be richer compared to the data derived from the typical CF tasks. To be able to analyse this kind of data, an analysis that could detect the important information behind children's different kinds of switching errors - beyond the number of correct responses would be needed (Carroll et al., 2016). One way of doing this is to distinguish between various performance patterns in the data, which describes qualitatively different switching performances (van der Maas & Straatemeier, 2008). By observing children's whole post-switch performance, different patterns of performance can be detected such as whether children successfully switch during all trials of the post-switch phase, or whether children consistently perseverate during all trials of the post-switch phase or whether children change between switching and perseverating during all trials of the post-switch phase. An important example of this was seen in work that used the Latent Markov Models to observe children's switching performance during the whole post-switch phase (van Bers et al., 2011). That is, when three to five-year-olds' performance in all trials during the post-switch phase was observed, three different performance patterns were detected. These performance patterns include children who successfully sorted by the new rule in all trials of the post-switch phase, children who perseverated by the previous rule in all trials of the post-switch phase, and children who changed back and forth between sorting successfully by the new rule and perseverating by the previous rule.

More various performance patterns were also observed in two to four-year-olds. Blakey and colleagues (2016) assessed CF in young children by using the 'Conflicting SwIFT' where children must overcome the response conflict in order to switch the rules successfully and the 'Distracting SwIFT' where children must ignore distracting unrelated information in order to switch the rules successfully. Researchers examined two to four-year-olds' performance across all trials of the post-switch phase by using the Latent Markov Models and the results yielded three different performance patterns. These performance patterns include children who switched to the new rule successfully, children who perseverated by keep using the no-longer relevant rule, and children who alternated between sorting correctly and sorting perseveratively along the course of the post-switch trials (For comparable work in older children, see also Dauvier et al., 2012).

Cognitive Flexibility from Five to Six years

Around the age of five years, children are capable of more enhanced forms of switching, and are much more dynamic in the types of behavior they display. By this age, five to six-year-olds have typically mastered switching from one rule to another and started to display the ability to switch multiple times, back and forth, between different rules.

At the age of five to six years, children can also concentrate on tasks for longer periods of time and comprehend instructions for more complicated tasks (Cragg & Chevalier, 2012). They are obviously not yet at adult levels of switching, and there remain a number of important developments children are still to undergo, in terms of the speed and consistency of their switching (Chevalier & Blaye, 2009). However, these developments are arguably more quantitative in nature than qualitative.

One classic method to examine CF in children with five-year-olds is to use the border/star version of the DCCS where children need to remember when to sort by different rules. In the border/star version of the DCCS, children need to sort by one rule (e.g., colour) when there is a border/star around the test card while children need to sort by the other rule (e.g., shape) when there is no border/star around the test card (Zelazo, 2006). This more challenging version of the DCCS is used to examine developmental changes in the switching ability of older children and adults. Studies using this version found that the number of the correct post-switch responses of five to six-year-olds was significantly higher than the number of the correct post-switch responses of four-year-olds (Hongwanishkul et al., 2016). The results reflected significant age-related development on the number of correct switching from five to six-years of age (Carlson, 2005). The quantitative increase in the number of correct switching during five to six-years of ages in this version suggests that CF continues to develop during school period in which CF is supported by the improvements in executive functions. That is, individual differences in the ability to maintain information in mind is likely to differentiate whether children switch correctly or not (Chevalier & Blaye, 2009).

It is around six years that we see a methodological improvement, from using accuracy and error rates as the basis of task performance, to using response time. To examine developments in CF after five years of age, researchers have started to use different computerized paradigms involving multiple rule switches, and where the indices of task performance are based on calculations derived from response time, rather than accuracy (Best et al., 2009). CF in this period is likely to be tested by investigating *switch costs* and *mixing costs* (Cragg & Nation, 2009). Switch costs are described as the additional processing required to sort by a rule, having on the previous trial sorted by a different rule. Switch costs are usually measured by deducting the average response time on *non*-switch trials from the average response time on *switch* trials. On the other hand, mixing costs are a monitoring cost, characterized as the cost of having to maintain the option to switch. Mixing costs are calculated by deducting the average response time on non-switch trials where the sorting rule does not change from the average response time on non-switch trials where the sorting rule could change, but this did not occur. From five to 11-years of ages, switch and mixing costs start to decline significantly (Chevalier & Blaye, 2009; Davidson et al., 2006). These studies indicate that assessing CF through computerized tasks is likely to be helpful because this method enables researchers to make very precise assessments about behavioral outcomes of CF by noting subtle differences in response time. However, as the manuscript focuses on early CF development where response times are less reliable, the importance of response time in CF will not be discussed further.

However, five to six-years of age is not the end point of CF development, and there remain a number of important developments still to occur during adolescence and adulthood (Best & Miller, 2010). For example, thinking and acting become more flexible (e.g., being able to switch consistently between an increased number of rules) and the switching costs continue to decrease during adolescence and adulthood (Davidson et al., 2006; Reimers & Maylor, 2005). The development of CF in adolescence and adulthood is usually assessed by using Wisconsin Card Sorting Task (WCST; Grant & Berg, 1948), which is similar to the DCCS in terms of sorting cards based on different rules. However, unlike the DCCS, the rules are required to be determined by interpreting the feedback from the experimenter in the WCST (Buchsbaum et al., 2005). Alternatively, the Minnesota Executive Function Scale (MEFS; Carlson & Zelazo, 2014) has been more recently developed to assess executive functions in general, including CF from two to 80-years of age through different computerized tasks. Studies using these tasks show that CF continues to develop in adolescence and adulthood (Huizinga & van der Molen, 2007; Perone et al., 2018). Nevertheless, because the focus of the current paper is on early childhood and presenting a revised understanding of how CF first emerges, the developments occurring during adolescence and adulthood will not be further covered in this section.

The Contribution of Domain-General Skills to Cognitive Flexibility

The paper has discussed age-related changes in CF, and it will now talk more broadly about the domain general skills that underpin CF. Developments in CF are known to be underpinned by improvements in a range of domain-general skills (Blakey et al., 2016). The most important skills in this regard are basic control of attention and early representational skills such as language, which underpin the development of CF in the first two years of life; as well as inhibitory control and working memory, which support the development of CF from around three years onwards.

During the first two years of life, early CF skills are supported by attentional control abilities and language. Both of these abilities have been shown to be important for the early development of goal-oriented actions (Hendry et al., 2016). That is, as children direct their attention to and verbalize the relevant aspect of a stimulus, they tend to have greater mental representations of the relevant information about the stimulus (Marcovitch & Zelazo, 2009). As a result of the greater mental representations, children can display increased control on directing or modifying their behavior (Kuhn et al., 2016). For instance, Miller and Marcovitch (2015) examined how attention and language abilities of 14-month-olds are related to executive function abilities of those children when they are 18 months of age. The findings demonstrated a positive correlation between children's performance on a variety of executive function measures and their attentional and language abilities, as measured by the frequency of focusing on others' behaviors and early vocabulary, respectively. Even in younger children, correlations between executive functioning and attention have been documented. Researchers showed that executive function abilities of 14-month-olds were significantly predicted by the attentional abilities of those children when they were at four months of age (Devine et al., 2019). Thus, the foundation of CF is supported early in life by attentional and linguistic processes.

Inhibitory control and working memory have been found to underpin CF development from around three years, with each making a distinct contribution to successful switching behavior. For instance, Blakey and colleagues (2016) tested how inhibitory control and working memory contribute to two- to four-year-olds' switching behavior by using different versions of the SwIFT: A *Distracting* SwIFT and a *Conflicting* SwIFT. In the Distracting SwIFT, without having the need of resolving the response conflict, children should update their sorting from the old rule to the new rule. Conversely, in the Conflicting SwIFT, children should update their sorting rule while also considering the response conflict because in that version of the SwIFT children could continue to sort by the previous rule when the rule changed. It was found that switching when there is no conflict to resolve was associated with higher *inhibitory control* scores. On the other hand, switching when there is a conflict to resolve was associated with higher *working* *memory* scores (Blakey et al., 2016). This offers that inhibitory control tends to contribute to CF through allowing children to disregard task-unrelated information while working memory tends to contribute to CF through allowing children to maintain and update the new sorting rule.

Conclusion and Future Directions in Cognitive Flexibility Research

The present paper has reviewed the development of CF and has outlined important recent advances in its assessment and analysis. It concludes that CF is best conceived of as an example of the flexible goal-oriented behavior that children learn to produce gradually during the first six years. It also highlights the importance of recognizing the complexity of children's switching behavior. As a consequence, when assessing this behavior, it is essential that researchers use tasks that allow children to respond freely, and analytic techniques capable of capturing the complexity of such responses. In the light of these recent developments, the existing theories of CF need to be updated so that they offer explanations about the development of CF more inclusively; through considering different kinds of switching behavior (e.g., overcoming distractions) that happens across a broader age range (e.g., from infancy and toddlerhood and to adolescence) and that is supported by more diverse kinds of abilities (e.g., attention and language in addition to inhibitory control and working memory).

Recent advances in CF research have highlighted a number of important points to be taken on board in future research. First, it is important to see CF not as a stand-alone executive function that emerges spontaneously at around three to four years of age; but rather as an integral part of the kind of flexible goal-oriented behavior that emerges gradually during the first six years of life (also see Doebel, 2020). This point bears emphasizing, not merely to situate research within an appropriate context, but also to avoid any tendency to rely on single tasks as the "best" measure of CF. Indeed, it is important for future research to develop multiple measures of CF that can be used in early childhood, as using multiple tasks and creating latent variables help minimize any error due to task impurity (Best et al., 2009; Hughes & Graham, 2002; Miyake et al., 2000).

Second, when studying the development of CF, it is essential to realize that children can respond to switching tasks in a variety of ways. Therefore, the tasks used to assess CF should reflect this variety. A criticism consistently levelled at the DCCS task is that its design only allows children to make perseverative errors since the two possible response options are to sort correctly by the post-switch rule, or incorrectly by the pre-switch rule (Carroll et al., 2016). It is known that children can make distraction errors or errors of inattention, so researchers should opt to use switching tasks that allow a broader range of behaviors.

Third, because children are capable of responding in qualitatively different ways when attempting to switch, researchers need advanced analytic techniques that can capture these differences. It is apparent from the line of work that was explained in previous sections that simply calculating the total number of successful switches in a block of trials is likely to miss crucial and informative aspects of children's performance so more precise analytic approaches should be considered.

Fourth, to properly unpick the mechanisms underpinning flexible goal-oriented behavior in children, it is essential to look at contributing domain-general processes. It is known that inhibitory control and working memory promote switching in the preschool and early school years. Conversely, there are a number of studies that show early goal-oriented behavior is supported by attentional control and language abilities, though the precise nature and duration of this support remains to be elucidated by future research.

Peer-review: Externally peer-reviewed.
Author Contributions: Conception/Design of Study- Y.Y.D., D.C., E.B.; Drafting Manuscript- Y.Y.D., D.C., E.B.; Critical Revision of Manuscript- Y.Y.D., D.C., E.B.; Final Approval and Accountability- Y.Y.D., D.C., E.B.
Conflict of Interest: The authors have no conflict of interest to declare.
Grant Support: The authors declared that this study has received no financial support.

Hakem Değerlendirmesi: Dış bağımsız.
Yazar Katkıları: XXXXXXX
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemiştir.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadığını beyan etmiştir.

References/Kaynakça

Atkinson, J., Hood, B., Wattam-Bell, J., & Braddick, O. (1992). Changes in infants' ability to switch visual attention in the first three months of life. *Perception*, *21*(5), 643-653. https://doi.org/10.1068/p210643

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development, 81*(6), 1641-1660. https://doi.org/10.1111/j.1467-8624.2010.01499.x

Best, J. R., Miller, P. H., & Jones, L. L. (2009). Executive functions after age 5: Changes and correlates. *Developmental Review*, *29*(3), 180-200. https://doi.org/10.1016/j.dr.2009.05.002

Blakey, E., Visser, I., & Carroll, D. J. (2016). Different executive functions support different kinds of cognitive flexibility: Evidence from 2-, 3-, and 4-year-olds. *Child Development*, *87*(2), 513-526. https://doi.org/10.1111/cdev.12468

Brooks, P. J., Hanauer, J. B., Padowska, B. & Rosman, H. (2003). The role of selective attention in preschoolers' use in a novel dimensional card sort. *Cognitive Development*, *18*(2), 195-215. https://doi.org/10.1016/S0885-2014(03)00020-0Buchsbaum, B. R., Greer, S., Chang, W. L., & Berman, K. F. (2005). Meta-analysis of neuroimaging studies of the Wisconsin Card-Sorting task and component processes. *Human Brain Mapping, 25*(1), 35-45. https://doi.org/10.1002/hbm.20128

Carlson, S. M. (2005). Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*, *28*(2), 595–616. https://doi.org/10.1207/s15326942dn2802_3

Carlson, S. M., Mandell, D. J., & Williams, L. (2004). Executive function and theory of mind: Stability and prediction from ages 2 to 3. *Developmental Psychology*, *40*(6), 1105 –1122. https://doi.org/10.1037/0012-1649.40.6.1105

Carlson, S. M., & Zelazo, P. D. (2014). Minnesota Executive Function Scale–Test Manual. St. Paul, MN: Reflection Sciences.

Carroll, D. J., Blakey, E., & FitzGibbon, L. (2016). Cognitive flexibility in young children: Beyond perseveration. *Child Development Perspectives*, *10*(4), 211-215. https://doi.org/10.1111/cdep.12192

Chevalier, N., & Blaye, A. (2008). Cognitive flexibility in preschoolers: The role of representation activation and maintenance. *Developmental Science*, *11*(3), 339–353. https://doi.org/10.1111/j.1467-7687.2008.00679.x

Chevalier, N., & Blaye, A. (2009). Setting goals to switch between tasks: Effect of cue transparency on children's cognitive flexibility. *Developmental Psychology*, *45*(3), 782-797. https://doi.org/10.1037/a0015409

Chevalier, N., Sheffield, T. D., Nelson, J. M., Clark, C. A. C., Wiebe, S. A., & Espy, K. A. (2012). Underpinnings of the costs of flexibility in preschool children: The roles of working memory and inhibition. *Developmental Neuropsychology*, *37*(2), 99–118. https://doi.org/10.1080/87565641.2011.632458

Clark, C. A., Sheffield, T. D., Wiebe, S. A., & Espy, K. A. (2013). Longitudinal associations between executive control and developing mathematical competence in preschool boys and girls. *Child Development*, *84*(2), 662-677. https://doi.org/10.1111/j.1467-8624.2012.01854.x

Clearfield, M. W., Diedrich, F. J., Smith, L. B., & Thelen, E. (2006). Young infants reach correctly in A-not-B tasks: On the development of stability and perseveration. *Infant Behavior and Development, 29*(3), 435-444. https://doi.org/10.1016/j.infbeh.2006.03.001

Clearfield, M. W., & Niman, L. C. (2012). SES affects infant cognitive flexibility. *Infant Behavior and Development, 35*(1), 29-35. https://doi.org/10.1016/j.infbeh.2011.09.007

Cragg, L., & Chevalier, N. (2012). The processes underlying flexibility in childhood. *Quarterly Journal of Experimental Psychology*, *65*(2), 209-232. https://doi.org/10.1080/17470210903204618

Cragg, L., & Nation, K. (2009). Shifting development in mid-childhood: The influence of between-task interference. *Developmental Psychology*, *45*(5), 1465. https://doi.org/10.1037/a0015360

Dauvier, B., Chevalier, N., & Blaye, A. (2012). Using a finite mixture of GLMs to explore variability in children's flexibility in a task-switching paradigm. *Cognitive Development*, *27*(4), 440-454. https://doi.org/10.1016/j.cogdev.2012.07.004

Davidson, M. C., Amso, D., Anderson, L. C., & Diamond, A. (2006). Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching. *Neuropsychologia*, *44*(11), 2037-2078. https://doi.org/10.1016/j.

neuropsychologia.2006.02.006

Deak, G. O., & Narasimham, G. (2003). Is perseveration caused by inhibition failure? Evidence from preschool children's inferences about word meanings. *Journal of Experimental Child Psychology*, *86*(3), 194-222. https://doi.org/10.1016/j.jecp.2003.08.001

Devine, R. T., Ribner, A., & Hughes, C. (2019). Measuring and predicting individual differences in executive functions at 14 months: A longitudinal study. *Child Development*, *90*(5), e618-e636. https://doi.org/10.1111/cdev.13217

Diamond, A. (1985). Development of the ability to use recall to guide action, as indicated by infants' performance on AB. *Child Development*, *56*(4), 868-883. https://doi.org/10.2307/1130099

Diamond, A., Carlson, S., & Beck, D. (2005). Preschool children's performance in task switching on the Dimensional Change Card Sort Task: Separating dimensions aids the ability to switch. *Developmental Neuropsychology, 28(2)*, 689–729. https://doi.org/10.1207/s15326942dn2802_7

Doebel, S. (2020). Rethinking executive function and its development. *Perspectives on Psychological Science, 15*(4), 942-956. https://doi.org/10.1177/1745691620904771

Doebel, S., & Zelazo, P. D. (2013). Bottom-up and top-down dynamics in young children's executive function: Labels aid 3-year-olds' performance on the Dimensional Change Card Sort. *Cognitive Development, 28*(3), 222-232. https://doi.org/10.1016/j.cogdev.2012.12.001

Doebel, S., & Zelazo, P. D. (2015). A meta-analysis of the Dimensional Change Card Sort: Implications for developmental theories and the measurement of executive function in children. *Developmental Review*, *38*, 241-268. https://doi.org/10.1016/j.dr.2015.09.001

Ellis, A. E., & Oakes, L. M. (2006). Infants flexibly use different dimensions to categorise objects. *Developmental Psychology, 42*(6), 1000. https://doi.org/10.1037/0012-1649.42.6.1000

Espy, K. A. (1997). The Shape School: Assessing executive function in preschool children. *Developmental Neuropsychology*, *13*(4), 495-499. https://doi.org/10.1080/87565649709540690

Evans, J. S. B., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science, 8*(3), 223-241. https://doi.org/10.1177/1745691612460685

Fisher, A. V. (2011a). Automatic shifts of attention in the Dimensional Change Card Sort task: Subtle changes in task materials lead to flexible switching. *Journal of Experimental Child Psychology, 108*(1), 211-219. https://doi.org/10.1016/j.jecp.2010.07.001

Fisher, A. V. (2011b). Processing of perceptual information is more robust than processing of conceptual information in preschool-age children: Evidence from costs of switching. *Cognition, 119*(2), 253-264. https://doi.org/10.1016/j.cognition.2011.01.015

Garon, N., Bryson, S. E., & Smith, I. M. (2008). Executive function in preschoolers: A review using an integrative framework. *Psychological Bulletin*, *134*(1), 31–60. https://doi.org/10.1037/0033-2909.134.1.31

Garon, N., Smith, I. M., & Bryson, S. E. (2014). A novel executive function battery for preschoolers: Sensitivity to age differences. *Child Neuropsychology, 20*(6), 713-736. https://doi.org/10.1080/09297049.2013.857650

Grant, D. A., & Berg, E. A. (1948). *Wisconsin Card Sorting Test* [Database record]. APA PsycTests. https://doi.org/10.1037/t31298-000

Hendry, A., Jones, E. J., & Charman, T. (2016). Executive function in the first three years of life: Precursors, predictors and patterns. *Developmental Review*, *42*, 1-33. https://doi.org/10.1016/j.dr.2016.06.005

Holmboe, K., Fearon, R. P., Csibra, G., Tucker, L. A., & Johnson, M. H. (2008). Freeze-Frame: A new infant inhibition task and its relation to frontal cortex tasks during infancy and early childhood. *Journal of Experimental Child Psychology*, *100*(2), 89-114. https://doi.org/10.1016/j.jecp.2007.09.004

Hongwanishkul, D., Happaney, K. R., Lee, W. S., & Zelazo, P. D. (2005). Assessment of hot and cool executive function in young children: Age-related changes and individual differences. *Developmental Neuropsychology, 28*(2), 617-644. https://doi.org/10.1207/s15326942dn2802_4

Hughes, C., & Graham, A. (2002). Measuring executive functions in childhood: Problems and solutions? *Child and Adolescent Mental Health, 7*(3), 131-142. https://doi.org/10.1111/1475-3588.00024

Huizinga, M., & Van der Molen, M. W. (2007). Age-group differences in set-switching and set-maintenance on the Wisconsin Card Sorting Task. *Developmental Neuropsychology, 31*(2), 193-215. https://doi.org/10.1080/87565640701190817

Hunnius, S., Geuze, R. H., & Van Geert, P. (2006). Associations between the developmental trajectories of visual scanning and disengagement of attention in infants. *Infant Behavior and Development*, *29*(1), 108-125. https://doi.org/10.1016/j.infbeh.2005.08.007

Ionescu, T. (2017). The variability-stability-flexibility pattern: A possible key to understanding the flexibility of the human mind. *Review of General Psychology, 21*(2), 123-131. https://doi.org/10.1037/gpr0000110

Ionescu, T. (2019). Putting the variability–stability–flexibility pattern to use: Adapting instruction to how children develop. *New Ideas in Psychology, 55*, 18-23. https://doi.org/10.1016/j.newideapsych.2019.04.003

Johansson, M., Marciszko, C., Brocki, K., & Bohlin, G. (2016). Individual differences in early executive functions: A longitudinal study from 12 to 36 months. *Infant and Child Development, 25(6)*, 533-549. https://doi.org/10.1002/icd.1952

Johnson, M. H., Posner, M. I., & Rothbart, M. K. (1991). Components of visual orienting in early infancy: Contingency learning, anticipatory looking, and disengaging. *Journal of Cognitive Neuroscience*, *3*(4), 335-344. https://doi.org/10.1162/jocn.1991.3.4.335

Jordan, P. L., & Morton, J. B. (2008). Flankers facilitate 3-year-olds' performance in a card-sorting task. *Developmental Psychology, 44*(1), 265. https://doi.org/10.1037/0012-1649.44.1.265

Kirkham, N. Z., Cruess, L., & Diamond, A. (2003). Helping children apply their knowledge to their behavior on a dimension-switching task. *Developmental Science, 6*(5), 449-467. https://doi.org/10.1111/1467-7687.00300

Kloo, D., & Perner, J. (2005). Disentangling dimensions in the dimensional change card-sorting task. *Developmental Science, 8*(1), 44-56. https://doi.org/10.1111/j.1467-7687.2005.00392.x

Kloo, D., Perner, J., Aichhorn, M., & Schmidhuber, N. (2010). Perspective taking and cognitive flexibility in the Dimensional Change Card Sorting (DCCS) task. *Cognitive Development, 25*(3), 208-217. https://doi.org/10.1016/j.cogdev.2010.06.001

Kuhn, L. J., Willoughby, M. T., Vernon-Feagans, L., Blair, C. B., & Family Life Project Key Investigators (2016). The contribution of children's time-specific and longitudinal expressive language skills on developmental trajectories of executive function. *Journal of Experimental Child Psychology*, *148*, 20-34. https://doi.org/10.1016/j.jecp.2016.03.008

Kulke, L., Atkinson, J., & Braddick, O. (2015). Automatic detection of attention shifts in infancy: Eye tracking in the fixation shift paradigm. *PloS One*, *10*(12), e0142505. https://doi.org/10.1371/journal.pone.0142505

Marcovitch, S., O'Brien, M., Calkins, S. D., Leerkes, E. M., Weaver, J. M., & Levine, D. W. (2015). A longitudinal assessment of the relation between executive function and theory of mind at 3, 4, and 5 years. *Cognitive Development*, *33*, 40-55. https://doi.org/10.1016/j.cogdev.2014.07.001

Marcovitch, S., & Zelazo, P. D. (2009). A hierarchical competing systems model of the emergence and early development of executive function. *Developmental Science*, *12*(1), 1-18. https://doi.org/10.1111/j.1467-7687.2008.00754.x

Miller, S. E., & Marcovitch, S. (2015). Examining executive function in the second year of life: Coherence, stability, and relations to joint attention and language. *Developmental Psychology*, *51*(1), 101–114. https://doi.org/10.1037/a0038359

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41*(1), 49-100. https://doi.org/10.1006/cogp.1999.0734

Morton, J. B., & Munakata, Y. (2002). Active versus latent representations: A neural network model of perseveration, dissociation, and decalage. *Developmental Psychobiology, 40*(3), 255-265. https://doi.org/10.1002/dev.10033

Muller, U., Dick, A. S., Gela, K., Overton, W. F., & Zelazo, P. D. (2006). The role of negative priming in preschoolers' flexible rule use on the Dimensional Change Card Sort task. *Child Development*, *77*(2), 395– 412. https://doi.org/10.1111/j.1467-8624.2006.00878.x

Muller, U., Zelazo, P. D., Hood, S., Leone, T., & Rohrer, L. (2004). Interference control in a new rule use task: Age-related changes, labelling, and attention. *Child Development, 75*(5), 1594-1609. https://doi.org/10.1111/j.1467-8624.2004.00759.x

Munakata, Y., Snyder, H. R., & Chatham, C. H. (2012). Developing cognitive control: Three key transitions. *Current Directions in Psychological Science, 21*(2), 71–77. https://doi.org/10.1177/0963721412436807

Perner, J., & Lang, B. (2002). What causes 3-year-olds' difficulty on the dimensional change card sorting task? *Infant and Child Development: An International Journal of Research and Practice, 11*(2), 93-105. https://doi.org/10.1002/icd.299

Perone, S., Palanisamy, J., & Carlson, S. M. (2018). Age-related change in brain rhythms from early to middle childhood: Links to executive function. *Developmental Science, 21*(6), e12691. https://doi.org/10.1111/desc.12691

Phipps, D. J., Hagger, M. S., & Hamilton, K. (2019, April 24). A Meta-Analysis of implicit and explicit attitudes in children and adolescents "Retrieved from https://osf.io/hycbp/". https://doi.org/10.31234/osf.io/52jrs

Piaget, J. (1954). *The construction of reality in the child.* (M. Cook, Trans.). Basic Books.

Reimers, S., & Maylor, E. A. (2005). Task switching across the life span: effects of age on general and specific switch costs. *Developmental Psychology, 41*(4), 661. https://doi.org/10.1037/0012-1649.41.4.661

Rennie, D. A., Bull, R., & Diamond, A. (2004). Executive functioning in preschoolers: Reducing the inhibitory demands of the dimensional change card sort task. *Developmental Neuropsychology, 26*(1), 423-443. https://doi.org/10.1207/s15326942dn2601_4

Towse, J. N., Redbond, J., Houston-Price, C. M. T., & Cook, S. (2000). Understanding the dimensional change card sort: Perspectives from task success and failure. *Cognitive Development*, *15*, 347-365. https://doi.org/10.1016/S0885-2014(00)00021-6

van Bers, B. M., Visser, I., van Schijndel, T. J., Mandell, D. J., & Raijmakers, M. E. (2011). The dynamics of development on the Dimensional Change Card Sorting task. *Developmental Science, 14*(5), 960-971. https://doi.org/10.1111/j.1467-7687.2011.01045.x

van der Maas, H.L.J., & Straatemeier, M. (2008). How to detect cognitive strategies: Commentary on

‘Differentiation and integration: guiding principles for analysing cognitive change’. *Developmental Science, 11*, 449–453. https://doi.org/10.1111/j.1467-7687.2008.00690.x

Wang, X., Liu, X., & Feng, T. (2021). The continuous impact of cognitive flexibility on the development of emotion understanding in children aged 4 and 5 years: A longitudinal study. *Journal of Experimental Child Psychology*, *203*, 105018. https://doi.org/10.1016/j.jecp.2020.105018

Wiebe, S. A., & Bauer, P. J. (2005). Interference from additional props in an elicited imitation task: When in sight, firmly in mind. *Journal of Cognition and Development*, *6*(3), 325-363. https://doi.org/10.1207/s15327647jcd0603_2

Wiebe, S. A., Lukowski, A. F., & Bauer, P. J. (2010). Sequence imitation and reaching measures of executive control: A longitudinal examination in the second year of life. *Developmental Neuropsychology*, *35*(5), 522–538. https://doi.org/10.1080/87565641.2010.494751

Yerys, B. E., & Munakata, Y. (2006). When labels hurt but novelty helps: Children’s perseveration and flexibility in a card-sorting task. *Child Development*, *77*(6), 1589-1607. https://doi.org/10.1111/j.1467-8624.2006.00961.x

Zelazo, P. D. (2004). The development of conscious control in childhood. *Trends in Cognitive Sciences, 8*(1), 12– 17. https://doi.org/10.1016/j.tics.2003.11.001

Zelazo, P. D. (2006). The Dimensional Change Card Sort (DCCS): A method of assessing executive function in children. *Nature Protocols*, *1*, 297–301. https://doi.org/10.1038/nprot.2006.46

Zelazo, P. D. (2015). Executive function: Reflection, iterative reprocessing, complexity, and the developing brain. *Developmental Review, 38*, 55-68. https://doi.org/10.1016/j.dr.2015.07.001

Zelazo, P. D., Frye, D., & Rapus, T. (1996). An age-related dissociation between knowing rules and using them. *Cognitive Development*, *11*(1), 37-63. https://doi.org/10.1016/S0885-2014(96)90027-1