# An exploration of cognitive flexibility development in South African 4- and 5-year-olds

La Raiba Mehmood | 2315152

School of Human and Community Development

Psychology Department

University of the Witwatersrand

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Supervisor:

Professor Kate Cockcroft

## Declaration

A research project submitted in partial fulfilment of the requirements for the degree of MA by coursework and research report in the field of Psychology in the Faculty of Humanities, University of the Witwatersrand, Johannesburg, 2025.

I declare that this research project is my own, unaided work. It has not been submitted before for any other degree or examination at this or any other university.

Signed: Date: 07 March 2025

## Abstract

This study explored the development of cognitive flexibility (CF) in South African preschoolers aged 4 to 5 years using the Three-Dimensional Change Card Sort (3DCCS) task. A mixed-methods approach integrated quantitative analysis of 3DCCS scores with qualitative Reflexive Thematic Analysis of participant engagement with the task. The study included a sample of 51 children. Quantitative results revealed a significant positive correlation between age and CF scores ($\rho = .45$, $p < .01$), while sex, socioeconomic status (SES) and bilingualism did not significantly predict CF outcomes. Qualitative findings highlighted diverse engagement strategies, including verbal and visual strategies, and physical interaction with task materials, reflecting developmental differences in CF. Observed behaviours ranged from confident independence to hesitation and external validation-seeking, showcasing individual variances in task adaptation. These findings underscore the importance of age as a primary factor in CF development and validate the applicability of the 3DCCS in non-WEIRD contexts. This research contributes to understanding early childhood cognitive development in culturally and linguistically diverse populations, with implications for educational interventions.


*Keywords*: cognitive flexibility, Three-Dimensional Change Card Sort (3DCCS) task, bilingualism, non-WEIRD, socioeconomic status, 4- and 5-year-olds, young children

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# Chapter 1: Theoretical and Conceptual Background

## 1. Introduction

Cognitive flexibility facilitates adaptive thought and behaviour in response to changing environments. It is an essential component of executive functions, intertwined with working memory and inhibitory control, supporting individuals in shifting between tasks, regulating attention, and adopting new strategies when confronted with change (Miyake et al., 2000; Dajani & Uddin, 2015). This cognitive ability develops rapidly during early childhood, particularly between the ages of 4 and 5 years, a period marked by significant advancements in executive function (EF) components (Best et al., 2009). Understanding how cognitive flexibility emerges and evolves during this formative stage is crucial for elucidating the underlying mechanisms that govern adaptive behaviour and cognitive development.

Research on cognitive flexibility has largely been conducted in WEIRD (Western, Educated, Industrialized, Rich, and Democratic; Henrich et al., 2010) contexts, highlighting the need to examine its development within diverse populations from low- and middle-income countries (LMIC), such as South Africa. South Africa's unique socio-economic and linguistic landscape presents an opportunity to explore how contextual factors, such as bilingualism and socio-economic status (SES), intersect with cognitive flexibility. The relationship between these factors and cognitive flexibility remains nuanced, with mixed findings in existing literature underscoring the need for further investigation (Crivello et al., 2016; Poon et al., 2022).

To assess cognitive flexibility in South African preschoolers, this study employed the Three-Dimensional Change Card Sort (3DCCS) task (Zelazo, 2006), a validated tool that captures developmental shifts in cognitive adaptability through its multidimensional framework (Deák & Wiseheart, 2015). The 3DCCS offers a means of examining how young children manage increasingly complex cognitive demands and adapt to changes in rules. While widely validated in WEIRD populations, the applicability of the 3DCCS within non-WEIRD settings like South Africa remains underexplored. Thus, this study seeks to evaluate the tool's suitability for this context and to understand how cognitive flexibility development may be influenced by age, sex, SES, and linguistic diversity.

## 2. Cognitive flexibility

Cognitive flexibility (CF), also referred to as set-shifting or switching, is the ability to adapt thoughts and behaviours in response to changing demands, rules, or environmental contexts (Armbruster et al., 2012; Cañas et al., 2003). This skill allows individuals to transition seamlessly between tasks, reorganize response strategies, and employ these strategies effectively in new situations (Dajani & Uddin, 2015). Central to CF is the capacity to focus on relevant information for an upcoming task while disengaging from information that is no longer pertinent (Armbruster et al., 2012). This adaptability enables individuals to think creatively, adopt alternative perspectives, and respond flexibly in dynamic environments (Buttelmann & Karbach, 2017).

Cognitive flexibility is a core component of executive functions (EFs), a set of higher-order cognitive processes that include working memory and inhibitory control. Working memory involves maintaining and manipulating information, while inhibitory control suppresses inappropriate responses or interference from irrelevant information. Cognitive flexibility complements these processes by allowing individuals to shift behaviours and thought patterns in line with new task rules or changing goals (Miyake et al., 2000). Together, these EF components form an interconnected system that supports goal-directed behaviour and problem-solving in complex situations.

Rather than functioning as an isolated cognitive process, CF is increasingly viewed as an emergent property of successful cognition, arising from the dynamic interplay of working memory and inhibitory control (Dajani & Uddin, 2015). For example, shifting flexibly between tasks or mental representations requires the ability to hold multiple rules in working memory while simultaneously inhibiting previously applied or irrelevant rules (Anderson & Reidy, 2012; Garon et al., 2008). This interdependence highlights the intricate nature of CF as it draws upon multiple cognitive resources to achieve adaptive behaviour.

The development of CF is closely tied to the maturation of its foundational components, particularly working memory and inhibitory control. Improvements in these underlying skills contribute significantly to the emergence of CF during early childhood (Cragg & Chevalier, 2012). However, the precise mechanisms and contributions of these components remain an area of ongoing investigation. Cognitive flexibility is further influenced by individual differences and environmental factors, making its developmental trajectory highly variable (Chevalier & Blaye, 2009). This complexity underscores the multifaceted nature of CF and its reliance on the coordinated functioning of various cognitive processes.

To assess cognitive flexibility, researchers often use tasks that require participants to switch between rules while inhibiting previously applied ones. A widely used measure is the Dimensional Change Card Sort (DCCS) task (Zelazo et al., 2003). In this task children are required to sort picture cards based on one dimension, such as colour, and then they must switch to sorting the cards by another dimension, such as shape. Each card contains dual features (e.g., red fish), which introduces response conflict during the post-switch phase. Successfully completing the task requires children to inhibit the prior sorting rule, maintain the new goal, and selectively focus on the relevant feature of the stimulus (Cragg & Chevalier, 2009). Performance on the DCCS task reflects developmental improvements in CF, with older children demonstrating greater flexibility due to advances in EF components.

Thus, to fully grasp the mechanisms underlying cognitive flexibility, it is crucial to examine its developmental trajectory, beginning in infancy and continuing through early childhood, where significant changes occur.

## *3.* Development of Cognitive Flexibility

The development of cognitive flexibility begins in infancy and progresses throughout life, undergoing substantial transformations across different developmental stages, enabling individuals to navigate complex and dynamic environments effectively (Blakey et al., 2015). This executive function is critical for adapting thoughts and behaviours to meet changing demands and circumstances and is associated with positive outcomes such as academic achievement, creativity, problem-solving skills, and social adaptability (Blakey et al., 2015; Armbruster et al., 2012; Buttelmann & Karbach, 2017). Understanding the developmental trajectory of CF offers valuable insights into how biological maturation interacts with environmental influences to shape cognitive growth, as well as how best to measure it at different points in the lifespan (Blakey et al., 2015).

During infancy, behaviour shifts from reactive responses to more controlled, goal-directed actions. By around six months of age, infants demonstrate the ability to form and update stimulus-response associations, signalling early CF development (Wiebe et al., 2010). Eye movement, an early form of controlled behaviour, reflects an infant’s capacity to selectively focus on relevant environmental stimuli. This attentional control serves as a precursor to broader executive functions, marking the emergence of more advanced cognitive regulation (Sheese et al., 2008).

By eight months, infants often display perseverative errors, such as persistently searching for an object in its original hiding place despite observing it being moved. These behaviours reflect challenges in inhibitory control and working memory, two executive functions that are correlated with cognitive flexibility (Diamond, 1985). By approximately one year, improvements in working memory allow infants to manage active and stored information more effectively, supporting more adaptive behaviours (Blakey et al., 2015). This progress is further evident by the age of two, as infants develop the ability to imitate observed actions while disregarding irrelevant distractions, highlighting advancements in attentional control and information maintenance (Wiebe et al., 2010).

By this stage, children can sort objects based on simple rules and, crucially, switch between these rules when required (Blakey et al., 2015). Tasks such as reversal categorization, where children alternate between sorting objects by one rule and then its opposite, demonstrate emerging flexible thinking abilities (Carlson et al., 2004). These foundational skills are strongly predictive of later developmental outcomes, such as theory of mind and academic engagement, as shown in longitudinal studies (Fitzpatrick & Pagani, 2012; Hughes & Ensor, 2007). Between the ages of two and three, growth in inhibitory control allows children to suppress irrelevant information, enabling them to focus on task-relevant details more effectively (Garon et al., 2008).

By age three, children begin to shift between rules more proficiently, although tasks involving response conflicts, such as sorting objects by one dimension (e.g., shape) and then switching to another (e.g., colour), may still pose challenges. This difficulty arises because children must suppress the previously learned rule while adapting to the new one, requiring advances in inhibitory control and working memory. The DCCS task is a widely used measure of CF during this stage. In this task, children sort picture cards by one dimension, such as colour, and are later instructed to switch to sorting by another dimension, such as shape. Importantly, the cards are bi-dimensional (e.g., a blue dog), requiring children to suppress the previously relevant sorting rule and adapt to the new one (Zelazo et al., 2003). Three-year-olds often struggle with this task, exhibiting perseveration by continuing to sort according to the original rule despite instructions to switch. However, modifications to the DCCS task have revealed that even three-year-olds can succeed when the cognitive demands of the task are reduced, for instance, reducing response conflicts or incorporating visual prompts (Kloo & Perner, 2005). These findings underscore the critical role of inhibitory control and working memory in facilitating CF during the preschool years.

By the age of four, most children successfully adapt to the new rule, demonstrating substantial advancements in CF and related executive functions (Chatham et al., 2012). To assess CF in children aged four to six years-old, researchers use more complex tasks involving multiple rule switches, a skill sometimes used interchangeably with CF but specifically referred to as set-shifting (Blakey et al., 2015). These tasks demand higher cognitive capabilities by incorporating additional dimensions such as colour, shape, and size (Jacques & Zelazo, 2001). At this stage, children also develop goal-setting abilities, which enable them to interpret task cues and translate these into actionable rules. These emerging skills are essential for succeeding in CF assessments like the Three-Dimensional Change Card Sort (3DCCS), which extends the traditional Dimensional Change Card Sort (DCCS) by increasing cognitive complexity through an added third dimension, requiring children to process multiple rules simultaneously and flexibly adapt to more intricate sorting demands (Blakey et al., 2015).

This gradual development of CF from infancy to the preschool years highlights its foundational role in adaptive behaviour. Improvements in working memory and inhibitory control provide the cognitive infrastructure for flexible thinking, enabling children to adapt their behaviour to changing contexts (Blakey et al., 2015). The refinement of CF during these early years lays the groundwork for later positive outcomes, including enhanced academic performance and better problem-solving skills. For instance, studies have demonstrated that CF is strongly associated with higher reading comprehension, mathematical abilities, and overall academic success (Engel de Abreu et al., 2014; Yeniad et al., 2013). Colé et al. (2014) found that CF predicted reading skills in second graders, while Santana et al. (2022) showed that CF was a significant predictor of math and reading performance in children aged 4 to 13 years.

These findings extend beyond WEIRD populations, emphasizing the universal importance of CF development while accounting for cultural and environmental influences. Studies conducted in diverse settings, including South Korea, Taiwan, and China, have consistently demonstrated a positive relationship between CF and academic performance in literacy and mathematics (Lan et al., 2011; Ponitz et al., 2009; McClelland et al., 2014). Such cross-cultural findings provide a valuable foundation for examining CF in non-WEIRD contexts like South Africa, where socio-economic and linguistic diversity may uniquely shape its development. Investigating CF in South African preschoolers aged four and five years offers an opportunity to explore these influences and contribute to a deeper understanding of cognitive flexibility during early childhood.

The developmental progression of cognitive flexibility underscores the importance of a theoretical lens to understand the interplay of underlying executive function components. The Unity and Diversity Model (Miyake et al., 2000) offers a framework for explaining how cognitive flexibility interacts with working memory and inhibitory control.

## *4.* Theoretical Framework: Unity and Diversity Model (Miyake et al., 2000)

The Unity and Diversity Model of Executive Functions (Miyake et al., 2000) provides the theoretical foundation for this study, offering a comprehensive framework to understand cognitive flexibility and its interconnectedness with other EFs. This model emphasizes the relationship between cognitive flexibility, working memory, and inhibitory control, and although it focuses on EFs in adults, it is also relevant for examining the development of cognitive flexibility in South African preschoolers. Wiebe et al. (2008) suggests that during the preschool years, executive functions may initially emerge as a unitary construct rather than the distinct components observed in adults. Similarly, Hughes et al. (2009) highlight that while EF components become more differentiated with age, early developmental stages often reveal overlapping processes, further supporting the applicability of this model to young children. By applying this theory within the unique cultural and socio-economic context of South Africa, the study aims to illuminate how these cognitive processes interact and are influenced by diverse environmental factors. The theory's emphasis on both the shared and distinct relationships between cognitive flexibility, inhibitory control and working memory make it a suitable framework for this research (Miyake et al., 2000).

The Unity and Diversity Theory emerged to address the complexity of EFs as a multidimensional construct. Miyake et al. (2000) proposed that EFs are composed of three core components: working memory updating, inhibitory control, and cognitive flexibility. These components share a common neurological foundation, facilitating cognitive control across tasks, yet they also operate independently in specific contexts (Karr et al., 2018). In particular, cognitive flexibility is crucial for managing complex tasks, shifting perspectives, and solving problems, particularly during early childhood when executive functions undergo rapid development (Zelazo, 2006).

The Unity and Diversity Model represents the end goal of mature, adult EF structure, where executive functions are characterized by distinct yet interrelated components such as working memory, inhibitory control, and cognitive flexibility (Miyake et al., 2000). However, during early childhood, the structure of executive functions is represented differently.

Research demonstrates that in infancy and early childhood, executive functions often manifest as a single, unified factor, reflecting total unity with little to no diversity (Wiebe et al., 2008; Hughes et al., 2009). This developmental difference underscores the importance of understanding the Unity and Diversity Model as a theoretical framework that illustrates the eventual differentiation of EFs while acknowledging that in young children, these functions remain largely undifferentiated and generalized. Such insights are crucial for interpreting EF development in early childhood within the context of this model. Furthermore, longitudinal studies have shown that this developmental trajectory begins before the age of five, with early signs of differentiation between working memory, inhibitory control, and cognitive flexibility becoming more pronounced over time (Huizinga et al., 2006; Willoughby et al., 2012). For instance, Lee et al. (2013) demonstrated in a study of Singaporean children aged 5 to 13 years that the three EFs are initially comprised of a generalized factor but gradually evolve into two distinct subdomains: working memory and a combined factor incorporating both inhibitory control and cognitive flexibility. Specifically, Lee et al. found that differentiation begins to emerge around age 6, suggesting that prior to this age—including in 4- and 5-year-olds—executive functions are predominantly unified. Additionally, Wiebe et al. (2008) used confirmatory factor analysis in a sample of preschoolers aged 2 to 6 years and found that EF structure at these younger ages is best represented as a single, unitary factor, further supporting the notion of limited differentiation in 4- and 5-year-olds. These findings highlight the dynamic nature of EF development and the importance of understanding its progression during early childhood.

The Unity and Diversity model (Miyake et al., 2000) has been widely applied in research examining the development and functioning of EFs across various contexts, providing a robust framework for understanding how these cognitive processes interact. For example, studies on children and adolescents have used it to investigate the impact of deficits in working memory and inhibitory control on academic performance, problem-solving abilities, and social interactions (Diamond, 2013). These applications have advanced our understanding of the interplay between EFs and adaptive behaviours, demonstrating that cognitive flexibility plays a pivotal role in enabling individuals to navigate complex and dynamic environments.

Research grounded in the Unity and Diversity model (Miyake et al., 2000) has also highlighted the influence of contextual factors on EF development. In non-WEIRD populations, studies have explored how cultural practices, socio-economic conditions, and educational systems shape the manifestation of EFs, including cognitive flexibility (Sabbagh et al., 2006; Meuwissen & Zelazo, 2014). For example, studies in East Asia have shown that cultural differences in parenting styles and educational practices influence the development of EFs, with implications for how children approach problem-solving and adapt to new tasks. Similarly, research in South Africa has shown that inhibition and working memory significantly predict pre-academic skills in preschoolers, whereas cognitive flexibility shows weaker associations with these skills (Cook et al., 2023). These findings suggest that while the Unity and Diversity Model's components are relevant, the relative contributions of these components may differ in culturally diverse settings like South Africa. Furthermore, the strong EF abilities observed in low-income South African children compared to high-income country norms highlight the role of unique contextual factors, such as multilingualism and collectivist cultural practices, in shaping EF development (Cook et al., 2023). These findings demonstrate the applicability of the Unity and Diversity model beyond Western contexts, emphasizing its relevance for examining EF development in diverse cultural settings.

In the context of South Africa, the Unity and Diversity model offers a valuable framework for exploring cognitive flexibility in preschool-aged children. South Africa's socio-economic and cultural diversity presents a unique opportunity to investigate how these factors influence the interaction of EFs. Linguistic diversity, for instance, is a hallmark of South African society, with many children growing up in bilingual or multilingual environments. By situating this study within the Unity and Diversity framework, it is possible to examine whether these contextual influences align with or diverge from findings in WEIRD populations. This model's emphasis on the interdependence of working memory, inhibitory control, and cognitive flexibility provides a comprehensive lens for understanding how socio-economic and cultural diversity shape cognitive flexibility development, offering both theoretical and practical insights into adaptive behaviour in the South African context.

While the Unity and Diversity Model offers a robust explanation of the mechanisms underlying cognitive flexibility, it is important to acknowledge that other models may also contribute valuable perspectives, particularly in early childhood. For example, the Dimensional Change Model (Zelazo, 2006) and the Hierarchical Competing Systems Model (Munakata, 2001) provide alternative frameworks for understanding the development of cognitive flexibility in young children. These models emphasize the role of rule-use and conflict resolution in executive functions, offering complementary insights to the Unity and Diversity Model. Furthermore, the development and manifestation of cognitive flexibility are shaped by various individual and contextual factors. Exploring age, bilingualism, and SES provides critical insights into the influences driving cognitive flexibility during early childhood, particularly within a culturally and linguistically diverse population.

## 5. Individual and Contextual Factors influencing Cognitive flexibility

As mentioned above, cognitive flexibility is influenced by multiple factors, reflecting the interplay of biological, social, and environmental determinants. Among these, age, bilingualism, and socioeconomic status (SES) stand out as particularly significant, shaping CF development in unique and complex ways (Best & Miller, 2010; Bialystok, 2001; Ursache & Noble, 2016). Thus, this study specifically investigates these factors in the context of South African preschoolers, aiming to explore how each contributes to the development of CF in early childhood.

### *5.1. Age*

Age is a crucial factor influencing the development of CF, particularly in preschool years when significant advancements in EFs such as working memory and inhibitory control occur. This study focuses on children aged 4 to 5 years, as this developmental window represents a pivotal period for CF growth (Blakey et al., 2015). During these years, children transition from rudimentary task-switching abilities to more sophisticated strategies, such as the ability to sort objects by one dimension (e.g., colour) and then flexibly switch to another dimension (e.g., shape), reflecting both quantitative improvements, such as faster response times and increased accuracy, and qualitative shifts, such as greater reliance on rule-based thinking in cognitive processing (Zelazo et al., 2003; Davidson et al., 2006).

Between the ages of 4 and 5 years, children's CF undergoes substantial refinement, driven by the maturation of foundational EFs, such as working memory and inhibitory control (Best et al., 2009). These abilities allow children to hold and manipulate task rules while suppressing previously learned responses, enabling them to switch between tasks more effectively. Davidson et al. (2006) further suggest that CF emerges as a potentially universal cognitive trait in all children of these ages, characterized by an increasing ability to adapt thought and behaviour to changing demands.

Quantitative changes in CF between ages 5 and 6 are often assessed through experimental tasks designed to measure CF. These assessments use dependent variables such as switch costs and mixing costs, which evaluate the efficiency and flexibility of task performance, providing insights into the developmental progression of CF (Blakey, 2015).

Switch costs measure the reaction time difference between tasks requiring a rule switch and those repeating the same rule, highlighting the demands on inhibitory control. Mixing costs, by contrast, assess the cognitive effort required to manage multiple tasks by comparing reaction times in blocks where children switch between tasks (mixed-task blocks) to blocks where they perform only one task repeatedly (single-task blocks). This comparison reflects the role of working memory in maintaining and coordinating multiple task rules simultaneously. However, in the present study, cognitive flexibility is assessed using CORSWOPS, which measures the proportion of correct switches relative to available switching opportunities. Unlike reaction-time-based measures such as switch and mixing costs, CORSWOPS provides a more direct assessment of children's ability to flexibly adapt to rule changes by considering actual task performance rather than response speed alone. This approach ensures that flexibility is evaluated in a manner that is developmentally appropriate for preschool-aged children (Deák & Wiseheart, 2015).

Studies consistently show that switch costs and mixing costs decrease significantly between the ages of 5 and 11, indicating progressive improvements in CF. For instance, Cragg and Nation (2009) found that reductions in task-switching costs during mid-childhood are associated with advancements in working memory, which facilitate the ability to use task cues to guide behaviour, and improvements in inhibitory control, which help minimize interference from previously relevant tasks. Similarly, Huizinga et al. (2006) and Kray et al. (2004) demonstrated that these improvements reflect both the efficiency of task-switching and the ability to manage competing cognitive demands, highlighting the interplay of multiple executive functions in CF development.

Beyond quantitative improvements, age-related changes in CF also reflect qualitative shifts in strategy use. Chevalier et al. (2013) conducted a study in the United States involving children aged 5 and 10, as well as young adults (18-24 years old), to investigate how different task cues influence CF performance. Participants were presented with either task cues (e.g., indicating the current sorting rule) or task cues accompanied by auditory transition cues (e.g., "different" to indicate a switch or "same" to maintain the rule). Results showed that transition cues enhanced accuracy among 5-year-olds but impaired performance among 10-year-olds and adults. The researchers argued that this discrepancy reflects a developmental shift in strategy use. Younger children rely on semantic processing of task cues, creating verbal labels to guide their actions, while older children and adults use a more efficient perceptual mismatch strategy, identifying task rules based on visual characteristics of the stimuli. This shift from verbal to visual perceptual strategies signifies a qualitative evolution in CF, where older individuals prioritize speed and efficiency in rule detection.

The preschool years also represent a time when children's task-switching abilities become more consistent and less prone to errors. Studies involving the DCCS task, reveal that 4-year-olds often struggle with perseveration, continuing to sort by the original rule despite instructions to switch. By age 5, however, most children can successfully adapt to new sorting rules, reflecting improved inhibitory control and working memory. Zelazo et al. (2003) demonstrated this developmental progression in Canadian preschoolers aged 3 to 5, highlighting the role of EF maturation in overcoming response conflicts and adopting new task goals.

Age-related improvements in CF are not limited to performance accuracy but also extend to speed and efficiency. Cepeda et al. (2001) examined task-switching abilities in children aged 6 to 10 years in the United States and found that older children exhibited faster reaction time and fewer errors on CF tasks, indicating greater cognitive efficiency, relative to their younger peers. These findings align with the broader literature, suggesting that age-related gains in CF are driven by the concurrent development of neural networks supporting EFs generally, particularly in the prefrontal cortex (Diamond, 2013).

Therefore, age is a critical determinant of CF development, with the preschool years serving as a foundational period for acquiring and refining this cognitive skill. As children transition from 4 to 5 years old, they exhibit both quantitative improvements in task-switching abilities and qualitative shifts in strategy use, reflecting the maturation of working memory, inhibitory control, and other EFs. These age-related changes lay the groundwork for later academic and social success, underscoring the importance of studying CF within this developmental window.

### *5.2. Sex Differences in Cognitive Flexibility*

Sex differences in cognitive flexibility remain a topic of debate in developmental psychology. While some studies report sex-based variations in executive function performance, others find no significant differences (Diamond, 2013; Lejbak et al., 2011). Structural and functional differences in brain development have been proposed as explanations, yet their influence on CF in early childhood remains uncertain (Voyer et al., 2017). Therefore, findings on sex differences in EF are mixed. Some research suggests that females tend to excel in inhibitory control and verbal working memory, whereas males demonstrate stronger spatial reasoning and motor coordination (Levine et al., 2016; Voyer et al., 2021). These differences have been linked to biological factors, such as hormonal influences, as well as early learning experiences (Gur & Gur, 2002; Halpern, 2013).

However, research specifically examining CF has found no significant sex differences in early childhood (Best & Miller, 2010). For example, Lejbak et al. (2011) found no substantial CF differences between boys and girls in preschool-aged children, with sex-based variations emerging only in later childhood and adolescence. Similarly, Wiebe et al. (2008) concluded that CF development in preschoolers is primarily driven by age-related neurological maturation rather than biological sex. While some studies indicate that boys and girls may rely on different cognitive strategies—for example, girls using more verbal self-regulation and boys using more spatial approaches—these differences do not necessarily translate into differences in CF performance (Diamond, 2013; Voyer et al., 2021).

Most research on sex and CF has been conducted in WEIRD populations, limiting its applicability to diverse cultural contexts (Henrich et al., 2010). Studies in non-WEIRD settings present inconsistent findings, with some reporting sex-related differences in EF, while others highlight the greater influence of socio-cultural factors over biological sex in shaping EF outcomes (Legare et al., 2018). In South African contexts, socio-cultural influences, such as educational access and environmental stimulation, may play a more important role than biological sex in shaping CF development (Cook et al., 2023). However, this study did not directly assess gender identity or the influence of gender roles and socialization. Therefore, all references to differences between boys and girls in this study are limited to biological sex as reported by caregivers, and any interpretations regarding gendered influences remain speculative.

Given these considerations, this study examines potential sex differences in CF among South African preschoolers using the Three-Dimensional Change Card Sort (3DCCS) task. Based on existing literature, it is hypothesized that boys and girls will perform similarly on the 3DCCS task, with any observed differences more likely reflecting individual engagement strategies rather than differences in cognitive flexibility itself. By investigating sex and CF in a non-WEIRD population, this study aims to determine whether previously reported sex differences in EF extend to South African preschoolers or whether contextual factors such as language exposure, socio-economic status (SES), and cultural background play a more significant role.

### *5.3. Bilingualism*

Bilingualism has been extensively studied for its potential influence on cognitive flexibility. This relationship stems from the cognitive demands associated with managing multiple languages, which require individuals to frequently switch between linguistic systems, suppress interference from one language while using another, and adapt to varying communicative contexts (Deak, 2003). These processes are thought to engage and enhance executive functions, particularly cognitive flexibility, inhibitory control, and working memory (Bialystok & Senman, 2004; Prior & MacWhinney, 2010). However, evidence regarding the bilingual advantage in cognitive flexibility has been inconsistent, with findings varying across studies, populations, age groups and methodologies (Bialystok, 2011; De Bruin et al., 2014; Paap et al., 2015).

A growing body of research supports the notion that bilingualism can enhance cognitive flexibility. For instance, Bialystok and Martin (2004) conducted a study in Canada with children aged 4 to 6 years and found that bilinguals outperformed monolinguals on tasks requiring rule-switching. Similarly, Kuipers and Thierry (2013) conducted a study in Wales involving toddlers aged 2 to 3 years, and demonstrated that bilingual children exhibited greater flexibility in reversing stimulus-response mappings compared to their monolingual counterparts. These findings suggest that the experience of managing two languages may promote the development of cognitive flexibility, even in early childhood.

The mechanisms underlying this advantage are often linked to the executive demands of bilingualism. In particular, the need to inhibit one language while using another is thought to strengthen inhibitory control, a key component of cognitive flexibility. This idea was supported by a study conducted in the United States by Bialystok and Senman (2004) involving children aged 4 to 5 years, which found that bilinguals were better able to adapt to changing task demands compared to monolinguals. The researchers attributed this finding to the bilinguals' enhanced ability to manage conflicting linguistic inputs, which likely generalized to non-linguistic tasks requiring cognitive flexibility.

Research also highlights the potential long-term benefits of bilingualism for cognitive flexibility. Prior and MacWhinney (2010) conducted a study in the United States with bilingual adults and found that they exhibited reduced switching costs during cognitive tasks that required alternating between mental sets. Although this study focused on adults, its findings suggest that the advantages of bilingualism for cognitive flexibility may persist across the lifespan, underscoring the importance of early bilingual experiences in shaping cognitive abilities.

Despite these positive findings, some studies challenge the universality of the bilingual advantage in cognitive flexibility. Li et al. (2020), conducted a study in the United States with participants aged 5 to 6 years, and reported no significant relationship between bilingualism and cognitive flexibility. Similarly, Booton et al. (2021), who studied kindergarteners aged 5 to 6 years in Australia, found no evidence of bilingual children outperforming monolinguals in tasks measuring cognitive flexibility. These findings suggest that the cognitive benefits of bilingualism may not be as consistent or robust as previously thought, with outcomes potentially influenced by factors such as language proficiency, task type, and cultural context.

Furthermore, Hommel et al. (2011) conducted a study in the Netherlands involving children aged 6 to 8 years, which found that bilingualism was associated with improvements in convergent thinking, a form of problem-solving that requires finding a single correct solution, but not in divergent thinking, which involves generating multiple creative solutions. This nuanced finding underscores the complexity of the bilingual experience and suggests that its cognitive effects may vary depending on the specific executive function being measured.

The variability in research findings on this topic is also often attributed to methodological differences. For example, studies employing tasks that involve non-verbal measures of cognitive flexibility, such as the 3DCCS, are more likely to report bilingual advantages than those using verbal tasks (Sampedro & Peña, 2019). Moreover, factors such as the age of acquisition, frequency of language use, and linguistic context can significantly influence the relationship between bilingualism and cognitive flexibility (Lehtonen et al., 2018).

In the South African contexts, where bilingualism is the norm, the relationship between bilingualism and cognitive flexibility may take on unique characteristics. South Africa is one of the most linguistically diverse countries in the world, with vast majority of children growing up in environments where they are exposed to multiple languages daily (Lew, 2021). This exposure often requires frequent code-switching and language mixing, which could enhance cognitive flexibility through the constant engagement of executive functions like attention-shifting and inhibitory control (Bialystok, 2001). Recent studies have begun to explore these dynamics within South Africa. For instance, a study by Deák et al. (2018) compared cognitive flexibility in Tswana-speaking South African children and U.S children (M = 4.4 years) using the 3DCCS task. The findings indicated that while both groups showed age-related increases in word-learning flexibility, South African children did not exhibit the same age-related improvements in rule-switching flexibility as their U.S. counterparts. This suggests that cultural and educational contexts may influence the development of cognitive flexibility.

While most research on bilingualism and cognitive flexibility has been conducted in Western contexts, the findings from these studies provide valuable insights into the potential cognitive benefits of bilingualism. However, they also highlight the need for further research in linguistically diverse settings like South Africa to understand how bilingual experiences interact with cultural and educational factors to shape cognitive development. By examining the role of bilingualism in cognitive flexibility among South African preschoolers, this study aims to contribute to a more nuanced understanding of the cognitive implications of managing multiple languages.

### *5.4. Socioeconomic Status (SES)*

Socioeconomic status appears to be a critical factor influencing the development of cognitive flexibility. It encompasses variables such as income, parental education, and occupational status, which collectively shape the environments in which children grow and learn. These environmental factors significantly impact brain development, cognitive stimulation, and access to educational resources, all of which play a vital role in shaping CF (Clearfield & Niman, 2012). While SES has been identified as a key predictor of CF development, research findings on its influence remain complex and, at times, contradictory.

Several studies highlight the significant impact of SES on CF development. Sarsour et al. (2011) conducted a study in the United States with 8- to 12-year-old children ($M = 9.9$; $SD = 0.96$) and found that family SES significantly accounted for variations in CF performance. Similarly, Ursache and Noble (2016) researched participants aged 3 to 21 years ($M = 12.21$; $SD = 4.91$) across nine United States cities and observed that higher SES was associated with improved CF. These studies suggest that children from higher SES backgrounds benefit from enriched cognitive environments, access to quality education, and reduced exposure to chronic stress, all of which foster the development of CF.

The mechanisms underlying SES disparities in CF often centre on differences in environmental stimulation and stress exposure. Higher SES families are more likely to provide cognitively enriching experiences, such as interactive reading, exposure to diverse vocabulary, and problem-solving activities. These experiences directly support the development of working memory and inhibitory control, foundational components of CF

(Hackman & Farah, 2009). Blair and Raver (2016) further emphasize that children from higher SES backgrounds are less likely to encounter chronic stressors, which can disrupt the development of neural circuits in the prefrontal cortex, a brain region critical for CF.

In contrast, children from lower SES backgrounds often face environmental challenges that hinder CF development. Limited access to educational resources and exposure to chronic stress can impair the maturation of executive functions. Blair et al. (2005) found that low-SES children with dysregulated cortisol responses, a physiological marker of stress, performed poorly on tasks measuring CF. Similarly, Clearfield and Niman (2012) demonstrated that preschoolers from low-SES were more likely to perseverate on the DCCS task, reflecting deficits in their ability to switch between rules. These findings highlight the cumulative impact of SES-related stressors on cognitive outcomes.

Despite these challenges, the relationship between SES and CF is not deterministic. Some studies suggest that low-SES children can exhibit resilience in cognitive tasks under specific conditions. For instance, Mittal et al. (2015) found that children from low-income families in India performed comparably to their higher-SES peers on tests of CF, particularly when supported by culturally embedded problem-solving practices. This underscores the role of protective factors, such as responsive caregiving and community support, in buffering the effects of socioeconomic disadvantage.

Research also points to cases where SES does not significantly predict CF outcomes. Poon et al. (2022) studied a sample of preschool-aged children in Hong Kong and found no consistent relationship between SES and CF, suggesting that cultural context and task-specific factors may mediate this relationship. Similarly, Pollak et al. (2010) reported that children from low-SES in the United States did not necessarily perform worse on CF tasks, with some outperforming their higher-SES counterparts under certain conditions. These findings challenge the assumption of a universal SES-CF gradient and highlight the importance of examining contextual factors.

In the South African context, the relationship between SES and CF warrants particular attention due to the country's high levels of socio-economic inequality. Children from lower SES backgrounds in South Africa often face challenges such as limited access to quality early childhood education, inadequate nutrition, and heightened exposure to stressors. These factors can hinder the development of executive functions, including CF. Conversely, children from higher SES families may benefit from access to better resources and educational opportunities, fostering cognitive development.

Despite these disparities, South Africa's unique socio-cultural context offers opportunities for resilience. Community-oriented problem-solving practices and multilingual environments may provide low-SES children with cognitive experiences that support CF development. For instance, the constant need to navigate multiple linguistic systems in a multilingual society like South Africa may enhance executive functions, potentially offsetting some of the disadvantages associated with lower SES (Bialystok, 2001).

Therefore, given the multifaceted influences on cognitive flexibility, it is essential to employ valid and contextually appropriate tools for assessment. The 3DCC task provides an opportunity to evaluate cognitive flexibility comprehensively, particularly in South African preschoolers, where cultural and socio-economic factors may uniquely shape development.

### *6.* The applicability of the 3DCCS task in South Africa

The measurement of cognitive flexibility is inherently tied to the appropriateness and validity of the assessment tools employed. Several assessments are available for measuring cognitive flexibility in young children, including the Dimensional Change Card Sort (DCCS), the Flexible Item Selection Task (FIST), and the Shape School task. The DCCS, a widely used tool, assesses children's ability to switch between sorting rules based on colour and shape (Zelazo, 2006), while the FIST examines children's ability to select and switch between conceptual pairs (Jacques & Zelazo, 2001). The Shape School task uses a game-like format to assess inhibition and switching (Espy, 1997). The 3DCCS was chosen for this study because it builds upon the DCCS by adding a third sorting dimension (size), increasing task complexity and providing a more sensitive assessment of cognitive flexibility in the preschool age range (Deák & Wiseheart, 2015). Although the 3DCCS has shown promising results in previous studies, most validations have been conducted in WEIRD populations, and its applicability across diverse cultural and socio-economic contexts remains underexplored (Deák & Wiseheart, 2015; Zelazo, 2006). Given South Africa's rich linguistic and cultural diversity, this study extends existing research by examining whether findings from WEIRD samples generalize to a more varied population, thereby contributing to a broader and more inclusive understanding of cognitive flexibility in early childhood.

In evaluating the suitability of the 3DCCS for South African preschoolers, it is important to consider its demonstrated effectiveness in capturing age-related improvements in cognitive flexibility. Research in WEIRD contexts has shown that younger children, typically around three years of age, struggle with switching between sorting rules, often perseverating on the initial rule. This difficulty highlights their developmental limitations in inhibitory control and working memory (Zelazo et al., 2003). By contrast, five-year-olds generally exhibit greater cognitive flexibility, transitioning between rules with more ease due to their more advanced executive functions (Deák & Kail, 2003). These developmental milestones are expected to manifest similarly in South African preschoolers, particularly within the age groups targeted in this study.

The 3DCCS's ability to capture nuanced developmental shifts in cognitive flexibility is supported by studies like that of Deák and Wiseheart (2015), who found that introducing an additional dimension increased the task's complexity, offering a richer evaluation of cognitive adaptability. In their study, four-year-olds faced challenges in rule-switching when confronted with the third dimension, whereas five-year-olds performed significantly better, showcasing the developmental trajectory of executive functions. Children's engagement behaviours and strategy use play a crucial role in their performance on cognitive flexibility tasks. Research has shown that children vary in how they approach executive function tasks, with some relying on verbal self-guidance, others using visual or motor strategies, and some seeking external validation from adults (Chevalier et al., 2012; Diamond, 2013). For example, Chevalier and Blaye (2008) found that young children who spontaneously used verbal labelling strategies were more successful in task-switching conditions. Similarly, studies have documented that children's attention regulation, persistence, and willingness to explore different rules can influence how effectively they adapt to task demands (Best & Miller, 2010). These engagement patterns are not only shaped by developmental maturation but may also reflect social, cultural, and contextual influences, such as expectations for independence or collaborative problem-solving (Greenfield, 2009; Legare et al., 2018). Including observations of children's engagement and strategy use provides a richer understanding of cognitive flexibility, beyond accuracy or reaction time, and helps capture individual differences in problem-solving approaches. These considerations are particularly relevant to the present study. In this study, a similar pattern was observed: four-year-olds exhibited difficulty adapting to the added complexity of the third dimension in the 3DCCS task, while five-year-olds demonstrated significantly higher accuracy and faster adaptation. This alignment with previous findings highlights the critical developmental advances occurring between these ages. This evidence underscores the task's potential to provide valuable insights into cognitive flexibility among preschoolers in South Africa, particularly in understanding how they engage with complex sorting tasks and adapt their behaviour in response to changing rules.

Moreover, the use of 3DCCS in this study stems from its ability to address key developmental milestones relevant to South African preschoolers. Research consistently shows that cognitive flexibility undergoes significant growth during this period, with children transitioning from perseverative tendencies, such as adhering to initial sorting rules, to demonstrating greater adaptability in switching between rules. Zelazo et al. (2003), in a Canadian study of preschoolers aged 3 to 5, highlighted that younger children often perseverate on the original sorting rule, while older preschoolers show marked improvements due to advancements in executive functions like working memory and inhibitory control. A similar developmental trajectory aligns would be anticipated in South African children.

Furthermore, cross-cultural research suggests the task's adaptability and relevance. Studies conducted in East Asian and European contexts have demonstrated that the 3DCCS effectively captures age-related improvements in cognitive flexibility, even in the presence of cultural differences in educational practices and parenting styles (Sabbagh et al., 2006). For example, Deák and Wiseheart (2015) used the 3DCCS to evaluate cognitive flexibility in American preschoolers aged 3 to 5, finding that the inclusion of the size dimension increased task complexity, allowing for a more detailed assessment of executive function development. Similarly, Legare et al. (2018) examined cultural variations in cognitive flexibility across diverse populations, including Tswana-speaking children from South Africa, and found that while fundamental executive function skills are universal, sociocultural factors significantly influence how these skills develop. While these findings provide some evidence of the test's cross-cultural suitability, research remains limited, particularly regarding African children. Given the unique socio-economic and linguistic diversity in South Africa, this study aims to establish whether the 3DCCS is an appropriate measure for assessing cognitive flexibility in this context, thereby expanding our understanding of early cognitive development beyond WEIRD populations.

South Africa's rich linguistic landscape and socioeconomic variability adds additional complexity to the 3DCCS. As these cognitive demands align well with the requirements of the 3DCCS, as the task mirrors the need to shift between multiple cognitive sets, similar to switching between languages. Bialystok (2001) argued that bilingual environments enhance executive functions, particularly cognitive flexibility, by providing consistent practice in managing competing cognitive demands. Thus, the 3DCCS could capture how these linguistic experiences influence cognitive flexibility among South African preschoolers. Additionally, socio-economic disparities in South Africa may pose challenges to the task's application. For these reasons, it is important to explore the 3DCCS task in a South African context, which would provide valuable insights into how socio-economic and linguistic factors intersect with cognitive flexibility outcomes.

Previous studies using the 3DCCS also shed light on its ability to reveal nuanced patterns in cognitive flexibility. Chevalier and Blaye (2008), in a French study of children aged 4 to 6, demonstrated that cognitive flexibility improvements were strongly associated with advances in working memory capacity and inhibitory control. Their findings highlight how the 3DCCS effectively captures these developmental trends, making it a reliable measure for assessing cognitive flexibility in populations with varying developmental trajectories. In the South African context, where access to resources and early learning opportunities varies widely, the 3DCCS offers a way to examine how such disparities shape cognitive flexibility.

Additionally, age-related differences observed in the 3DCCS are expected to manifest in South African preschoolers, providing valuable data on their cognitive development. Younger children, such as 4-year-olds, are likely to exhibit greater difficulty in adapting to new sorting rules, reflecting less mature inhibitory control and working memory. In contrast, 5-year-olds are anticipated to show more advanced cognitive flexibility, successfully transitioning between sorting rules with greater efficiency (Deák & Wiseheart, 2015). This pattern has been consistently observed in WEIRD populations, as evidenced by studies like that of Zelazo et al. (1996), which demonstrated significant improvements in cognitive flexibility between the ages of 4 and 5.

The exploration of the 3DCCS in South Africa addresses a critical gap in the literature. While much of the existing research on cognitive flexibility has focused on WEIRD populations, the unique socio-cultural dynamics of South Africa provide an opportunity to assess the validity and reliability of this task in a non-WEIRD context. Milosavljevic et al. (2023) examined executive function skills in preschool-aged children in South Africa and The Gambia, highlighting that these skills can be reliably assessed using validated tasks. Their findings suggest that tasks like the 3DCCS could provide valuable insights into cognitive flexibility development in South African children.

This study investigates how 4- and 5-year-old South African preschoolers engage with the 3DCCS, evaluating its suitability for this population. Additionally, it examines the influence of demographic factors, such as age, sex, SES, and the number of languages spoken, on cognitive flexibility. By addressing these objectives, this research advances our understanding of executive function development in diverse populations and provides valuable insights for early childhood education and developmental psychology. While the

3DCCS has been widely used to assess cognitive flexibility in Western populations, its applicability and cultural relevance in South Africa remain largely unexplored. There is limited research examining how sociocultural factors, such as bilingualism and socioeconomic status, influence cognitive flexibility in this context. Furthermore, little is known about whether findings from WEIRD samples generalize to linguistically and culturally diverse populations, such as South African preschoolers. This study addresses these gaps by investigating the development of cognitive flexibility in South African children and evaluating the suitability of the 3DCCS for use in this context.

## Research Aim

The aim of this study is to explore the development of cognitive flexibility in 4- and 5-year-old South African preschoolers using the 3DCCS task and to assess the task's suitability for this population (Deák & Wiseheart, 2015).

## Research Objectives

- To assess the performance of 4- and 5-year-old preschoolers on the 3DCCS task.
- To explore how preschoolers engage with the 3DCCS task, including the strategies they use.
- To examine the influence of demographic factors (age, sex, socioeconomic status, and number of languages spoken) on cognitive flexibility performance.
- To evaluate the appropriateness and cultural fit of the 3DCCS task for use with South African preschoolers.

## Research Questions

### Primary Research Question

How does cognitive flexibility develop in 4- and 5-year-old South African preschoolers as assessed by the 3DCCS?

**Secondary Research Questions**

- How does age, sex, socioeconomic status, and number of languages spoken affect cognitive flexibility in South African preschoolers?
- What engagement strategies do preschoolers display while completing the 3DCCS task?
- How appropriate is the 3DCCS task for assessing cognitive flexibility in this cultural context?

# Chapter 2: Methods

In this chapter, the research design, sample, instruments and procedure of the study are described.

## 1. Research design

This study employed a Sequential Explanatory Design, a mixed-method approach that collects and analyses quantitative data first, followed by qualitative data to explain or expand on the quantitative findings (Creswell & Plano Clark, 2018). This design is particularly useful when exploring complex developmental phenomena, as it allows researchers to examine not only "what" differences exist but also "how" and "why" those differences arise. In the current study, it enabled the researcher to first examine demographic patterns in cognitive flexibility performance and then use qualitative observations to gain insights into how children engaged with the 3DCCS task. This combination of methods strengthened the validity of the findings and provided a more holistic understanding of cognitive flexibility development in South African preschoolers.

Guided by a post-positivist framework, the quantitative component employed a non-experimental, correlational, two-group comparison design. The study focused on two age groups, 4-year-olds and 5-year-olds, allowing for the analysis of numerical data from the 3DCCS to explore relationships between cognitive flexibility and key demographic factors such as age, number of languages spoken, and SES (Field, 2013). This quantitative approach provided measurable insights into developmental differences and patterns of cognitive flexibility across the selected age groups.

The post-positivist framework acknowledges that while objective reality exists, our understanding of it is inherently shaped by researcher assumptions, measurement limitations, and context (Creswell & Creswell, 2018). This paradigm was selected because it accommodates both quantitative and qualitative approaches, recognises the role of researcher bias, and supports the use of multiple forms of evidence to investigate complex phenomena like cognitive flexibility. It aligns with the study's goal of combining statistical data with contextually rich observations to generate a more nuanced understanding.

In addition to the quantitative analysis, a qualitative component was included to evaluate the appropriateness and suitability of the 3DCCS task for South African preschoolers. The qualitative data offered rich, descriptive insights into how cognitive flexibility develops within the unique cultural and linguistic context of South Africa (Creswell & Creswell, 2017). By integrating qualitative findings with quantitative results, the study aimed to provide a comprehensive understanding of cognitive flexibility development in preschoolers, bridging statistical analysis with contextual depth.

## 2. Sample and Sampling

This study employed a non-probability sampling strategy, combining convenience and snowball sampling techniques to recruit participants (Field, 2013). The final sample consisted of 51 children, drawn from eight preschools in Johannesburg, specifically located in the areas of Robertsham, Ormonde, Mayfair, and Soweto. Initially, permission was sought from nine preschools, but one school did not receive any responses from caregivers and was therefore excluded. The preschools were selected using purposive criteria: they provided early childhood education programs, served linguistically and socioeconomically diverse populations, and were accessible to the researcher. Access to the schools was obtained by contacting school principals, presenting a formal request letter outlining the study's aims, and providing ethics approval documentation from the University of the Witwatersrand and permission from the Gauteng Department of Education.

Moreover, the initial sample included 53 participants; however, two participants were excluded because their ages fell outside the specified range of 4 to 5 years. The final sample consisted of 27 children aged 4 years and 24 children aged 5 years, with a mean participant age of 4.47 years ($SD = 0.504$).

Participants were selected based on their availability and willingness to participate, ensuring alignment with the study's objectives (Field, 2013). Inclusion criteria required that children were enrolled at one of the participating preschools, were aged 4 or 5 years, and had parental or caregiver consent to participate. Exclusion criteria were applied to ensure the validity of the cognitive flexibility assessment and included any known diagnosis of a neurodevelopmental disorder (e.g., ADHD, ASD), or a history of neurological injury or serious medical conditions reported in the demographic questionnaire. These criteria were important to ensure that participants' performance on the 3DCCS task reflected typical developmental variation rather than being influenced by medical or developmental conditions.

While this sampling approach limited generalizability, it was deemed appropriate for accessing a specific population within the constraints of the research. The sample demographic information is summarized in Table 1 in Chapter 3 (Results).

## 3. Instruments

The following measures were employed: a demographic questionnaire, Three-Dimensional Card Change Sort (3DCCS) Task, and an Observation Form. These are each detailed below.

### *3.1. Demographic questionnaire (Appendix A)*

The demographic questionnaire provided essential background information about the participants and their caregivers. It collected data on factors such as the child's language ability, health history, household composition, and the educational background of their caregivers. The questionnaire consisted of 18 questions, most of which employed closed-ended response formats, such as yes/no or multiple-choice options. Additionally, a SES component was included in the study through the Socioeconomic Status Short-Form Questionnaire (SES-SQ), adapted from Roohafza et al. (2021). The questionnaire comprised six items, including the caregiver's education level and employment status. However, since the original questionnaire only included the education level and employment status for the head of the household, average scores were created for this study to account for the presence of multiple caregivers. Furthermore, while the original study clearly categorized employment status, this study presented it as an open-ended question. The responses were subsequently grouped into the appropriate categories based on the original study's classification.

One of the questions in the SES-SQ asked about technology access. In the original questionnaire, access to technology was scored as 0 if technology was available in the household, and 2 if it was not. However, this scoring was reversed for this study, as, in the South African context, access to technology is more strongly correlated with wealth, unlike in the original population. The maximum possible score for the SES-SQ was 17, with a minimum score of 0. The overall reliability of the SES questionnaire was supported by a Cronbach's alpha coefficient of 0.64, indicating satisfactory internal consistency (Roohafza et al., 2021).

### *3.2. The Three-Dimensional Card Change Sort (3DCCS) Task (Zelazo, 2006)*

The 3DCCS task was used to measure cognitive flexibility in preschool-aged children. In this task, participants alternated between three sorting rules based on the dimensions of animal species (e.g., fish, dogs, birds), colour (e.g., blue, red, yellow), and size (e.g., small, medium, large). The test was divided into three blocks of trials, each corresponding to one of these sorting rules.

During each block, children were presented with six test cards and instructed to sort them according to the current rule. The sorting was conducted using four containers, each labelled with a target card aligned with the sorting rule. To assess attention and comprehension, distractor cards (e.g., a frog card) were introduced during the trials. The placement of test cards was randomized within each block to ensure variability, and the order of the sorting rules was also randomized across participants.

Prior to the task, children's understanding of the property labels (e.g., colour, size) was verified through practice questions and examples. For each block, participants were taught the new sorting rule and encouraged to sort accordingly. Positive feedback was provided after each trial to maintain engagement and motivation (Zelazo, 2006). The 3DCCS task was scored out of a total of 18 points, with 6 points allocated to each block. If the child successfully switched tasks correctly, they were awarded 1 point; if they did not switch correctly, they received 0 points. Therefore, the maximum possible score was 18, and the minimum possible score was 0.

Additionally, CORSWOPS (Correct Switches / Opportunities to Switch) scores were calculated to assess cognitive flexibility while accounting for differences in subtask difficulty. This score was computed using the formula:

$$\textbf{CORSWOPS Score} = \frac{\text{Correct Switches}}{\text{Opportunities to Switch}}$$

The maximum possible CORSWOPS score was 1, indicating perfect flexibility, and the minimum score was 0, indicating no successful switches.

### *3.3. Observation Form (Appendix B)*

A self-constructed observation form was used to document the qualitative observations of participants' performance during the 3DCCS task. The form consisted of 14 questions which was designed to capture various aspects of the preschoolers' behaviour, including any challenges encountered during the task, questions or comments made, and instances where instructions or questions needed to be repeated.

The observation form also included a section for recording the child's ability to follow instructions, any divergent or creative responses, and the strategies employed by the participants to complete the sorting tasks. Additionally, the total time taken to complete the

3DCCS task was also recorded. This instrument provided a nuanced understanding of the children's cognitive flexibility and their engagement with the task.

**4. Procedure**

The study commenced once caregivers returned the signed consent forms together with the completed demographic questionnaires to the class teacher. Each participant underwent an individual assessment that lasted approximately 10–15 minutes. These sessions were conducted in a quiet room within the school premises to minimize distractions and ensure a comfortable environment for the child. The researcher coordinated closely with the class teacher to ensure that the assessment did not interfere with teaching activities. Tasks were conducted only during times approved by the teacher, and participation was entirely voluntary, allowing children the freedom to engage without coercion.

The primary evaluation involved administering 3DCCS instrument to measure cognitive flexibility. Following each child's completion of the task, the researcher filled out the observation form, documenting any notable behaviours, responses, and difficulties encountered during the session.

The entire data collection process spanned two months, with sessions scheduled to align with school availability and participant convenience. This approach ensured that the study was conducted ethically and efficiently, minimizing disruption to the children's routine while gathering the necessary data.

**5. Ethical consideration**

This study adhered to the ethical guidelines established by the American Psychological Association (APA). Ethical clearance was obtained from the University of the Witwatersrand Human Research Ethics Committee (HREC, non-medical; Protocol No: H24/07/21; Appendix G) (Connelly, 2014). Additionally, a formal request for permission to conduct research within their jurisdiction was submitted to the Gauteng Department of Education (GDE). After receiving approval, consent was also secured from the relevant preschools and teachers (Appendices E and F). Teachers were then briefed on the study's methods and procedures.

A participant information sheet (Appendix C) outlining the study's purpose, procedures, and contact information for feedback was distributed to prospective participants and their caregivers. This document informed caregivers that only anonymous group data would be collected, with no individual feedback provided. It also emphasized participants' right to withdraw from the study or decline participation without any negative consequences. During the testing phase, the researcher closely monitored participants for any signs of discomfort or distress. In the rare event that a participant exhibited strong negative emotions or discomfort, the testing would have been halted immediately to ensure their well-being; however, no such incidents occurred.

Informed consent was obtained using a consent form (Appendix D), which addressed participant concerns. Caregivers were given the participant information sheet, the consent form, and the demographic questionnaire (Appendix A) in an envelope distributed by the class teachers. Caregivers completed the forms and returned them to the teachers, from whom the researcher later collected them. Participants also provided verbal assent, ensuring transparency and voluntary participation (Connelly, 2014). Informed consent is a fundamental ethical principle in research, ensuring that participants and their caregivers fully understand the nature, purpose, risks, and benefits of the study before voluntarily agreeing to participate (World Medical Association, 2013). It protects participants' autonomy, promotes transparency, and safeguards their rights, helping to prevent coercion or undue influence.

Given that data collection was conducted in person, complete anonymity could not be guaranteed; however, measures were taken to ensure anonymity from the point of data capture. Numerical codes were assigned to each participant, and all results were reported anonymously. Confidentiality was strictly maintained, with only the researcher and supervisor having access to participants' personal information. Data security protocols were rigorously followed: digital files were stored on a password-protected hard drive, while physical documents were kept in a locked cabinet.

## 6. Data analysis

The data collected in this study were analysed using IBM SPSS Statistics (Version 29.1; IBM Corp., 2022). To evaluate the normality of the study variables, skewness and kurtosis indices were computed. Additionally, histograms and normality tests, including the Shapiro-Wilk and Kolmogorov-Smirnov tests, were used to assess normality (Field, 2013). Descriptive statistics were generated to provide an overview of the sample characteristics and key variables.

To address the first research question, whether demographic variables were associated with cognitive flexibility in South African preschoolers, correlation coefficients and multiple regression analyses were conducted. These statistical methods allowed for the examination of relationships between demographic factors, such as age and socio-economic status, and cognitive flexibility scores derived from the 3DCCS.

For the qualitative component of the study, Braun and Clarke's (2019) reflective thematic analysis was employed to answer the second research question. The analysis involved familiarisation with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the report. The researcher engaged in repeated reading of the observation notes to immerse in the data, followed by systematic coding to capture meaningful features related to children's engagement with the 3DCCS task. Codes were then organised into potential themes, which were reviewed and refined to ensure coherence and consistency. Further details of the coding process and thematic development are provided in chapter 4.

# Chapter 3: Results

This study explored the construct of cognitive flexibility in South African preschoolers using the 3DCCS task. A mixed-methods approach was adopted, combining quantitative and qualitative methodologies to provide a comprehensive understanding of the topic. The quantitative phase of the study investigated the relationship between demographic variables and performance on the 3DCCS task. Descriptive and inferential statistical techniques were employed to analyse the data using IBM SPSS Statistics, version 29.1. First, descriptive statistics were generated to summarize the sociodemographic profile of the sample and the distribution of 3DCCS task scores. Second, correlation analyses were conducted to examine relationships between key demographic variables (age in months, number of languages spoken and SES) and the 3DCCS scores. To further address the research question, "Are there any differences in the cognitive flexibility of South African preschoolers based on demographic variables?" regression analyses were performed to determine whether these key demographic variables predicted variance in the 3DCCS scores.

The qualitative phase of the study sought to explore how preschoolers engaged with the 3DCCS task. Data for this phase were collected using observation forms containing open-ended questions, which allowed for the identification of themes. Reflexive Thematic Analysis was conducted to address the qualitative research question: How did preschoolers engage with the 3DCCS task? In this chapter, the results of both phases of the study are presented. The quantitative results are discussed first, followed by the qualitative findings.

## Quantitative Results

### 1. Descriptive statistics

This section is divided into three subsections. The first subsection describes the type of data associated with each variable and the methods used to assess whether the data were suitable for parametric analysis. Before analysing the relationships between key variables, it was important to understand their distributions within the sample. Therefore, the second subsection presents the sociodemographic characteristics of the sample. Lastly, the third subsection provides an overview of the distribution of 3DCCS task accuracy scores and CORSWOPS Max (flexibility) scores, summarizing the performance of the sample of preschoolers on the 3DCCS task.

### *1.1. Assessing Data Suitability for Parametric Analysis*

Data suitability for parametric analysis was assessed using several methods. Three primary assumptions for parametric statistical analysis include random independent sampling, absence of extreme outliers, and an approximately normal distribution of test scores (Field, 2013). Although the sample was a convenience sample of volunteers, the data collection process ensured that each participant completed the 3DCCS task once without repetition.

The 3DCCS task measured cognitive flexibility on a continuous scale, with a maximum possible score of 18 points. Each game within the task; animal, colour, and size, was scored out of 6 points. Thus, the overall task had a minimum score of 0 and a maximum of 18. Additionally, CORSWOPS (correct swops) scores were also recorded as a variable in the study, with a minimum score of 0 and a maximum score of 1. Socioeconomic status was assessed using the SES-SQ questionnaire (Roohafza et al., 2021), which provided scores on an ordinal scale ranging from 0 (indicating the lowest SES) to 17 (indicating the highest SES). Based on established cut-off scores, low SES was classified as ≤ 4.5, middle SES as 4.5–8.5, and high SES as 8.5 – 17**.**

To assess for the presence of extreme outliers in the above scores, standardized residuals, Cook's distance, leverage points, and Mahalanobis distance were evaluated. No extreme outliers were identified, and therefore the entire sample was retained for analysis. Lastly, to evaluate the distributions of variables, the Shapiro–Wilk test (recommended for sample sizes <50; Mishra et al., 2019), skewness and kurtosis coefficients, and histograms were examined. Several variables showed significant Shapiro–Wilk test results, skewness values beyond ±1, and kurtosis values beyond ±3 (Appendix H, Table 1). Histograms (Figures 1–10) further indicated that several variables were not approximately normally distributed. Consequently, non-parametric analyses, where applicable, were deemed more suitable for the statistical analysis in this study.

### 1.2. *Sociodemographic Profile of Sample*

A consideration of the sociodemographic characteristics of the sample is essential for contextualizing the findings of this study. Descriptive statistics were used to explore the profile of the 51 participants in terms of age, sex, number of days they attended preschool, number of caregivers, and the caregivers' education levels (Table 1).

**Table 1**

*Participants' Sociodemographic Profiles*

| Variable | Categories | Frequency (n) | Precent (%) |
|---|---|---|---|
| Age (in years) | 4 | 27 | 52.9 |
| | 5 | 24 | 47.1 |
| Sex | Male | 26 | 51 |
| | Female | 25 | 49 |
| Preschool Days | 0 | 1 | 2 |
| | 3 | 3 | 5.9 |
| | 5 | 47 | 92.2 |
| Number of Caregivers | 1 | 8 | 15.7 |
| | 2 | 35 | 68.6 |
| | 3 | 7 | 13.7 |
| | 4 | 1 | 2 |

| Parental Education | Fathers level of education | | Mothers level of education | | Other Caregiver | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Not applicable | 6 | 10.7 | 1 | 1.8 | 45 | 80.4 |
| Primary school Complete | - | - | 1 | 1.8 | - | - |
| Secondary School not complete | 1 | 1.8 | 1 | 1.8 | 1 | 1.8 |
| Matric complete | 14 | 25 | 15 | 26.8 | 5 | 8.9 |
| Undergraduate degree complete | 8 | 14.3 | 18 | 32.1 | - | - |
| Postgraduate degree complete | 12 | 21.4 | 7 | 12.5 | - | - |
| Other | 4 | 7.1 | 4 | 7.1 | - | - |

***Note.*** Age, sex, preschool days, and number of caregivers: $N = 51$.
Parental education (father): $N = 45$. Parental education (mother): $N = 47$. Parental education (other caregiver): $N = 51$. Percentages may not total 100% due to missing responses.

The sample included a nearly equal number of male and female participants. In terms of age, there were slightly more 4-year-olds (52.9%) than 5-year-olds in the sample. The mean age of the participants was 4.47 years (SD = 0.504). Most participants attended preschool five days a week (92.2%), with only one participant not attending preschool at all. Regarding the number of caregivers, the majority of participants (68.6%) had two caregivers, with only one participant reporting four caregivers. Educational levels of the caregivers varied. Fathers were most frequently reported to have achieved postgraduate education (21.4%), while mothers were predominantly reported to have an undergraduate degree (32.1%). For other caregivers, 80.4% of participants either marked the education level as '*not applicable'* or did not report this information. Lastly, none of the participants reported chronic illnesses or neurological disorders. The only medications noted by caregivers were for common flu or fever symptoms.

Table 2 presents the descriptive statistics for socioeconomic status (SES) and the number of languages spoken by the participants.

**Table 2**

*Descriptive Statistics for Socioeconomic Status and Number of Languages Spoken*

| Variable | Mean | *SD* | Mode | Range |
|---|---|---|---|---|
| Socioeconomic status | 12.70 | 2.95 | 13.0[a] | 2.5 - 17 |
| No of languages spoken | 1.45 | .58 | 1 | 1 - 3 |
| 4-year-old | 1.44 | .58 | 1 | 1 - 3 |
| 5-year-old | 1.46 | .59 | 1 | 1 - 3 |

**Note.** $n$ = 51. SD = Standard Deviation. Mode values marked with *a* indicate multiple modes may exist. The smallest value is shown.

In terms of socioeconomic status, the mean SES score was 12.70 (Table 2), suggesting that participants were generally positioned toward the higher end of the SES range. The most frequently reported SES score (mode) was 13.0. However, the standard deviation (SD = 2.95) indicates variability, with participants from both lower and higher SES groups represented. When examining SES categories separately, the mean SES score for the low SES group was 3.25 (N = 2, SD = 1.06), for the middle SES group it was 7.5 (N = 2, SD = 0.71), and for the high SES group it was 13.32 (SD = 1.99). The number of languages spoken by participants ranged from one to three, with a mean of 1.45 (SD = 0.58). The most commonly reported number of languages spoken was one. All participants were reported to be taught in English at their respective preschools. Additionally, English was the primary language spoken at home for the majority of participants (33 children, 64.7%). Among the bilingual and multilingual participants, the most common additional home languages reported alongside English were isiZulu, Sesotho, and Setswana, with a smaller number of children also speaking Urdu, Pashto, and Turkish. This linguistic diversity reflects the multicultural composition of the sample and provides a meaningful context for exploring the potential influence of bilingualism on cognitive flexibility in a South African setting.

### *1.3. Descriptive Statistics for 3DCCS task*

The descriptive statistics for the 3DCCS accuracy score and the CORSWOPS Maximum Score (flexibility) are presented in Table 3 by dimension, as well as for the overall task. Participants performed best in the Animal Task, with a mean score of 5.96 (SD = 0.28), while the lowest scores in the 3DCCS task were observed in the Size Task, with a mean score of 4.18 (SD = 2.17). The total 3DCCS task scores ranged from 8 to 18, with a mean score of 15.29 (SD = 2.93). Additionally, the CORSWOPS Maximum Score, which reflects the number of opportunities for switches during the task, had a mean score of 0.91 (SD = 0.25), which is close to the upper range (1.00) for this score, suggesting good flexibility in the sample overall.

**Table 3**

*Descriptive Statistics for the 3DCCS Tasks and CORSWOPS MAX Score*

| | Group | Mean | *SD* | Range |
|---|---|---|---|---|
| Total Accuracy: Animal Task | Overall | 5.96 | .28 | 4 – 6 |
| | 4-year-old | 5.93 | .39 | 4 - 6 |
| | 5-year-old | 6 | .00 | 6 - 6 |
| | Male | 6 | .00 | 6 - 6 |
| | Female | 5.92 | .40 | 4 - 6 |
| | Low SES | 6 | .00 | 6 - 6 |
| | Medium SES | 6 | .00 | 6 - 6 |

| | | | | |
|---|---|---|---|---|
| | High SES | 5.96 | .29 | 4 - 6 |
| Total Accuracy: Colour Task | Overall | 5.16 | 1.65 | 0 – 6 |
| | 4-year-old | 4.89 | 1.85 | 0 - 6 |
| | 5-year-old | 5.46 | 1.38 | 1 - 6 |
| | Male | 5 | 1.83 | 1 - 6 |
| | Female | 5.32 | 1.46 | 0 - 6 |
| | Low SES | 5.5 | .70 | 5 - 6 |
| | Medium SES | 6 | .00 | 0 - 6 |
| | High SES | 5.11 | 1.71 | 0 - 6 |
| Total Accuracy: Size Task | Overall | 4.18 | 2.17 | 0 – 6 |
| | 4-year-old | 3.44 | 2.29 | 0 - 6 |
| | 5-year-old | 5 | 1.72 | 0 - 6 |
| | Male | 4.35 | 2.00 | 0 - 6 |
| | Female | 4 | 2.36 | 0 - 6 |
| | Low SES | 1.5 | 2.12 | 0 - 6 |
| | Medium SES | 6 | .00 | 6 - 6 |
| | High SES | 4.21 | 2.14 | 0 - 6 |
| Total 3DCCS task score | Overall | 15.29 | 2.93 | 8 – 18 |
| | 4-year-old | 14.26 | 3.05 | 8 - 18 |
| | 5-year-old | 16.46 | 2.34 | 11 - 18 |
| | Male | 15.35 | 2.65 | 9 - 18 |
| | Female | 15.24 | 3.24 | 8 - 18 |
| | Low SES | 13 | 2.83 | 11 - 18 |
| | Medium SES | 18 | .00 | 18 - 18 |
| | High SES | 15.28 | 2.93 | 8 - 18 |
| CORSWOPS Max Score | Overall | .91 | .25 | .14 – 1 |
| | 4-year-old | .86 | .29 | .14 - 1 |
| | 5-year-old | .96 | .17 | .14 - 1 |
| | Male | .93 | .22 | .14 - 1 |
| | Female | .89 | .28 | .14 - 1 |
| | Low SES | .50 | .24 | .33 - .67 |
| | Medium SES | 1 | .00 | 1 - 1 |
| | High SES | .92 | .24 | .14 - 1 |

***Notes.*** *n* = 51. *SD* = standard deviation.

## 2. Inferential statistics

The inferential analyses consisted of three parts. Firstly, Spearman correlations were conducted to examine the relationships between cognitive flexibility (as measured by the total 3DCCS score and the CORSWOPS MAX score) and key demographic variables, including age in months, sex, number of languages spoken, and SES. Secondly, a Friedman test was conducted to compare total accuracy scores across the three 3DCCS task conditions (animal, colour, and size) to assess whether performance varied by task type. Lastly, multiple regression analyses were performed to determine the extent to which the demographic variables predicted cognitive flexibility (as measured by the total 3DCCS score and the CORSWOPS MAX score).

### *2.1. Correlation Analyses*

Table 4 presents the results of Spearman correlation analysis conducted to explore the relationships between the total 3DCCS score, CORSWOPS Max score, and key demographic variables, including age in months, sex, number of languages spoken, and SES scores. The Spearman correlation coefficient is a nonparametric measure of the strength and direction of association between two variables and data must be measured on an ordinal, interval, or ratio scale, which was the case for all variables included here.

**Table 4**

*Spearman Correlations between Total 3DCCS Accuracy Score, Flexibility (CORSWOPS MAX) Score, and Demographic Variables*

| | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| 1.Age in Months | - | | | | | |
| 2. Sex | .245 | | | | | |
| 3. No. of Spoken Languages | -.019 | -.011 | - | | | |
| 4. Total SES | -.155 | -.352* | -.228 | - | | |
| 5. Total 3DCCS Score | .446** | -.018 | -.217 | .065 | - | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 6. CORSWOPS Max Score | .199 | .017 | -.248 | .086 | .501** | - |

***Note.*** *n = 51. Correlations marked with ** indicate significance at p < .01 (2-tailed).*

Spearman's correlation analysis indicated a statistically significant, moderate positive correlation between total 3DCCS score and age in months (r = .45, p = .001), suggesting that cognitive flexibility improves with age. Additionally, a statistically significant, moderate positive correlation was found between total 3DCCS score and CORSWOP MAX score (r = .50, p < .001), which aligns with expectations as they measure related constructs. Sex was not significantly correlated with total 3DCCS score (r = .018, p = .901) or CORSWOP MAX score (r = .071, p = .619), suggesting that boys and girls performed similarly on both tasks. No other significant correlations were observed among the remaining variables.

### *2.2. Friedman Test for Total Accuracy Across Conditions.*

A Friedman test was conducted to compare total accuracy scores across the three conditions: animal, colour, and size task. The test was appropriate as the dependent variable (total accuracy score) was measured at a continuous scale, and the same participants completed all three conditions, satisfying the assumption of related samples. Additionally, the assumption of independent observations within each condition was met, as each child's responses were independent of others. Since the Friedman test does not assume normality, it was suitable given that the data were not normally distributed (Field, 2013).

The results indicated a statistically significant difference in total accuracy across conditions, $\chi^2(2) = 32.56$, $p < .001$. Table 5 presents the mean ranks for total accuracy across the three conditions.

**Table 5**

*Friedman Test Results for Total Accuracy Across conditions*

| Condition | Mean Rank |
|---|---|
| Total accuracy animal | 2.38 |
| Total accuracy colour | 2.04 |
| Total accuracy size | 1.58 |

***Note.*** Higher mean ranks indicate higher accuracy.

Given the significant test result, post hoc pairwise comparisons were conducted using Wilcoxon signed-rank tests with Bonferroni correction to identify where the differences lay. The results are summarized in Table 6

**Table 6**

*Pairwise Comparisons for Total Accuracy Across tasks (Bonferroni Corrected)*

| Pairwise Comparison | Z | SE | *Z* | *p* | Adj. sig |
|---|---|---|---|---|---|
| Total accuracy size – Total accuracy colour | .461 | .198 | 2.33 | .020 | .060 |
| Total accuracy size – Total accuracy animal | .804 | .198 | 4.06 | <.001 | .000 |
| Total accuracy colour – Total accuracy animal | .343 | .198 | 1.73 | .083 | .249 |

***Note.*** Pairwise comparisons were conducted using Wilcoxon signed-rank tests with Bonferroni correction applied. The significance level was set at $\alpha = .05$. The adjusted significance values (Adj. Sig.) account for multiple comparisons. SE = standard error.

Pairwise comparisons revealed that the total accuracy in the size condition was significantly lower than both the animal ($p < .001$, adjusted $p = .000$) and colour ($p = .020$, adjusted $p = .060$) conditions. However, there was no statistically significant difference between the animal and colour conditions ($p = .083$, adjusted $p = .249$) after applying the Bonferroni correction. These results suggest that the Size Task was the most challenging, while the Animal and Colour Tasks were the easiest.

### *2.3. Multiple Regression Analyses*

To investigate whether demographic variables (age in months, number of languages spoken, and socioeconomic status [SES] predicted variance in total 3DCCS scores, post-regression outputs were examined to assess whether the assumptions of multiple linear regression were met. The first assumption requires the independent variables to be measured on a continuous scale. Since age in months, number of spoken languages, and SES scores were measured on continuous scales, this assumption was satisfied. The second assumption stipulates that a linear relationship should exist between the variables. This was assessed using scatterplots, which revealed that all relationships appeared either linear or non-existent. The third assumption, independence of observations, was ensured by the research design. Each participant completed the 3DCCS task only once, eliminating concerns about repeated measures or non-independent errors. The fourth assumption of homoscedasticity was assessed by plotting the standardized residuals against the predicted values. The scatterplot revealed an adequate homogeneity of variance (Appendix I, Figure 1), suggesting that this assumption was satisfied. The fifth assumption requires an approximately normal distribution of residuals. A histogram of standardized residuals (Appendix I, Figure 2) indicated that the errors were approximately normally distributed, satisfying this assumption. The sixth assumption addresses multicollinearity among the independent variables. Multicollinearity was assessed using Pearson correlation coefficients and variance inflation factors (VIF). Weak correlations were observed among the independent variables: SES and age in months ($\rho(51) = -0.036$, $p = .80$), SES and number of languages spoken ($\rho(51) = -0.330$, $p = .018$), and age in months and number of languages spoken ($\rho(51) = -0.017$, $p = .908$). Additionally, all VIF values were below 2, and tolerance values exceeded 0.2, suggesting that multicollinearity was not a concern. The final assumption involves detecting the presence of outliers. Several diagnostic measures were computed, including standardized residuals, Cook's distance, leverage values, and Mahalanobis distances. No outliers were detected based on standardized residuals, as all values fell within the range of -3 to 3. Similarly, no outliers were identified using Cook's distance or Mahalanobis distances. However, this observation was retained in the analysis because it was not identified as an outlier by the other diagnostic measures (standardized residuals, Cook's distance, or Mahalanobis distances) and was therefore deemed appropriate to include in the sample.

As shown in Table 7, the regression model predicting variance in total 3DCCS scores based on demographic variables was statistically significant, ($F(4,46)=3.78$, $p=.010$, $R^2=.247$). This indicates that approximately 24.7% of the variance in total 3DCCS scores ($R^2=.247$, Adjusted $R^2=.182$) was explained by the demographic variables. Among the predictors, age in months was the only statistically significant positive predictor of 3DCCS scores ($\beta = .446$, $t(46) = 3.37$, $p = .002$), suggesting that higher ages were associated with higher scores. In contrast, sex ($\beta = -.12$, $t(46) = -.88$, $p = .38$), SES ($\beta = -.02$, $t(47) = -.11$, $p =$

.91) and number of spoken languages ($\beta$ = -1.24, $t(47)$ = -1.81, $p$ = .08) were not significant predictors of total 3DCCS scores.

**Table 7**

*Results of Multiple Regression Analysis predicting 3DCCS Total accuracy Scores*

| Predictor | *B* | *SE* | *β* | *p* | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | LB | UB |
| SES | -.02 | .13 | -.02 | .91 | -.286 | .26 |
| Sex | -.71 | .81 | -.12 | .38 | -2.34 | .92 |
| No of languages spoken | -1.24 | .69 | -.24 | .08 | -2.62 | .14 |
| Age in months | .20 | .06 | .42 | .002 | .08 | .32 |

***Notes***. $n$ = 51. $B$ = unstandardised $B$, $SE$ = standard error, $\beta$ = standardised beta coefficient, CI = confidence interval, LB = lower bound, UB = upper bound.

**Regression Analysis Assessing CORSWOP MAX Scores and Demographic Variables.** A multiple regression analysis was conducted to examine the relationship between CORSWOP MAX scores and demographic variables: age in months, sex, total SES, and number of spoken languages (see Table 8). Since the demographic variables (age in months, number of spoken languages, and SES scores) served as independent variables and were measured on a continuous scale, the first assumption of regression analysis was satisfied. The assumptions of linearity between variables, independent observations, normally distributed residuals, and absence of extreme outliers were assessed, as previously described. However, the assumption of homoscedasticity was violated (Appendix I, Figure 3). To address this violation, bootstrapping with 1,000 resamples was applied to obtain robust standard errors and confidence intervals (Field, 2013).

**Table 8**

*Results of Multiple Regression Analysis predicting CORSWOPS MAX score*

| Predictor | *B* | *SE* | *β* | *p* | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | LB | UB |
| SES | .01 | .02 | .14 | .47 | -.03 | .04 |
| Sex | .05 | .08 | .10 | .58 | .12 | .20 |
| No of languages spoken | -.07 | .08 | -.18 | .36 | .23 | .08 |
| Age in months | .004 | .006 | .102 | .48 | -.009 | .02 |

***Notes***. *n* = 51. *B* = unstandardised *B*, *SE* = standard error, *β* = standardised beta coefficient, CI = confidence interval, LB = lower bound, UB = upper bound.

The multiple regression model was not statistically significant, F(4,46) = 1.00, p = .416, $R^2$ = .080, indicating that the demographic predictors collectively explained only 8.0% of the variance in CORSWOP MAX scores. Furthermore, none of the individual predictors were statistically significant.

Overall, the quantitative analyses revealed key insights into cognitive flexibility and its relationship with demographic factors. Spearman correlations indicated that age was positively associated with cognitive flexibility, as measured by the total 3DCCS score, but no significant associations were found between cognitive flexibility and other demographic variables, including sex, SES, and number of spoken languages. The Friedman test showed that task performance varied across conditions, with participants performing best in the Animal and Colour Tasks and worst in the Size Task, suggesting that task complexity influences cognitive flexibility outcomes. Multiple regression analyses further confirmed that age was the only significant predictor of 3DCCS scores, while other demographic factors did not contribute significantly to variance in cognitive flexibility. However, the regression model predicting CORSWOP MAX scores was not significant, indicating that demographic variables did not meaningfully predict performance on this measure.

## 3. Qualitative results

This section presents the qualitative findings of the study, addressing the research question: How did preschoolers engage with the 3DCCS task? To analyse preschoolers' engagement with the 3DCCS task, Reflexive Thematic Analysis (RTA) was employed following Braun and Clarke's (2019) six-phase framework. The qualitative data was derived from the observational questionnaires completed after each child's participation in the task. These observational forms recorded various aspects of engagement, including the child's ability to switch between sorting rules, the strategies they used, their behaviours, and overall task engagement.

The thematic coding process began with familiarization with the data, where the observational forms were reviewed multiple times to ensure a comprehensive understanding of recorded behaviours and responses. This step allowed for an initial grasp of potential patterns in how children engaged with the task. Following this, initial codes were generated, capturing recurring behaviours such as seeking confirmation, verbal strategies, physical engagement, hesitancy, distraction, confidence, and enthusiasm. These codes were broad at first to ensure all aspects of engagement were considered before being refined. After coding, themes were identified by grouping related codes into higher-order categories that best represented key aspects of task engagement. For instance, codes related to seeking reassurance, verbal self-talk, and visual scanning were clustered under the broader theme of "Strategies used during the task". This process ensured that the themes were representative of the diverse ways in which children engaged with the task. Next, themes were reviewed and refined to ensure they were internally coherent, distinct from one another, and supported by the data. Some themes were combined when they overlapped, while others were split into sub-themes to capture more nuanced differences in behaviour.

Once finalized, themes were defined and named, ensuring they accurately captured key aspects of the children's engagement styles. For example, "Proactive engagement" was identified as a theme to describe participants who went beyond the task requirements by tidying up materials or offering to help, while "Disengagement" captured moments where children exhibited minimal involvement or required frequent prompting. Finally, the themes were structured into a coherent narrative, incorporating direct examples from the observational data to provide an in-depth qualitative analysis of children's engagement styles.

Through this systematic thematic analysis, the study provided a data-driven interpretation of how preschoolers engaged with the 3DCCS task, offering insights into the cognitive, behavioural, and emotional dimensions of their interactions. This approach ensured that findings were firmly grounded in the recorded observations rather than predetermined categories, allowing for a nuanced understanding of engagement patterns among preschoolers. Table 6 below summarizes these themes, including the number of participants and the frequency of occurrences for each theme.

**Table 6**

*Themes identified per number of participants.*

| Themes | Number of participants |
|---|---|
| 1. **1. Completion of Tasks** | |
| 1.1 Animal task | 51 |
| 1.2 Colour task | 51 |
| 1.3 Size task | 51 |
| 1.4 Time taken | 51 |
| **1. Strategies** | |
| 2.1 Self-guided verbal strategies | 10 |
| 2.2 Visual strategies | 12 |
| 2.3 Seeking confirmation/reassurance | 14 |
| **2. Behaviours** | |
| 3.1 Distracted or hesitant behaviour | 15 |
| 3.2 Shy and did not talk much | 8 |
| 3.3 Confident without seeking confirmation | 14 |
| **3. Engagement** | |
| 4.1 Enjoyment or enthusiasm | 12 |
| 4.2 Asking questions or comments | 10 |
| 4.3 Proactive engagement. | 5 |
| 4.4 Disengagement. | 7 |

**Theme 1. Completion of Tasks: Accuracy, Time Taken, and Task-Specific Performance**

The completion of tasks was analysed in terms of how well each child performed across the three sorting rules: animal, colour, and size. Additionally, time taken to complete the entire task was considered as an indicator of efficiency and engagement. A comparative analysis between 4-year-olds and 5-year-olds revealed clear developmental differences, with 5-year-olds demonstrating greater accuracy in switching between sorting rules. Furthermore, sex differences were explored to assess whether boys and girls exhibited variations in accuracy, task completion time, or engagement strategies.

***1. Task Completion and Accuracy***

Across all sorting dimensions, 5-year-olds demonstrated superior accuracy and faster task completion times compared to 4-year-olds. While both age groups performed well in the animal sorting task, notable differences emerged in the colour and size tasks, with size sorting posing the greatest challenge for both age groups.

***1.1. Animal Task***

The animal sorting task was the most accurately completed across both age groups, with all participants sorting the animal cards correctly, except for one child who made a mistake in the task. Both 4- and 5-year-olds performed well, but 5-year-olds were more consistent and completed the task faster, reflecting their improved cognitive flexibility and confidence in following simple rules. This suggests that by age 5, children apply straightforward categorization rules with greater ease and efficiency, whereas some 4-year-olds required more processing time before making decisions. For example:

> **Participant 9** *(4-year-old)* correctly sorted all the cards but hesitated briefly before placing them.
> **Participant 39** *(5-year-old)* completed the task without hesitation or needed any confirmation.

These findings highlight the developmental progression in task efficiency and confidence, with 5-year-olds demonstrating more automaticity in rule application. While 4-year-olds showed strong accuracy, their occasional hesitation suggests ongoing refinement in cognitive processing speed and decision-making.

### *1.2. Colour Task*

The colour sorting task revealed notable differences in performance between 4- and 5-year-olds, with both age groups finding it somewhat more challenging than the animal task. While most children were able to sort the cards correctly based on colour, 4-year-olds struggled more frequently with switching from the animal rule to the colour rule, often reverting to sorting by animal. In contrast, 5-year-olds demonstrated better accuracy and consistency, though some still made errors, particularly in the later items of the task. This suggests that while 5-year-olds have improved cognitive flexibility, the ability to switch between dimensions (animal to colour) is still developing at this age. For example:

> **Participant 10** *(4-year-old)* During the colour game, the child experienced difficulty switching from the previous animal sorting rule and continued to sort according to the animal rule.
>
> **Participant 31** *(5-year-old)* The child initially showed the ability to switch to the colour game. However, from item 3 to item 6, the child reverted to sorting according to the animal rule.

These findings highlight the developmental progression in cognitive flexibility, with 5-year-olds showing greater ease in switching between rules compared to 4-year-olds. While 4-year-olds often reverted to the animal rule, 5-year-olds were more likely to adapt to the new sorting rule, reflecting their improved ability to manage competing cognitive demands. However, the colour task remained more challenging for both groups, indicating that switching between dimensions requires further refinement in cognitive flexibility during early childhood.

### *1.3. Size Task*

The size task was the most challenging for both 4- and 5-year-olds, with many children struggling to switch from the previous sorting rules (animal or colour) to the size rule. While 5-year-olds demonstrated better performance compared to 4-year-olds, both age groups made frequent errors, particularly in the later items of the task. This indicates that the ability to switch between multiple dimensions (animal, colour, and size) is still developing during this stage, with 5-year-olds showing greater proficiency but not yet mastering the task.

**Participant 13** ***(4-year-old)*** In the size game, the child incorrectly sorted items, placing items 1, 2, 4, and 5 according to the colour rule, while items 3 and 6 were sorted according to the animal rule.

**Participant 50** *(5-year-old)* The child made only one mistake throughout the task, specifically on item 6 of the size game, where they sorted it according to the colour rule instead of size.

These findings underscore the complexity of the size task, which requires children to inhibit previously learned rules and adapt to a new sorting dimension. While 5-year-olds showed improved accuracy and fewer errors compared to 4-year-olds, both groups found the task difficult, reflecting the cognitive demands of managing multiple dimensions simultaneously. The size task highlights the ongoing development of cognitive flexibility during early childhood, with 5-year-olds demonstrating incremental progress but still facing challenges in fully mastering multidimensional rule-switching.

***2. Time Taken to Complete the Task***

The time taken to complete the tasks varied significantly between 4- and 5-year-olds, reflecting differences in cognitive processing speed, confidence, and task-switching efficiency. On average, 4-year-olds took longer to complete the tasks, with an average time of 10-12 minutes, while 5-year-olds completed the tasks more quickly, averaging 8-10 minutes. This difference highlights the developmental progression in cognitive flexibility and task efficiency, with 5-year-olds demonstrating faster decision-making and reduced hesitation compared to 4-year-olds. For example:

**Participant 6** *(4-year-old)* The child took 13 minutes to complete the task … frequently hesitating and sought confirmation before placing the cards.

**Participant 35** *(5-year-old)* The child completed the task in 8 minutes … working confidently and independently without needing confirmation or approval.

These findings suggest that 5-year-olds are more efficient in processing and applying sorting rules, likely due to their more advanced cognitive flexibility and working memory capacity. In contrast, 4-year-olds required more time to process instructions and make decisions, often hesitating or seeking reassurance before proceeding. The faster completion times among 5-year-olds reflect their growing ability to manage multiple cognitive demands and switch between tasks with greater ease. However, the variability in time taken within both age groups underscores the individual differences in cognitive development during early childhood.

**Theme 2. Strategies used by participants when completing the 3DCCS task.**

Multiple strategies were utilized by the participants when completing the 3DCCS task. These strategies offered valuable insights into how these young children engaged with the activity, reflecting how participants focused, and their approach to the task. However, not all participants employed observable strategies; some simply placed the cards into the boxes without exhibiting any distinct approach. For those who did adopt strategies, a range of methods was noted, including seeking confirmation from the researcher, using visual and verbal strategies, and physical engagement with the task cards.

***1. Seeking Confirmation from the Researcher***

One of the most common strategies observed was seeking confirmation/reassurance from the researcher. This behaviour was prevalent across participants, regardless of their demeanour or confidence levels. Children would frequently look at the researcher or ask questions to ensure they were performing the task correctly. This behaviour was more pronounced among 4-year-olds, who often relied heavily on external validation. 4-year-olds frequently sought reassurance from the researcher, often pausing after each card placement to look for a nod or verbal affirmation. This behaviour suggests that 4-year-olds are still developing the confidence to trust their own decision-making and rely more on external cues to guide their actions. For example:

> **Participant 5** *(4-year-old)* The child asked, 'Is this right?' after placing several cards in the boxes during the size game. This repetitive questioning highlighted their uncertainty and reliance on external validation.
> **Participant 12** *(4-year-old)* The child would pause after each card placement, looking up at the researcher for a nod or verbal affirmation before proceeding to the next item.

While some 5-year-olds still sought confirmation, they did so less frequently and often only during more challenging parts of the task, such as transitioning between sorting rules. This suggests that 5-year-olds are more confident in their ability to follow instructions but may still need occasional reassurance when faced with increased cognitive demands.

> **Participant 47** *(5-year-old)* The child hesitated before placing each card, particularly when transitioning between sorting rules.
> **Participant 40** *(5-year-old)* The child sorted the cards efficiently but paused occasionally to look at the researcher, waiting for a nod or smile before proceeding to the next card.

The reliance on seeking confirmation reflects the developmental progression in cognitive flexibility and self-regulation. 4-year-olds often depend on external validation to navigate uncertainty, as they are still refining their ability to process and apply task rules independently. In contrast, 5-year-olds demonstrate greater confidence and autonomy, seeking confirmation less frequently and only in more complex situations. This shift highlights the growing ability of 5-year-olds to internalize task rules and rely on their own cognitive resources, marking a significant step in their executive function development.

### *1.1 Visual Strategies*

Visual strategies were another prominent approach used by participants during the 3DCCS task. These strategies involved children relying on visual cues to guide their decision-making process. By comparing the features of the cards with the sorting boxes, participants utilized perceptual cues to align the cards with the task requirements. This approach highlights how children process and interpret visual information as part of their problem-solving strategy. However, there were notable differences in how 4- and 5-year-olds employed these strategies, reflecting developmental progression in cognitive flexibility and attention to detail.

For instance, 4-year-olds frequently relied on visual strategies, often comparing the cards to the sorting boxes in a deliberate and methodical manner. They tended to focus on one dominant feature (e.g., colour or shape) and used it as a primary cue for sorting. However, they sometimes struggled to integrate multiple dimensions (e.g., colour and size) simultaneously, leading to errors in more complex tasks like the size game. For example:

> **Participant 7 (4-year-old)** The child held the card close to the box and stated, 'This is exactly the same as the picture on the box,' before confidently placing it inside. This

behaviour indicated a deliberate comparison between the visual features of the card and the sorting criteria.

**Participant 34 (4-year-old)**: "The child focused intently on the image of a fish on the card and the corresponding box, saying, 'This is a different colour fish,' before sorting it into the correct box. This suggests the participant used colour as a key feature for visual matching.

While 5-year-olds also used visual strategies, they demonstrated greater efficiency and flexibility in applying them. They were more likely to integrate multiple visual cues (e.g., colour, size, and shape) when sorting, particularly in more complex tasks like the size game. This ability to process multiple dimensions simultaneously reflects their advanced cognitive flexibility and working memory capacity. For example:

**Participant 47** *(5-year-old)* The child paused briefly while holding a card, then aligned it next to the box and remarked, 'It's the same size,' before inserting it into the box. This observation reflects the participant's ability to use size as a visual sorting criterion.

**Participant 22** *(5-year-old)* The child confidently verbalized, 'This one is big, so it goes here,' while sorting the size game, demonstrating their ability to integrate size and shape cues effectively.

These examples demonstrate how visual comparison formed an integral part of the children's cognitive processes during the task. By aligning the card's features, such as colour, size, or shape, with the criteria presented on the box, participants engaged in a detailed analysis of the visual information. This strategy highlights the importance of perceptual discrimination in tasks that rely on concrete and observable sorting rules. The reliance on visual strategies aligns with developmental findings that young children often depend on external, tangible cues when engaging with problem-solving tasks (Case, 1985). The act of comparing images provides an accessible method for children to interpret and apply sorting rules, particularly in tasks that require distinguishing between multiple criteria.

***1.2 Physical engagement with the cards***

Physical engagement with the materials was observed among many participants during the 3DCCS task. This strategy involved children using physical gestures or fidgeting with the cards before placing them, which appeared to help them process the task requirements or regulate their focus. While not as overtly cognitive as verbal or visual strategies, these behaviours suggest that children used tactile interactions as a means of externalizing their cognitive processes. However, there were subtle differences in how 4- and 5-year-olds engaged physically with the materials, as well as some sex-based variations in the types of physical behaviours exhibited. For instance, 4-year-olds often used physical engagement as a way to manage their focus and process the task demands. They frequently fidgeted with the cards or tapped them on the table before making a decision, which seemed to serve as a self-soothing mechanism or a way to externalize their thought processes. For example:

> **Participant 15** *(4-year-old)* The child frequently fidgeted with the edge of the table while thinking about where to place the card. This subtle behaviour suggested a way to manage focus and maintain engagement during the task.

While 5-year-olds also engaged physically with the materials, they demonstrated more controlled and purposeful movements. They were less likely to fidget aimlessly and instead used physical actions, such as rotating or aligning the cards, to aid their decision-making process. This reflects their improved motor control and ability to use physical actions strategically to support cognitive tasks. For example:

> **Participant 27** *(5-year-old)* The child aligned the card carefully with the box before placing it, demonstrating a deliberate and controlled use of physical engagement to guide their sorting.

These examples illustrate how physical engagement functioned as a tool for externalizing cognitive processing and regulating focus during the task. Children often used their hands to manipulate the cards as part of their thought process, whether through fidgeting, tapping, or aligning the cards. Additionally, sex-based differences emerged in how physical engagement was expressed. Boys were more likely to engage in fidgeting behaviours, such as tapping the table, playing with the cards, or shifting in their seats, whereas girls demonstrated more controlled and deliberate movements, such as rotating or aligning the cards before sorting. For example:

> **Participant 28** *(5-year-old, boy)* The child frequently fidgeted with the card while thinking about where to place the card.
> **Participant 36** *(5-year-old, girl)* The child rotated the card in their hands while examining it, appearing to process the task visually and physically before making their decision.

These actions suggest that physical engagement provided participants with a means of grounding their focus or enhancing their processing of the task demands. Kinaesthetic strategies are often seen in young children as a way of externalizing thought processes or dealing with uncertainty during problem-solving tasks (Piaget, 1952). For instance, tapping or rotating the cards might act as a self-soothing mechanism to reduce hesitation or as a tool for reinforcing decisions about the sorting criteria. Moreover, physical engagement with materials could also reflect developmental differences in how children approach tasks requiring concentration and problem-solving. Young children are known to use bodily actions as part of their cognitive processes, which aligns with embodied cognition theories suggesting that physical movements and gestures are integral to learning and thinking (Barsalou, 2008). However, the higher frequency of fidgeting behaviours among boys may indicate differences in self-regulation strategies, with boys potentially using movement-based engagement as a way to sustain focus, while girls adopted more structured physical interactions to support task completion

### *1.3 Verbal Strategies*

Verbal strategies were another notable approach employed by participants during the 3DCCS task. These strategies involved children using self-guided verbalization, such as repeating the rules aloud, making descriptive statements, or producing related sounds. Verbal strategies often served to reinforce task rules, helping children process and maintain focus. This form of self-talk not only reflects cognitive engagement but also highlights the use of language as a tool for regulating actions and supporting decision-making. While there was no significant difference in the use of verbal strategies between 4- and 5-year-olds, a slight sex-based difference was observed, with girls more likely to speak to themselves during the task. For example:

**Participant 18** *(4-year-old, boy)* The child repeatedly verbalized the sorting rule during the task, saying, 'blue dog goes here,' before placing the card in the correct box during the colour game. This repetition demonstrated the participant's active engagement in recalling and applying the task instructions.

**Participant 40** *(5-year-old, girl)* The child incorporated sound effects while sorting animal cards, stating, 'Woof woof goes here,' when placing a dog card in the appropriate box. The use of animal sounds reflected a creative way of linking the task's visual and verbal components.

**Participant 33** *(5-year-old, boy)* The child whispered the instructions to themselves, saying, 'Big goes here, small goes there,' while completing the size game. This behaviour illustrated how participants used verbal cues to scaffold their understanding and maintain focus on the sorting rule.

These examples demonstrate how verbal strategies, such as repeating rules or creating verbal associations, helped children reinforce their understanding of the task and maintain focus. Verbal strategies such as these highlight the role of self-guided language in aiding cognitive flexibility. By articulating the task rules or creating verbal associations, participants actively reinforced their understanding and application of the sorting criteria. Additionally, verbal strategies appeared to reduce hesitation or uncertainty for some participants. For instance, those who verbalized the rules often placed the cards more confidently and with fewer delays. This suggests that self-talk may also function as a form of self-regulation, helping participants navigate the task independently.

**Theme 3. Behaviour used by participants while completing the 3DCCS task.**

The behaviours exhibited by participants during the 3DCCS task provided critical insights into their emotional states, levels of engagement, and how their approached the task. These behaviours ranged from signs of confidence and focus to displays of hesitation, distraction, or shyness. Behavioural observations are essential in understanding how children navigated the task, as they reveal not only cognitive processes but also affective and social dimensions of their engagement. This section explores the diverse behaviours observed, categorized into three primary patterns: distracted or hesitant behaviour, shy and reserved behaviour, and confident behaviour. Each category highlights how children's emotions and social tendencies influenced their task performance and engagement.

***1. Distracted or Hesitant Behaviour***

Distracted or hesitant behaviour was one a frequently observed patterns among participants during the 3DCCS task. This behaviour often manifested as pauses, delays, or moments of disengagement, where children seemed unsure of their actions or momentarily lost focus. Such behaviours can reflect a variety of underlying factors, including task difficulty, uncertainty about the rules, or individual differences in attention and cognitive flexibility. While no significant age-related differences were observed in the overall frequency of distraction or hesitation, subtle variations in how children exhibited these behaviours suggest that 4-year-olds and 5-year-olds may have different underlying reasons for disengagement. Additionally, no clear sex-based differences emerged, as both boys and girls displayed similar patterns of hesitation and momentary distraction during the task. For example:

> **Participant 12** *(4-years-old)* frequently hesitated before placing a card in the box, often looking around the room or fidgeting with their hands. This behaviour suggested a struggle to maintain focus and process the sorting rule.
>
> **Participant 8** *(4-year-old)* paused repeatedly, holding the card mid-air while appearing to think deeply about its placement. These pauses were often accompanied by subtle gestures, such as tapping the card on the table.
>
> **Participant 32** *(5-year-old***)** became visibly distracted during the size game, glancing out the window several times and requiring the instructions to be repeated before continuing with the task.

These observations suggest that 4-year-olds exhibited more frequent and prolonged hesitation, particularly when required to switch between sorting rules. Their hesitation often appeared to be driven by cognitive uncertainty, as they struggled to override previously learned rules and apply the new one. In contrast, 5-year-olds also displayed moments of hesitation, but these instances were generally shorter and occurred less frequently. When 5-year-olds hesitated, it often seemed more reflective, suggesting that they were carefully processing their decision rather than experiencing difficulty with the rule switch itself. This distinction indicates that while both age groups encountered moments of uncertainty, older children demonstrated a greater ability to regulate their thought process and transition between rules more effectively.

Thus, these patterns of distraction or hesitation may suggest that some aspects of the task required participants to focus on maintaining the sorting rules while applying them. Hesitant behaviour could reflect thoughtful, but slower, processing as children worked through the task at their own pace. For instance, the prolonged pauses observed in several participants might indicate their attempts to reconcile the rules or adjust to changes. Distraction, on the other hand, could arise from external factors or varying levels of engagement with the task. Preschoolers are known to have variable attention spans, and the structured nature of the 3DCCS task may have required sustained focus that was not equally maintained by all participants (Diamond, 2013).

***2. Shy and Reserved Behaviours***

Shy and reserved behaviours were observed in several participants during the 3DCCS task, characterized by minimal verbal communication, avoidance of eye contact, and subdued physical expressions. While these behaviours may reflect individual temperament or personality traits, they also provide insight into how participants managed their engagement and focus during the task. Some children engaged with the task quietly and independently, while others displayed hesitation or uncertainty in their interactions with the researcher. However, despite their reserved demeanour, many participants were able to follow instructions accurately and complete the task successfully. task-related uncertainty. In terms of age and sex-based differences, no significant distinctions were observed in how 4- and 5-year-olds or boys and girls exhibited shy behaviours during the 3DCCS task. Both age groups displayed similar levels of reserved engagement, with no clear developmental trend suggesting that older children were more outgoing or confident than younger children.
For example:

**Participant 26** avoided eye contact throughout the task, frequently looking down at the table while holding the card.

**Participant 28** nodded in response to instructions but did not speak at all during the task. The child maintained a quiet focus and appeared to process the task internally rather than seeking external confirmation.

**Participant 50** displayed shy behaviour by walking into the room behind the teacher and keeping their head down. During the task, the participant’s responses were limited, like they state only “ok” after instructions.

These examples highlight how some participants engaged with the task in a subdued and introspective manner. Shy behaviours, such as avoiding verbal communication or eye contact, may indicate feelings of uncertainty or discomfort in a structured setting. However, these behaviours did not necessarily impede task completion, as many participants successfully completed the task despite their reserved engagement style. This suggests that shy behaviours should not be equated with difficulty in understanding or performing the task, but rather reflect individual differences in social interaction styles. Furthermore, shy and reserved behaviours may also be culturally influenced, as different cultures dictate how children are expected to engage with adults, particularly unfamiliar ones. In many collectivist cultures, children are socialized to be respectful, cautious, and avoid direct eye contact with adults, especially in structured or evaluative settings (Rubin et al., 2009). In contrast, individualistic cultures emphasize verbal engagement and direct eye contact as signs of confidence and participation (Chen et al., 1998). Given that the study took place in South Africa, a country with diverse cultural backgrounds, it is possible that some participants' reserved behaviours were shaped by cultural norms that encourage deference to adults in formal settings. As a result, children who displayed minimal verbal communication or avoided eye contact may have been following learned social norms rather than experiencing task-related uncertainty.

### *3. Confident Behaviour*

Confident behaviour was another notable pattern observed during the 3DCCS task. This behaviour was characterized by participants' assured and decisive actions when engaging with the task. Confidence was demonstrated both in children who completed the task independently without seeking external validation and in those who, while confident, still sought confirmation from the researcher. Furthermore, there were no significant age or gsex-based differences in how confidence was expressed, as both 4- and 5-year-olds, as well as boys and girls, displayed confident behaviours at similar rates. This suggests that confidence in task engagement at this stage of development is more likely influenced by individual temperament rather than age-related cognitive development or sex-specific factors.

### *3.1 Confident Behaviour Without Seeking Confirmation*

Some participants displayed confidence by completing the task independently, without looking to the researcher for feedback or reassurance. These children often placed the

cards quickly and decisively, showing a strong understanding of the task rules and a willingness to rely on their own judgment.
For example:

> **Participant 5** quickly placed the cards into the boxes without pausing or hesitating. Their focused demeanour and decisive actions suggested a clear understanding of the task requirements.
>
> **Participant 11** completed the task while maintaining eye contact with the materials, rarely glancing at the researcher or asking for assistance. This behaviour indicated a high level of self-reliance.
>
> **Participant 22** confidently verbalized, “This one is big, so it goes here,” while sorting the size game and did not wait for a response or reassurance from the researcher.

These examples suggest that confident behaviour without confirmation reflects a high level of task engagement and cognitive independence. Participants who exhibited this behaviour seemed to trust their understanding of the sorting rules and demonstrated a clear focus on the task. Furthermore, participants who were confident and did not seek confirmation almost always achieved a perfect score on the task.

### *3.2 Confident Behaviour While Seeking Confirmation*

In contrast, some participants exhibited confident behaviour but still sought confirmation from the researcher. While they appeared assured in their task execution, they also intermittently checked for validation, either through verbal cues or eye contact. This combination of confidence and social referencing highlights how some children balance independence with the need for external reassurance.
For example:

> **Participant 9** confidently placed the cards in the box but frequently glanced at the researcher to ensure they were on the right track. This behaviour suggested a mix of self-assurance and a desire for positive feedback.
>
> **Participant 31** stated, “I’m putting it here because it’s the same size, right?” before placing the card in the box. While the child demonstrated an understanding of the task rules, they still sought confirmation verbally.
>
> **Participant 27** sorted the cards efficiently but paused occasionally to look at the researcher, waiting for a nod or smile before proceeding to the next card.

This blend of confidence and confirmation-seeking reflects a developmental stage where children are becoming more independent but still value social feedback to reinforce their actions. Social referencing is a common behaviour in preschool-aged children, as it helps them gauge the appropriateness of their actions in unfamiliar contexts (Feinman, 1982).

**Theme 4. Engagement During the 3DCCS Task**

Engagement during the 3DCCS task was evident in the various ways participants interacted with the activity, both cognitively and emotionally. Engagement behaviours provided insights into the participants' levels of interest, motivation, and involvement in the task. Some children demonstrated high levels of enthusiasm, actively participating with excitement and curiosity, while others displayed more subdued forms of engagement, such as asking questions or making comments to clarify their understanding. This theme explores the diverse expressions of engagement observed among participants, categorized into three primary forms: enjoyment and enthusiasm, asking questions or making comments, and proactive engagement.

***1. Enjoyment and Enthusiasm***

Enjoyment and enthusiasm were prominently observed in some participants during the 3DCCS task. These behaviours were characterized by smiles, laughter, verbal expressions of excitement, and positive body language. Such displays of enthusiasm often reflected the participants' engagement with the task, suggesting that they found the activity enjoyable and stimulating. For example:

> **Participant 4** smiled throughout the task and exclaimed, “This is fun!” while sorting cards in the colour game. This verbal expression highlighted their positive emotional engagement with the task.
> **Participant 15** wiggled in their seat with excitement during the size game, frequently smiling and saying, “I like this game!”
> **Participant 18** initiated a high-five with the researcher after completing the task. This action suggested both a sense of accomplishment and a positive connection with the researcher.

**Participant 21** gave the researcher a hug upon finishing the task, indicating both emotional warmth and satisfaction with their performance.

These behaviours suggest that for some participants, the 3DCCS task provided an enjoyable and engaging experience. Enthusiastic participants often appeared more motivated to complete the activity and demonstrated higher levels of focus and energy. Such enjoyment may also have facilitated task performance, as participants with such behaviours did perform better.

***2. Asking Questions and Making Comments***

Another form of engagement observed during the 3DCCS task was the participants' tendency to ask questions and make comments. These behaviours reflected their curiosity, creativity, and efforts to connect with the task on a deeper level. Questions and comments often served as a means for children to clarify their understanding, share their observations, or express their thoughts. A recurring question among participants focused on the absence of foil card in the task.

For instance:

**Participant 8** asked, "Why are there no frog cards?" while completing the animal sorting game.

**Participant 20** expressed a similar sentiment, stating, "I like frogs. Why don't we have frog cards here?" This comment reflected not only their interest in the task but also their personal connection to the content.

Participants also made comments that revealed their imaginative engagement with the task:

**Participant 12** remarked, "This dog looks like a father dog," while sorting a card into the appropriate box. This observation demonstrated how the child incorporated creative thinking into the activity.

**Participant 21** said, "This one looks tricky," while carefully examining a card during the size game.

Additionally, some participants asked questions to ensure they were following the task rules:

- **Participant 14** inquired, "Can I do this again if I make a mistake?" This question reflected their desire to understand the task expectations and to perform it correctly.

These examples highlight the importance of questions and comments as indicators of both cognitive and emotional engagement. By asking questions and making observations, participants demonstrated their active involvement in the task and their ability to connect it to their personal experiences and understanding of the world.

***3. Proactive Engagement***

Proactive engagement was observed in some participants who demonstrated initiative and active involvement in the 3DCCS task beyond its basic requirements. These behaviours included tidying up materials, offering help, or finding ways to contribute to the task's completion in creative and thoughtful ways. Proactive engagement highlights not only the children's focus on the task but also their sense of agency and desire to go beyond what was expected. For example:

> **Participant 10** tidied the boxes after completing the task, stating, "I will help you clean." This behaviour reflected a sense of responsibility and a willingness to contribute beyond their role as a participant.
> **Participant 18** rearranged the cards they had already sorted, saying, "I want them to look neat," demonstrating attention to detail and pride in their work.
> **Participant 22** offered assistance by asking, "Do you want me to help with the other cards?" after completing their turn, indicating an interest in staying involved and supporting the researcher.

These actions demonstrate how proactive engagement allowed some participants to take ownership of the task and interact with it in ways that reflected their personal initiative and motivation. This level of engagement is significant, as it shows that the task provided a platform not only for cognitive interaction but also for fostering autonomy and responsibility. Proactive behaviours also align with developmental theories emphasizing the importance of agency in early childhood.

***4. Disengagement***

While many participants engaged actively with the 3DCCS task, some exhibited disengagement, characterized by minimal focus, reduced effort, or a lack of responsiveness to instructions. Disengagement behaviours ranged from passive participation, where children completed the task with little apparent cognitive investment, to active disengagement, where children displayed signs of boredom, distraction, or avoidance behaviours. Understanding disengagement is crucial, as it can indicate challenges in sustaining attention, motivation, or understanding task demands. For example:

> **Participant 23** looked out the window multiple times during the session and had to be reminded to continue sorting, indicating difficulty maintaining focus.
> **Participant 38** was distracted and fidgeted with their hands, requiring repeated instructions before completing the task.

Disengagement in preschool-aged children can be influenced by various cognitive and environmental factors, including attention span, task complexity, and social comfort levels. Research suggests that young children’s ability to sustain attention fluctuates naturally, making it challenging for some to remain engaged in structured tasks for extended periods (Diamond, 2013). Additionally, disengagement may be socially or culturally influenced, as some children may be less likely to fully participate when interacting with an unfamiliar adult in a formal or evaluative setting (Rubin et al., 2009).

Overall, the qualitative findings underscore the diversity in how preschoolers, particularly at different ages, approach cognitive tasks, highlighting both developmental progressions and individual differences in engagement, strategy use, and confidence levels. These insights provide a nuanced understanding of early cognitive flexibility, demonstrating how young children actively process, adapt, and engage with problem-solving tasks based on their developmental capacities, social tendencies, and task-related experiences.

# Chapter 4: Discussion

The primary aim of this study was to explore the development of cognitive flexibility in South African preschoolers aged 4 to 5 years, using the 3DCCS task. This question was addressed by investigating the relationship between cognitive flexibility and key demographic variables, including age, SES, and bilingualism. Additionally, the study aimed to evaluate the suitability of the 3DCCS task for this population and to understand how children engaged with the task. As outlined in Chapter 1, the study thus investigated: (1) how cognitive flexibility develops in 4- and 5-year-old South African preschoolers when assessed using the 3DCCS, (2) whether there are differences in cognitive flexibility based on demographic variables (age, sex, SES, and number of languages spoken), and (3) how preschoolers engaged with the 3DCCS task.

In the previous chapter, the results of the study were presented in line with these research questions. Regarding the development of cognitive flexibility, the quantitative results revealed a significant positive correlation between age and CF scores, with 5-year-olds outperforming 4-year-olds in task accuracy and efficiency. On the other hand, socioeconomic status, sex and bilingualism did not significantly predict cognitive flexibility outcomes, suggesting that these factors may not be influential in CF during early childhood in this sample. The qualitative findings highlighted diverse engagement strategies, including verbal and visual strategies, physical interaction with task materials, and behaviours ranging from confident independence to hesitation and external validation-seeking. Notably, age-related differences were observed in these engagement patterns: 5-year-olds demonstrated greater confidence and independence, were more likely to use visual comparison strategies, and exhibited reduced reliance on external validation, whereas 4-year-olds more frequently sought confirmation, engaged in self-guided verbalization, and displayed greater hesitation before switching rules. These patterns further confirm the quantitative finding that cognitive flexibility improves with age. Thus, findings provided rich insights into how children approached the task, reflecting their developmental progress and individual differences in cognitive flexibility.

In the following sections, these results are discussed in an integrated manner in order to provide an understanding of the development of cognitive flexibility in South African preschoolers, the influence of demographic variables on CF outcomes, and the applicability of the 3DCCS task in this context. The theoretical and practical contributions of this study are discussed next, alongside theoretical and methodological limitations that may have influenced the results, followed by suggestions for future research in this area of study.

1. **The development of cognitive flexibility in 4- and 5-year-olds**

The primary aim of this study was to explore how cognitive flexibility develops in 4- and 5-year-old South African preschoolers when assessed using the 3DCCS task. The quantitative results revealed a significant positive correlation between age and cognitive flexibility scores, with 5-year-olds outperforming 4-year-olds in both accuracy and switching efficiency on the 3DCCS task. This finding aligns with the Unity and Diversity Model of executive functions (Miyake et al., 2000), which posits that cognitive flexibility, working memory, and inhibitory control are interrelated cognitive processes that develop in tandem during early childhood. The observed positive correlation between age and cognitive flexibility in this study supports this model, as older children (5-year-olds) demonstrated not only better cognitive flexibility but also more efficient use of working memory (e.g., integrating multiple dimensions like size and colour) and stronger inhibitory control (e.g., suppressing previously learned sorting rules) compared to 4-year-olds. These age-related improvements in cognitive flexibility, working memory, and inhibitory control suggest that these executive functions develop interdependently, consistent with the Unity and Diversity Model. The focus in this study was on a nuanced understanding of how cognitive flexibility develops in this population and how the 3DCCS task captures these developmental changes.

Thes findings from the current study are consistent with the developmental literature, which highlights significant advancements in cognitive flexibility between the ages of 4 and 5, mainly due to the maturation of executive functions such as working memory and inhibitory control (Best et al., 2009; Blakey et al., 2015; Chevalier et al., 2012; Zelazo et al., 2003). Studies using the DCCS task have consistently shown that while 3-year-olds struggle with rule-switching, performance improves significantly by age 5 (Zelazo et al., 2003). For example, 5-year-olds demonstrated greater efficiency in rule-switching, such as transitioning from sorting by colour to sorting by size with minimal hesitation, whereas 4-year-olds often perseverated on previous rules (e.g., continuing to sort by colour even after being instructed to switch to size). This improvement is attributed to the development of hierarchical rule representation and increased efficiency in inhibitory control, which allows older children to override previously learned responses and apply new sorting rules more flexibly (Diamond, 2013).

Moreover, the positive correlation between age and cognitive flexibility observed in the current study is consistent with previous research conducted in both WEIRD and non-WEIRD contexts. Studies in Western countries have consistently found that cognitive flexibility improves significantly between ages 4 and 5, with older children demonstrating greater accuracy and efficiency on tasks like the 3DCCS (Zelazo et al., 2003; Munakata et al., 2012). Similarly, research in non-WEIRD contexts, such as South Korea and China, has also reported age-related improvements in cognitive flexibility during early childhood (Lan et al., 2011; McClelland et al., 2014). These findings suggest that the developmental trajectory of cognitive flexibility may be largely universal, with age serving as a primary predictor of CF outcomes across diverse cultural and linguistic contexts. However, research on cognitive flexibility in non-WEIRD populations remains limited, particularly within African contexts, where cultural, linguistic, and educational environments differ significantly from those in Western settings. This gap underscores the importance of the present study, which contributes to the scarce body of research on executive function development in African preschoolers and provides valuable insights into how cognitive flexibility emerges in this unique sociocultural setting.

Although age appears to be the primary driver of cognitive flexibility development, environmental factors such as educational exposure and external scaffolding may still influence the extent to which children demonstrate flexible thinking at different developmental stages. For example, a study by Doebel and Zelazo (2015) found that while age was a significant predictor of DCCS performance, the presence of external cues and social scaffolding also played a crucial role in facilitating flexible thinking. This aligns with the qualitative findings of the present study, which showed that younger children (4-year-olds) demonstrated emerging cognitive flexibility when provided with external support, suggesting that structured guidance can enhance rule-switching abilities even at earlier developmental stages. In this study, external support included verbal prompts, non-verbal cues, corrective feedback, and encouragement from the researcher, all of which appeared to aid younger children in overcoming perseveration errors and improving task performance. For example, some 4-year-olds initially struggled to apply the new sorting rule but adjusted their responses after the researcher repeated or rephrased the instructions (e.g., “Remember, now we’re sorting by size,” or “What shape or size do you see here?”). Non-verbal cues, such as pointing gently to the sorting dimension without indicating the correct answer, and verbal encouragement like “You’re doing well, keep going” or “Take your time, think about it,” also helped sustain engagement and reduce frustration. This suggests that while 4-year-olds may not yet have fully developed the ability to independently update and apply new task rules, they can do so when rules are externally reinforced. Importantly, the reflexive thematic analysis approach used in this study acknowledges that the researcher was not a neutral observer but an active participant whose presence and supportive behaviours shaped the observed engagement patterns. This is consistent with research by Chevalier et al. (2013), which found that younger preschoolers rely more heavily on external reinforcement to guide executive function tasks, whereas older children become more autonomous in their rule application.

Beyond verbal reinforcement, non-verbal cues also played a critical role in guiding decision-making on the 3DCCS task. Some 4-year-olds hesitated before placing a card and glanced at the researcher for confirmation, proceeding only after receiving a subtle nod or an encouraging facial expression. This suggests that while younger children demonstrate an emerging capacity to shift between rules, they may still require external validation before fully committing to a response. These findings further support Vygotsky's (1978) sociocultural theory, which posits that higher-order cognitive functions, including executive functions like cognitive flexibility, develop through guided social interaction. From this perspective, external support functions as a scaffold that temporarily compensates for underdeveloped self-regulatory abilities, allowing children to practice and refine their executive function skills within a structured environment.

The qualitative findings provided additional insights into how age influences cognitive flexibility. For example, 5-year-olds demonstrated greater ease in transitioning between sorting rules, particularly in more complex tasks such as the size game. They were more likely to integrate multiple dimensions (e.g., colour, size, and shape) when sorting, reflecting their advanced cognitive flexibility. In contrast, 4-year-olds frequently reverted to earlier rules, such as sorting by colour or animal, even when instructed to switch to a new rule. This behaviour reflects their ongoing development of inhibitory control and working memory, as they struggled to suppress previously learned responses and adapt to new task demands (Zelazo et al., 2003). According to the Unity and Diversity Model (Miyake et al., 2000), these executive functions are not isolated processes but are interrelated and work together to support cognitive flexibility. Specifically, working memory enables children to hold and manipulate rule sets, while inhibitory control helps them suppress previously learned sorting rules, allowing for successful rule-switching. Therefore, these qualitative observations align with the quantitative results, highlighting the significant role of age in shaping cognitive flexibility during early childhood.

Thus, the findings of this study suggest that while 4-year-olds are still developing cognitive flexibility, they can demonstrate emerging rule-switching abilities when provided with external scaffolding. For instance, the qualitative data revealed that 5-year-olds were more likely to use advanced strategies, such as integrating multiple dimensions (e.g., size, colour, and shape) when sorting, reflecting their improved working memory capacity. They were also better at inhibiting previously learned responses, such as sorting by colour, when instructed to switch to a new rule, such as sorting by size. This ability to hold multiple rules in working memory while suppressing irrelevant information is a hallmark of cognitive flexibility and suggests an interplay between executive functions, particularly working memory and inhibitory control (Miyake et al., 2000). In contrast, 4-year-olds often struggled with these tasks, as their working memory and inhibitory control were less developed, leading to perseveration errors and difficulty adapting to new rules (Zelazo et al., 2003). However, the qualitative observations also indicated that some 4-year-olds were capable of successfully switching rules when provided with external support, such as verbal prompts, non-verbal cues, and corrective feedback from the researcher. This finding aligns with the idea that cognitive flexibility, inhibitory control, and working memory function as a unified construct in early childhood before gradually differentiating into distinct but interrelated executive function components. While this study did not directly measure the individual executive function components or their intercorrelations, the findings suggest an association between cognitive flexibility, working memory, and inhibitory control. The qualitative and quantitative results highlight the role of external guidance in supporting emerging executive functions, suggesting that structured scaffolding can help children practice holding task rules in mind, inhibiting prior responses, and applying new sorting criteria more effectively.

2. **Differences in cognitive flexibility based on demographic variables (sex, SES and number of languages spoken)**

The quantitative findings of this study suggest that sex, SES, and the number of languages spoken did not significantly predict cognitive flexibility performance on the 3DCCS task, with age emerging as the only significant predictor. These results align with research suggesting that individual differences in cognitive flexibility during early childhood are primarily driven by universal neurocognitive development rather than environmental or demographic factors (Best & Miller, 2010; Zelazo et al., 2003). The second multiple regression analysis, which used CORSWOPS (flexibility) scores as the dependent variable, confirmed this pattern, demonstrating that none of these demographic factors significantly influenced either overall cognitive flexibility performance or flexibility in switching between rules.

While these findings contrast with some research suggesting that SES and bilingualism may influence executive function development, particularly in children over the age of 6 (Halse et al., 2019; Nguyen, 2024), they are consistent with studies highlighting age as the primary driver of cognitive flexibility improvements in early childhood (Best & Miller, 2010; Chevalier et al., 2012). The qualitative findings further support this interpretation, as children across different sex, SES, and linguistic backgrounds exhibited similar engagement strategies, error patterns, and reliance on external validation when performing the task. In particular, the absence of sex-based differences in this study aligns with research suggesting that sex-based variations in executive function may not emerge until later in development (Lejbak et al., 2011; Schmidt et al., 2009). The quantitative results provide further evidence for this, as boys and girls achieved comparable accuracy and efficiency scores, with no statistically significant differences between the groups. While some research suggests that females may exhibit superior inhibitory control and verbal processing skills relative to males (Voyer et al., 2016), others argue that these differences, if present, tend to emerge later in development due to hormonal and social influences (Saylik et al., 2018). The lack of sex-based differences in the present study may reflect the non-verbal nature of the 3DCCS task, which does not heavily rely on verbal working memory or linguistic abilities, skills where girls have been reported to outperform boys in some studies (Reed et al., 2017). However, research suggests that sex-based differences in executive function tasks become more pronounced at higher cognitive loads, particularly in verbal working memory tasks, whereas simpler rule-switching tasks like the 3DCCS tend to produce comparable performance across the sexes (Reed et al., 2017).

The qualitative findings further support the absence of sex-based differences in cognitive flexibility, as both boys and girls exhibited comparable task engagement strategies, hesitation patterns, and reliance on external validation. For instance, Participant 27 (male) and Participant 49 (female) both struggled with the transition from the colour to the size sorting phase and frequently sought confirmation before placing their cards, demonstrating similar perseverance errors. However, while overall cognitive flexibility performance was similar between sexes, the qualitative observations revealed subtle differences in engagement behaviours, which were not captured in the quantitative analyses. Boys were more likely to fidget, tap the cards, or show restless movements during the task, while girls displayed more controlled, deliberate movements and engaged in fewer spontaneous behaviours. These differences suggest that while sex may not influence cognitive flexibility scores, boys and girls may employ different behavioural strategies to regulate focus and process task demands.

Similarly, socioeconomic status did not significantly predict cognitive flexibility performance, indicating that children from different SES backgrounds performed similarly on the 3DCCS task. One possible explanation for this null finding is the relatively high SES distribution of the sample, with most participants scoring toward the upper end of the SES range. This limited variability may have obscured potential SES effects, as children from lower-SES backgrounds were under-represented. The qualitative findings support this interpretation, as children from both lower- and higher-SES backgrounds demonstrated similar problem-solving strategies, hesitation patterns, and flexibility in rule-switching. For instance, Participant 5 (low SES) and Participant 18 (high SES) both successfully switched sorting rules without significant differences in speed, accuracy, or reliance on external prompts. Additionally, children from lower-SES backgrounds were just as likely to use verbal and visual strategies during the 3DCCS task, reinforcing the notion that cognitive flexibility may be less influenced by SES in this setting. Moreover, educational access and environmental factors may have mitigated SES-related disparities in cognitive flexibility within this sample. Most participants attended preschool five days a week, which may have provided sufficient cognitive stimulation to support cognitive flexibility development, regardless of SES. Research suggests that high-quality early childhood education can buffer the effects of socioeconomic disadvantage on cognitive flexibility performance (Blair & Raver, 2016). Additionally, in cultures that emphasize community-based learning and shared problem-solving, children from lower-SES backgrounds may develop cognitive flexibility through informal but cognitively enriching experiences, such as navigating multilingual environments or engaging in collective decision-making tasks. Research suggests that bilingualism and multilingualism enhance cognitive flexibility by requiring individuals to manage multiple languages, switch between linguistic systems, and adapt to diverse communicative contexts (Bialystok, 2017). These factors may explain why SES did not emerge as a significant predictor in the present study, as even children from relatively lower-SES backgrounds may have had access to enriching learning experiences that supported their cognitive flexibility development.

This finding contradicts some prior research conducted in high-income Western contexts, where lower-SES children exhibited weaker cognitive flexibility due to disparities in cognitive stimulation, access to quality education, and increased exposure to chronic stress

(Ursache & Noble, 2016). However, it is important to note that the sample in Ursache and Noble's study had a much wider age range (M = 12.21 years, SD = 4.91, range = 3–21 years) compared to the preschool-aged children in the current study. The inclusion of older children and adolescents in their sample may have influenced their findings, as SES-related disparities in cognitive flexibility could become more pronounced with age due to cumulative environmental effects. In contrast, the relatively younger age of participants in this study (4–5 years) may explain why SES did not emerge as a significant predictor, as early childhood may represent a period where cognitive flexibility is primarily shaped by age-related neurodevelopmental maturation rather than socioeconomic influences. The present study findings align with research conducted in non-WEIRD settings, such as South Africa, where SES-related differences in cognitive flexibility appear to be less pronounced in preschool children (Pollak et al., 2010). These findings suggest that the relationship between SES and cognitive flexibility may be context-dependent, influenced by factors such as age, cultural environment, and access to early educational resources. Further research with more diverse SES representation, particularly within younger age groups, is necessary to clarify the extent to which socioeconomic disparities shape cognitive flexibility in early childhood.

The quantitative findings also revealed no significant correlation between bilingualism and cognitive flexibility performance, indicating that bilingual children did not outperform their monolingual peers on the 3DCCS task. This result is not entirely unexpected, as the bilingual advantage hypothesis suggests that cognitive flexibility benefits are most pronounced when both languages are highly automatized, requiring strong proficiency and regular use of both languages (Bialystok, 2001; Hommel et al., 2011). Given the young age of participants in this study, it is unlikely that they had fully developed proficiency in a second language, which may explain the absence of a bilingual advantage. Additionally, most participants in the sample were not bilingual, with the majority speaking only English at home and not yet being consistently exposed to a second language. This limited linguistic experience further reduces the likelihood of bilingualism influencing cognitive flexibility at this stage of development. Another potential explanation for the absence of a bilingual advantage in this study is the linguistic environment of South Africa, where exposure to multiple languages is the norm rather than the exception. Unlike in predominantly monolingual societies, bilingual children in South Africa may not experience the same executive function demands associated with language inhibition and switching, as they are not required to suppress one language while using another to the same extent. In multilingual South African communities, linguistic fluidity and frequent code-switching are common, potentially reducing the need for strict language inhibition (McCormick, 2002). Additionally, many participants in this study were exposed to English as the primary language of instruction, which may have reduced the cognitive demands typically associated with managing multiple languages.

Recent meta-analyses have reported mixed evidence regarding the bilingual advantage hypothesis, with some studies finding small cognitive benefits for bilingual children, while others report no significant differences between monolingual and bilingual groups (Lehtonen et al., 2018; Paap et al., 2015). The present findings align with studies suggesting that bilingualism does not universally confer cognitive flexibility benefits, particularly in young children who have not yet reached full proficiency in multiple languages. Although some bilingual participants demonstrated verbal self-guidance during the 3DCCS task, an approach linked to enhanced working memory (Bialystok & Martin, 2004), this did not translate into measurable cognitive flexibility advantages on this non-verbal task.

The qualitative findings further support this interpretation, as both monolingual (n = 30) and bilingual (n = 21) children exhibited comparable engagement strategies, rule-switching abilities, and reliance on external feedback. For instance, Participant 22 (bilingual) and Participant 8 (monolingual) demonstrated similar hesitation patterns and perseveration errors during the size sorting task. However, subtle differences were observed in strategy use, with bilingual children more likely to verbalize task rules aloud before sorting. While this suggests that bilingual children may rely more on verbal processing strategies, cognitive flexibility benefits linked to bilingualism are often more pronounced in verbal tasks requiring active language switching, rather than in non-verbal tasks like the 3DCCS (Sampedro & Peña, 2019). Thus, differences in task demands may explain why bilingualism did not lead to cognitive flexibility advantages in this study.

Beyond group-level comparisons, the qualitative data also provided insights into how children approached the task, particularly in terms of their interactions with the researcher, their level of confidence, and their need for validation before making decisions. Interestingly, these engagement behaviours did not systematically align with sex, SES, or bilingual status but instead appeared to be influenced by individual engagement styles and cultural norms surrounding adult-child interactions. In many non-WEIRD cultural contexts, including South Africa, children are often socialized to engage with adults, particularly authority figures with deference and attentiveness rather than assertiveness or independence (Henrich et al., 2010).

This was reflected in the qualitative data, where some children were more reserved in their responses, avoided direct eye contact, or waited for explicit approval before proceeding with their sorting decisions. For example, Participant 26 avoided eye contact with the researcher and hesitated before making sorting choices, despite demonstrating an understanding of the task rules. Similarly, Participant 28 nodded in response to instructions but did not verbally engage. These patterns align with research indicating that children from collectivist cultures may be more likely to display reserved engagement behaviours in structured learning environments, particularly when interacting with unfamiliar adults (Chen et al., 1998; Rubin et al., 2009). While some children relied on verbal self-guidance or actively sought confirmation, others approached the task with quiet attentiveness. This variation in engagement strategies may have influenced how children performed on the 3DCCS, particularly in terms of hesitation, rule-switching confidence, and responsiveness to external feedback. Future research should explore how cultural norms surrounding adult-child interactions may shape cognitive flexibility performance in structured tasks.

Conversely, some participants were more verbally expressive and engaged more actively with the researcher, often asking for clarification or seeking feedback. For example, Participant 12 (4-year-old) frequently asked, “Is this right?” before placing a card, suggesting a desire for external validation rather than independent rule application. This behaviour was not necessarily linked to cognitive flexibility deficits but instead reflected culturally influenced engagement styles. In some cultures, children are encouraged to seek guidance and confirmation from adults, particularly in educational settings, which may explain the higher frequency of verbal reinforcement-seeking behaviours among certain participants (Chao, 1994; Keller, 2007). Additionally, the degree of comfort in engaging with the researcher varied across participants. Some children displayed enthusiasm and confidence, while others were more hesitant, even when they demonstrated correct rule-switching abilities. This behavioural variability suggests that cultural factors, rather than cognitive flexibility per se, may shape how children express their problem-solving abilities and interact with adults in structured assessment contexts.

### 3. Engagement with the 3DCCS task

The findings of this study reveal distinct patterns in how preschoolers engaged with the 3DCCS task, with performance and engagement varying across the three sorting dimensions: animal, colour, and size. The quantitative analysis demonstrated significant differences ($\chi^2(2) = 32.56$, $p < .001$) in the sample's accuracy scores across these dimensions. While there was no statistically significant difference between performance on the animal and colour tasks, participants obtained the lowest accuracy score in the size task, suggesting that it posed greatest difficulty. The qualitative findings provided further insight into these differences, highlighting how task order, familiarity with the sorting dimension, and working memory demands influenced engagement and cognitive flexibility performance. Together, these results suggest that children's ability to engage with rule-switching tasks is not only dependent on cognitive flexibility but also on the cognitive load imposed by each sorting rule and the level of abstraction involved in the sorting dimension.

Although there were no statistically significant differences between children's performance on the animal and colour tasks, the qualitative data suggested that the animal sorting task appeared easier for both 4- and 5-year-olds. This was evident in higher accuracy scores and shorter completion times in the animal task compared to the colour task. There are several possible explanations for this. First, the animal task was always presented first (following the standardised administration procedure), so that children were introduced to the task in a cognitively fresh state before experiencing any working memory interference from previous rule-switching demands. Research shows that task order effects can influence performance, particularly in young children, as executive function tasks requiring rule-switching tend to become increasingly demanding as children progress through them (Zelazo et al., 2003; Chevalier et al., 2012).

Second, animals are concrete objects that children are highly familiar with, making this dimension easier to process compared to more abstract attributes like colour or size. Studies on early cognitive development suggest that children tend to categorize objects based on tangible, meaningful attributes that they frequently encounter in their daily environment (Gelman & Coley, 1990). For example, Participant 39 (5-year-old) completed the animal sorting task with ease and confidence, quickly placing each card without hesitation, whereas Participant 10 (4-year-old) showed some initial uncertainty but was still able to complete the task successfully. This pattern aligns with a developmental hierarchy of conceptual understanding, where children acquire the ability to categorize objects based on shape first, followed by colour, and lastly by size (Smith, 1989; Landau et al., 1988). Research suggests that young children rely more heavily on shape to identify and group objects, as it provides the most salient and stable cue for categorization (Smith et al., 2002). Colour, while an important feature, requires more cognitive effort to integrate into categorization processes, particularly when objects can vary in hue. Size, being a relative rather than absolute property, is the most abstract and cognitively demanding feature to process, which may explain why it posed the greatest challenge in this study. These findings align with those of Sloutsky and Fisher (2004), who found that children aged 4 to 5 years rely heavily on object-based categories, such as animals, when organizing information, as these categories are more intuitive and do not require complex cognitive processing. The qualitative differences observed in this study suggest that, while animal and colour sorting tasks were statistically comparable in difficulty, the children may have found the animal task conceptually easier due to their natural reliance on object-based categorization and its alignment with the developmental sequence of conceptual understanding.

In contrast, the colour sorting task appeared more challenging than the animal task, as reflected in lower accuracy scores and increased hesitation among participants when completing it. Young children often find it more challenging to categorize objects based on colour compared to shape or function, as colour does not inherently define an object's identity, making it a more abstract perceptual attribute (Verhoeven, 2013; Sloutsky, 2010). Research indicates that children primarily rely on shape and functional attributes for categorization, as these features are more directly linked to an object's meaning and use, whereas colour is used less consistently as a categorization cue in early childhood (Satlow & Newcombe, 1998; Sandhofer & Smith, 2001). Furthermore, colour-based categorization is more cognitively demanding than object-based categorization because it requires children to suppress their natural inclination to focus on objects' functional and semantic properties (Bornstein, 1985). The qualitative data support this, as several children struggled to switch from the animal sorting rule to the colour rule, often defaulting back to the previous rule despite being given new instructions. For instance, Participant 10 (4-year-old) continued sorting by animal even after the researcher explained the colour rule, suggesting perseveration errors. This aligns with research on executive function development, which shows that cognitive flexibility tasks requiring suppression of previously learned sorting rules place greater demands on inhibitory control and working memory (Best & Miller, 2010; Blakey et al., 2015). Despite these challenges, some children were able to successfully adapt to the colour sorting task, particularly 5-year-olds, who exhibited greater rule-switching efficiency than 4-year-olds. This supports findings by Davidson et al. (2006), who reported that older preschoolers develop stronger inhibitory control, allowing them to shift between abstract categorization rules more effectively.

The size sorting task emerged as the most difficult, with the lowest accuracy scores and the highest rates of hesitation and perseveration errors. Several factors may have contributed to this difficulty. First, size is a relational concept rather than a categorical one, making it more cognitively complex for young children to process compared to concrete categories like animals or perceptual attributes like colour. Research suggests that preschoolers struggle with relational reasoning tasks, as these require comparisons between multiple objects rather than classification based on a single defining feature (Gentner & Rattermann, 1991). Unlike animals or colours, size requires children to evaluate multiple stimuli simultaneously to determine relative differences, which places greater demands on working memory (Halford et al., 1998). Second, the size sorting task was always presented last, meaning that children had already engaged in two prior rule-switching phases before reaching this task. This cumulative cognitive load likely contributed to increased fatigue, greater working memory demands, and more frequent errors. Studies on executive function suggest that task-switching performance declines when cognitive load accumulates across multiple trials, particularly in young children whose working memory and inhibitory control are still developing (Chevalier et al., 2012). The qualitative findings reflect this difficulty, as many children hesitated significantly before sorting by size, and several continued to use the previous colour rule rather than transitioning to size-based sorting. For example, Participant 13 (4-year-old) sorted multiple items incorrectly by colour rather than size. This is consistent with research showing that younger preschoolers often struggle with abstract rule-switching tasks and require external scaffolding to successfully complete them (Doebel & Zelazo, 2015).

In addition to accuracy differences across the dimensions of the 3DCCS tasks, the qualitative data revealed individual variations in engagement strategies, hesitation patterns, and reliance on external validation. While some children confidently completed each sorting condition with minimal assistance, others displayed more uncertainty and sought reassurance from the researcher before making decisions. These individual differences were observed across both age groups, rather than being specific to particular dimensions of the task. This aligns with research showing that executive function development is not uniform across preschoolers, with some children exhibiting stronger cognitive flexibility and problem-solving strategies than others (Diamond, 2013). Several children engaged in self-guided verbalization, repeating sorting rules aloud to reinforce their understanding, a strategy that has been observed in young children as they develop self-regulatory executive function skills (Blakey et al., 2015). For example, Participant 18 (4-year-old) verbalized, "This one is big, so it goes here," while sorting, indicating an attempt to reinforce the size rule through verbal rehearsal. In contrast, 5-year-olds were more likely to use visual comparison strategies, examining the cards closely before making a decision, rather than relying on verbal cues. These findings support research by Chevalier et al. (2013), which suggests that as executive function skills develop, children transition from externally guided problem-solving strategies to more efficient, internalized cognitive processing.

Overall, these findings suggest that task complexity, rule familiarity, and cognitive load influenced preschoolers' engagement with the 3DCCS task. Although there were no statistically significant differences between performance on the animal and colour sorting tasks, the qualitative data indicated that children found animal sorting easier, possibly due to their reliance on object-based categorization, which develops earlier than colour- and size-based categorization (Smith, 1989; Landau et al., 1988). The size task was the most difficult, as reflected in significantly lower accuracy scores and increased hesitation, rule perseveration, and reliance on external validation. The observed patterns align with developmental research suggesting that children first categorize objects based on shape rather than colour or size, as shape is a concrete and salient feature that provides consistent perceptual information (Smith et al., 2002).

## 4. Reflexivity

As the researcher, I acknowledge that my personal background and positionality shaped the research process and influenced the interpretation of the data. I identify as a Muslim female South African adult with an academic background in developmental psychology. These social and cultural identities informed how I approached the research context, interacted with participants, and interpreted their behaviours.

In particular, I recognize that some of my interpretations, such as linking behaviours like shyness, avoidance of eye contact, or limited verbal responses to cultural norms were influenced by my own assumptions and cultural lens. While these behaviours were noted in relation to cultural differences, it is important to acknowledge that they may also reflect power dynamics between an adult researcher and young participants, rather than solely cultural explanations.

To strengthen reflexivity and reduce the risk of over-interpreting behaviours through a narrow cultural lens, I engaged in frequent discussions with a colleague conducting a similar study on cognitive flexibility. These conversations provided an opportunity to critically reflect on my interpretations and to consider alternative explanations for participant behaviours. By including this reflexive awareness, the study acknowledges the influence of researcher subjectivity and aims to enhance the trustworthiness and transparency of the qualitative findings.

## 5. Contributions of the study

This study contributes to the understanding of cognitive flexibility development in early childhood in a South African preschool sample, by examining the roles of age, sex, SES, and bilingualism. The quantitative findings confirmed that none of these demographic factors significantly predicted cognitive flexibility performance, with the exception of age. The qualitative findings provided additional insight into these results, revealing that children across different demographic groups exhibited similar engagement strategies, hesitation patterns, and reliance on external validation. These results suggest that cognitive flexibility development is primarily shaped by neurocognitive maturation, (which would account for the age-related differences) rather than external demographic influences.

The study also provides tentative support for the Unity and Diversity Model (Miyake et al., 2000), demonstrating that cognitive flexibility draws on other executive functions of working memory and inhibitory control in this age group. Additionally, the qualitative findings align with Vygotsky's (1978) theory of cognitive development, as younger children were observed to use external validation and verbal self-guidance, while older children engaged in more independent problem-solving strategies.

By integrating both quantitative and qualitative data, this study provides a more nuanced understanding of cognitive flexibility development than studies relying solely on quantitative measures. Furthermore, it adds to cross-cultural research by examining cognitive flexibility in a non-WEIRD context. While the study did not find evidence for SES or bilingualism as predictors of cognitive flexibility, it highlights the need to consider cultural and environmental contexts when interpreting these relationships.

## 6. Limitations and Recommendations for Future Research

While this study provides valuable insights into the development of cognitive flexibility in early childhood, certain limitations should be acknowledged to provide context for the findings. One notable limitation is the sample size, which, while sufficient for statistical analysis, was relatively small. A larger sample would allow for greater statistical power and generalizability, ensuring that the findings more accurately reflect the broader population of South African preschoolers. Additionally, the sample composition was somewhat homogenous in terms of educational exposure, as most participants attended preschool regularly. This may have limited the variability in socioeconomic status and other environmental influences that could impact cognitive flexibility development. Future research should aim to include children from a wider range of SES backgrounds and educational settings to determine whether access to early learning environments plays a more substantial role than observed in this study. Additionally, a more refined and detailed assessment of SES is needed to capture its potential impact on cognitive flexibility more accurately.

Another consideration is the cross-sectional nature of the study, which provides only a snapshot of cognitive flexibility development rather than tracking changes over time. A longitudinal design would allow researchers to observe how cognitive flexibility develops within the same individuals, providing a clearer picture of how age and environmental factors interact to shape executive function development. Additionally, while the 3DCCS task is a well-established measure of cognitive flexibility, it may not capture all aspects of cognitive flexibility, particularly in relation to bilingualism. The task is non-verbal, which may explain the lack of a bilingual advantage, as prior research suggests that bilingual benefits are more pronounced in tasks requiring active language switching or verbal working memory. Future studies should consider using a variety of cognitive flexibility tasks, including verbal tasks that require language-switching, to assess whether bilingual children demonstrate advantages in different cognitive domains.

Another limitation of this study is the limited representation of fully bilingual participants in the sample. While the study included children who were exposed to multiple languages, the degree of bilingual proficiency and dominance was not formally assessed. This may have influenced the findings, particularly regarding the absence of a bilingual advantage in cognitive flexibility outcomes. Future research should aim to recruit and explicitly identify fully bilingual samples, using detailed language proficiency assessments, to determine whether the bilingual advantage emerges more clearly in this population.

The qualitative findings provided valuable insights into how children engaged with the task, but future research could enhance these observations by incorporating additional behavioural and cognitive measures, such as eye-tracking and/or reaction time analysis, to capture subtle cognitive flexibility differences beyond accuracy scores. Additionally, while the study provided important cross-cultural insights into cognitive flexibility development in a South African context, cultural norms surrounding adult-child interactions may have influenced engagement behaviours. Future research should explore how cultural expectations around independence, structured learning, and authority figures shape cognitive flexibility performance, potentially by comparing findings across different cultural or educational contexts.

## 7. Conclusion

The findings of this study provide important insights into the development of cognitive flexibility in early childhood, particularly within a South African preschool sample. They confirm that age is the primary predictor of cognitive flexibility development, with five-year olds demonstrating significantly better performance on the 3DCCS task four-year olds. This aligns with research indicating that cognitive flexibility improves as executive function components such as inhibitory control and working memory mature. In addition, sex, SES, and bilingualism did not significantly predict cognitive flexibility outcomes, suggesting that these demographic variables may exert a weaker influence on cognitive flexibility in early childhood than assumed. The qualitative findings reinforced these conclusions, revealing that children across different demographic backgrounds exhibited similar task engagement strategies, problem-solving approaches, and reliance on external validation when performing the 3DCCS task. These results contribute to the ongoing discussion about the extent to which environmental and social factors shape early cognitive development and highlight the need to consider cross-cultural perspectives when interpreting cognitive flexibility outcomes.

This study provides some evidence for the Unity and Diversity Model (Miyake et al., 2000) that cognitive flexibility strengthens with age and is interrelated with other executive functions, such as working memory and inhibitory control. The qualitative observations also support Vygotsky's (1978) sociocultural theory, as younger children relied more on external validation and verbal self-guidance, while older children used internalized cognitive strategies to complete the task independently. These findings highlight the role of social and linguistic interactions in cognitive flexibility development, particularly in early childhood. The lack of a bilingual advantage in this study supports research suggesting that bilingualism's cognitive benefits depend on factors such as language proficiency, task demands, and cultural context, rather than being universally present in all executive function tasks. Additionally, the absence of a significant SES effect may reflect the influence of early educational access, as children in this sample may have had sufficient cognitive stimulation to support cognitive flexibility development regardless of SES background. This underscores the need for future research to consider both qualitative and quantitative measures to capture the nuanced effects of sociocultural and environmental influences on executive function development in diverse populations. Beyond its theoretical contributions, this study highlights the importance of using a mixed-methods approach to examine cognitive flexibility. While the quantitative findings confirmed that demographic factors did not significantly predict cognitive flexibility performance, the qualitative data provided deeper insights into children's engagement strategies and cognitive processing styles. This underscores the value of integrating both qualitative and quantitative measures to capture the complexity of executive function development more effectively.

Additionally, this study contributes to the broader body of research on executive function in non-WEIRD populations, emphasizing the need for culturally relevant developmental models. Future research should continue to examine how sociocultural factors, such as multilingual exposure and early educational environments, influence cognitive flexibility outcomes, ensuring that theoretical frameworks accurately reflect cognitive development across diverse settings.

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# Appendix

## Appendix A: Demographic Questionnaire (Caregivers)

The following questions ask about the background of the child you are caring for, and some questions on the background of the parent/guardian/caregiver. Please answer this as truthfully as possible.

1. What is your child's name and surname?

   ______________________________________________

2. What is the child's date of birth (YYYY-MM-DD)?

   ______________________________________________

3. What is the sex of the child?

   ☐ Female ☐ Male

4. What language does the child speak at the most at home?

   ☐ Afrikaans ☐ English ☐ IsiNdebele ☐ IsiXhosa

   ☐ IsiZulu ☐ Sepedi (North Sotho) ☐ Sesotho ☐ Setswana

   ☐ SiSwati ☐ Tshivenda ☐ Xitsonga

   ☐ Other (please specify):_______________

5. What other language/s can the child speak fluently? Please select all the other languages that the child can speak fluently.

   ☐ Afrikaans ☐ English ☐ IsiNdebele ☐ IsiXhosa

   ☐ IsiZulu ☐ Sepedi (North Sotho) ☐ Sesotho ☐ Setswana

   ☐ SiSwati ☐ Tshivenda ☐ Xitsonga

   ☐ Other (please specify):_______________

6. How many times a week does the child attend nursey/ grade R/grade RR?
7. ☐ 1 day ☐ 2 days ☐ 3 days ☐ 4 days ☐ 5 days ☐ None

8. If the child attends school, please indicate what language is used by the educators to teach children at the school?

   ☐ Afrikaans ☐ English ☐ IsiNdebele ☐ IsiXhosa

☐ IsiZulu ☐ Sepedi (North Sotho) ☐ Sesotho ☐ Setswana

☐ SiSwati ☐ Tshivenda ☐ Xitsonga

☐ Other (please specify):______________

9. Is the child on any medication?

   ☐ Yes ☐ No

   If yes, what medication do they take?

   ________________________________________________________________________

10. Has the child ever been diagnosed with any chronic illness?

    ☐ Yes ☐ No

    If yes, what illness have they been diagnosed with?

    ________________________________________________________________________

11. Has the child experienced any one of the following: a brain injury, epilepsy, learning disability/disorder, or recent diagnosis with meningitis or encephalitis?

    ☐ Yes ☐ No

    If yes, please specify what they have experienced?

    ________________________________________________________________________

12. How many caregivers (parents, grandparents, nannies, etc.) are there in the child's household?

    ☐ 0 ☐ 1 ☐ 2 ☐ More than 2 (specify number:…….)

13. Additionally, please indicate who primarily looks after the child on a day-to-day basis?

    ________________________________________________________________________

14. What is the highest level of schooling of the parents/other primary caregiver (mark the most appropriate)?

| **Mother: Level of Education** | | **Father: Level of Education** | | **Other Caregiver: Level of Education** | |
|---|---|---|---|---|---|
| Not applicable | | Not applicable | | Not applicable | |
| No schooling | | No schooling | | No schooling | |
| Less than primary school completed | | Less than primary school completed | | Less than primary school completed | |
| Primary school completed | | Primary school completed | | Primary school completed | |
| Grade nine completed | | Secondary school not completed | | Secondary school not completed | |
| Matric completed | | Matric completed | | Matric completed | |
| Undergraduate degree completed | | Undergraduate degree completed | | Undergraduate degree completed | |
| Postgraduate degree complete | | Postgraduate degree complete | | Postgraduate degree complete | |
| Other (please specify): | | Other (please specify): | | Other (please specify): | |

15. What is the current occupation of the parents/other primary caregiver?

**Mother:** ________________ **Father:** ________________ **Other Caregiver:** ________________

## SECTION B (SOCIO-ECONOMIC STATUS)

1. How many rooms does your house have?
   ☐ Without a room ☐ One room ☐ Two rooms ☐ Three or more rooms

2. Do you own a car?
   ☐ No ☐ Yes

3. Do you use a notebook, laptop, or tablet at home?
   ☐ No ☐ Yes

4. Does your family engage in activities such as fun outings, leisure activities, or travel abroad?
   ☐ No ☐ Yes

## Appendix B: Child Observation Schedule

1. Could the child switch between instructions?
2. If No, what response/s did they give instead, and on which test items?
3. What strategies did the child use to complete the task? e.g., talking to herself, tracing with fingers on pictures etc.
4. Did the child ask any questions/make any comments regarding the tasks (outside of strategies used to complete the task)?
5. If yes, what did they ask/comment on?
6. Did questions need to be repeated?
7. If yes, how many times and which questions?
8. Did instructions need to be repeated?
9. If yes, how many times and which instructions?
10. Did questions and/or instructions need to be translated?
11. Did questions and/or instructions require more detailed explanations?
12. If yes, which questions/instructions and what detail was needed/given?
13. Note any behaviours by child while completing the task:
14. How long did the child take to complete the entire task?

**Appendix C: Participant Information Sheet (Caregiver)**

PSYCHOLOGY
THE SCHOOL OF HUMAN AND COMMUNITY DEVELOPMENT (SHCD)

Private Bag 3, Wits, 2050 • Tel: 011 717 4541 • Fax: 011 717 4559 • E-mail: psych.SHCD@wits.ac.za

Dear Caregiver,

My name is La Raiba Mehmood. I am a Master of Arts in Social and Psychological Research (Coursework and Research Report) student at the University of the Witwatersrand, Johannesburg. My supervisor is Professor Kate Cockcroft. I am conducting a research study about cognitive flexibility in preschoolers. The study is titled**: "An exploration of cognitive flexibility development in South African 4- and 5-year-olds."** I would like to invite your child/ward to participate in this study.

I am studying how young children can switch between different tasks easily. This is important for their learning and thinking. Your child/ward will play a game where they sort cards by shape, colour, and size. Your child/ward will complete a task called the Three-Dimensional Change Card Sorting (3DCCS) task. They will sort cards according to different criteria like shape, colour, and size. The task will take place before or after class time at the school, ensuring it does not affect your child's regular class activities. It will take about 20-30 minutes. The activities will be conducted in a quiet area within the school.

In addition to your child/ward's participation, I would like to ask for your consent to complete a short demographic questionnaire, which will take about 15 minutes. The questionnaire asks questions about your child/ward's background (such as the language they speak and their health) and your background (such as your education and work history).

If you agree to participate and for your child/ward to take part in this study, please complete the attached consent form, which indicates your agreement to complete the demographic questionnaire and your consent for your child/ward's participation in the study
Your child's name, your name, and the school's name will not be used in any reports or publications from this study. The demographic questionnaire asks for your child/ward's name

only to match it with their test score initially. After this, all names will be removed from the data. All information will be stored safely. With your permission, other researchers may use the collected data, but it will not contain any personal information. You will be asked to consent specifically to this secondary use of data in the consent form.

If your child/ward feels uncomfortable or distressed at any point during the task, they can stop immediately. We will ensure a supportive environment and provide any necessary assistance. Participating in this study will not directly benefit you or your child/ward. There are no physical risks involved in participating in this study. This study aims to understand better how preschool children think, which may help improve learning and development strategies for young children.

This research will be written up as a master's research report and may be published in articles, books, and presented at conferences. The report will be available on the university library website. If you would like a summary of this report, I will be happy to send it to you once the research is completed. If you have any questions before or after the study, please contact me or my supervisor using the details below. For concerns or complaints about the ethical procedures of this research, contact the University Human Research Ethics Committee (Non-Medical) at telephone: +27(0) 11 717 1408, email: hrecnon-medical@wits.ac.za.

If you agree that you and your child/ward can participate in this study, please fill in the consent forms below and complete the short demographic questionnaire. Your signature will mean that you understand what the study is about, what you and your child/ward will be asked to do, and that any questions you had have been answered satisfactorily.
Yours sincerely,
La Raiba Mehmood (Researcher); Email: 2315152@students.wits.ac.za

Supervisors:
Prof Kate Cockcroft; Tel: 011 717 4511; Email: Kate.Cockcroft@wits.ac.za

**Appendix D: Participant Consent Forms**

**Caregiver Consent Form for Child/ren's Participation**

**"An exploration of cognitive flexibility development in South African 4- and 5-year-olds."**

**La Raiba Mehmood (Researcher)**

I,………………………… …., agree for my child/ward, ………………………………, to participate in the study.

| | | |
|---|---|---|
| The research study was explained to me. I understand what this study is about. | YES | NO |
| I understand that I can volunteer my child/ward to take part in the study. | YES | NO |
| I understand that my child/ward is not anonymous to the researcher. | YES | NO |
| I understand that the data collected, including scores from the 3DCCS task, behavioural observations, may be used by the researcher in their research report/manuscript/book chapter. | YES | NO |
| I understand that my name, child/ward's name, or the centre's name will not be used by the researcher in any reports of the study. | YES | NO |
| I agree that other researchers may use the information obtained from myself and my child/ward (depending on their own ethics clearance being obtained), but my name, child/ward's name, the centre's name, and any personal information will not be used or passed on. | YES | NO |
| I understand that this research study will be written up as a research report, and may be published in articles, books, and presented at conferences. | YES | NO |
| I understand and I agree that the data collected including scores from the 3DCCS task and behavioural observations, obtained from my child/ward, may be used for secondary analysis by the researcher or another researcher. | YES | NO |

_________________________________ (name of caregiver/guardian signature)

_________________________________ (name of child/ward)

_________________________________ (signature)

_________________________________ (date)

________________________________ (name of researcher/person seeking consent)

________________________________ (signature)

________________________________ (date)

**Participant Consent Form for Parent's Participation**

**Study Title: "An exploration of cognitive flexibility development in South African 4- and 5-year-olds."**

**Researcher: La Raiba Mehmood**

I, _____________________________, agree to participate in the study.

Please indicate your agreement with the following statements by selecting "YES" or "NO":

| | | |
|---|---|---|
| The research study was explained to me. I understand what this study is about. | YES | NO |
| I understand that I can volunteer to take part in the study. | YES | NO |
| I understand that I am not anonymous to the researcher. | YES | NO |
| I agree to complete the demographic questionnaire provided as part of this study. | YES | NO |
| I understand that my name, child/ward's name, or the centre's name will not be used by the researcher in any reports of the study. | YES | NO |
| I understand that the data collected, including my responses in the demographic questionnaire, may be used by the researcher in their research report/manuscript/book chapter. | YES | NO |
| I understand that my name or the school's name will not be used by the researcher in any reports of the study. | YES | NO |
| I agree that other researchers may use the information obtained from me (depending on their own ethics clearance being obtained), but my name, the school's name, and any personal information will not be used or passed on. | YES | NO |
| I understand that this research study will be written up as a research report and may be published in articles, books, and presented at conferences. | YES | NO |
| I understand and agree that the data collected, including my responses in the demographic questionnaire, may be used for secondary analysis by the researcher or another researcher. | YES | NO |

________________________________ (name of caregiver/guardian signature)

________________________________ (name of child/ward)

________________________________ (signature)

________________________________ (date)

________________________________ (name of researcher/person seeking consent)

________________________________ (signature)

________________________________ (date)

**Appendix E: Permission Letter from The School**

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Dear Sir/Madam,

Re: Permission to Conduct Research

My name is La Raiba Mehmood. I am a Master of Arts in Social and Psychological Research (Coursework and Research Report) student at the University of the Witwatersrand, Johannesburg. My supervisor is Professor Kate Cockcroft. I am seeking permission to conduct research at your school.

I am conducting a research study about cognitive flexibility in preschoolers. The study is titled: "An Exploration of Cognitive Flexibility Development in South African 4- and 5-year-olds."

The research will entail collecting data from preschool-aged children (4- and 5-year-olds). Specifically, I will be inviting preschool-aged children from your school to participate in this study. If they agree, they will be asked to complete tasks related to cognitive flexibility during their regular school hours. Data collection will take approximately 30 minutes and will occur on the school premises.

Participants will be asked to provide verbal consent before the research begins. Their responses will be treated confidentially, and identities will remain anonymous. Individual privacy will be maintained in all published and written data resulting from the study.

The results of this study will be communicated through academic channels such as a dissertation.

Research participants will not be advantaged or disadvantaged in any way. They will be assured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks associated with participating in this study.

I kindly request permission in writing to conduct my research at your School. The permission letter should be on the school's letterhead, signed, and dated, and should specifically reference myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response at your earliest convenience.

Yours sincerely,

La Raiba Mehmood

Tel: 071 058 1492

Email: : 2315152@students.wits.ac.za

Supervisor: Professor Kate Cockcroft

Tel: 011 717 4511

Email: Kate.Cockcroft@wits.ac.za

**Appendix F: Permission Letter from The Teachers**

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Dear Sir/Madam,

Re: Permission to Conduct Research

My name is La Raiba Mehmood. I am a Master of Arts in Social and Psychological Research (Coursework and Research Report) student at the University of the Witwatersrand, Johannesburg. My supervisor is Professor Kate Cockcroft. I am seeking permission to conduct research during your class.

I am conducting a research study about cognitive flexibility in preschoolers. The study is titled: "An Exploration of Cognitive Flexibility Development in South African 4- and 5-year-olds."

The research will entail collecting data from preschool-aged children (4- and 5-year-olds). Specifically, I will be inviting preschool-aged children from your class to participate in this study. If they agree, they will be asked to complete tasks related to cognitive flexibility during their regular school hours. Data collection will take approximately 30 minutes and will occur on the school premises.

Participants will be asked to provide verbal consent before the research begins. Their responses will be treated confidentially, and identities will remain anonymous. Individual privacy will be maintained in all published and written data resulting from the study.

The results of this study will be communicated through academic channels such as a dissertation.

Research participants will not be advantaged or disadvantaged in any way. They will be assured that they can withdraw their permission at any time during this project without any penalty. There are no foreseeable risks associated with participating in this study.

I kindly request permission in writing to conduct my research during your class. The permission letter should be on the school's letterhead, signed, and dated, and should specifically reference myself by name and the title of my study.

Please let me know if you require any further information. I look forward to your response at your earliest convenience.

Yours sincerely,

La Raiba Mehmood

Tel: 071 058 1492

Email: : 2315152@students.wits.ac.za

Supervisor: Professor Kate Cockcroft

Tel: 011 717 4511

Email: Kate.Cockcroft@wits.ac.za

## Appendix G: Ethics Clearance

UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Research Office

HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)
R14/49 Mehmood

CLEARANCE CERTIFICATE PROTOCOL NUMBER: H24/07/**21**

PROJECT TITLE An exploration of cognitive flexibility development in South African 4- and 5-year-olds.

INVESTIGATOR(S) Ms L Mehmood

SCHOOL/DEPARTMENT Human and Community Development/

DATE CONSIDERED 19 July 2024

DECISION OF THE COMMITTEE Approved
Risk Level: Minimal

EXPIRY DATE 26 August 2027

DATE 03 September 2024 CHAIRPERSON ___________________________________ (Professor J Watermeyer)

cc: Supervisor : Professor K Cockcroft

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DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and A SIGNED COPY returned to the Secretary electronically. Unreported changes to the application may invalidate the clearance given by the HREC (Non-Medical)

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure be contemplated from the research procedure as approved I/we undertake to submit an amendment of the protocol to the Committee. I/we agree to completion of a regular progress report. For Minimal and Low Risk studies, this is due annually on 31 December. For Medium and High Risk studies, this is due twice annually on 30 June and 31 December.

___________________________ __06____/___09____/_____2024__
Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER ON ALL ENQUIRIES

## Appendix H: Normality outputs

**Table 1**

*Normality Statistics for Working Memory and Demographic Variables*

| Variable | Skewness | Kurtosis | Shapiro-Wilk |
|---|---|---|---|
| Age in years | .121 | -2.068 | <.001 |
| Age in months | .234 | -.926 | .133 |
| Sex | -.040 | -2.082 | <.001 |
| Number of Spoken languages | .850 | -.236 | <.001 |
| Socioeconomic Status | -1.395 | 2.784 | <.001 |
| Total accuracy: animal task | -7.141 | 51.00 | <.001 |
| Total accuracy: colour task | -1.917 | 2.441 | <.001 |
| Total accuracy: shape task | -.799 | -.855 | . <.001 |
| Total Accuracy Score | -.860 | -.201 | <.001 |
| CORSWOPS Max score | -2.486 | 4.758 | <.001 |

*Notes.* *$p < .05$.

**Figure 1**

Distribution Pattern of Age by Years (n = 51)

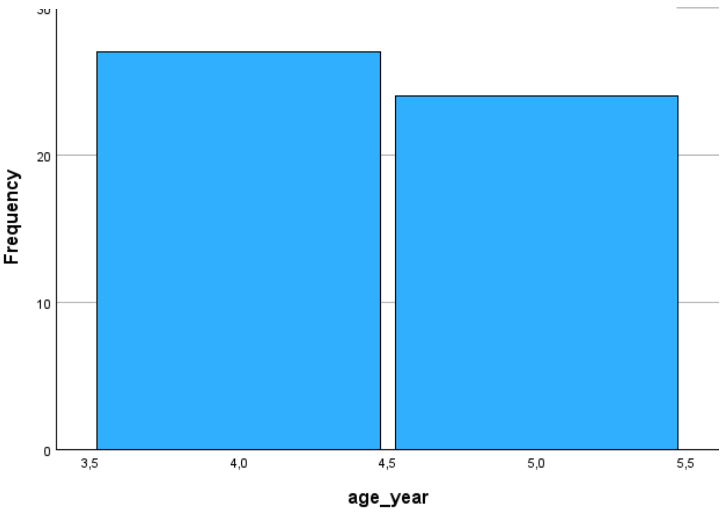



**Figure 2**

Distribution Pattern of Age by Months (n = 51)

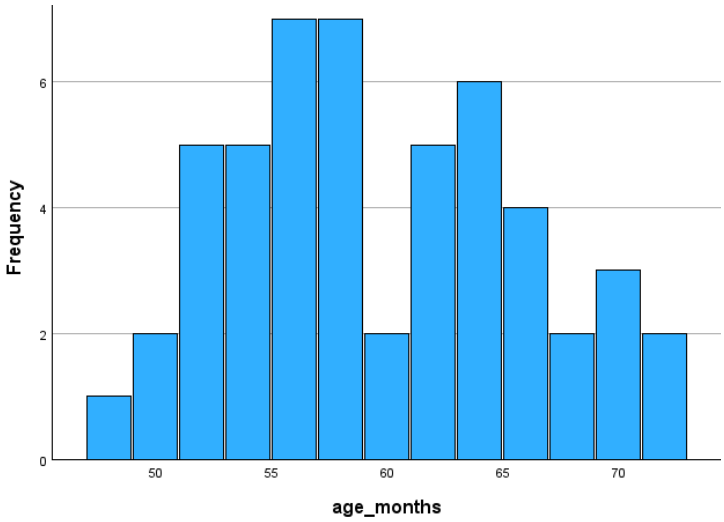



**Figure 3**

Distribution Pattern of Sex (n = 51)

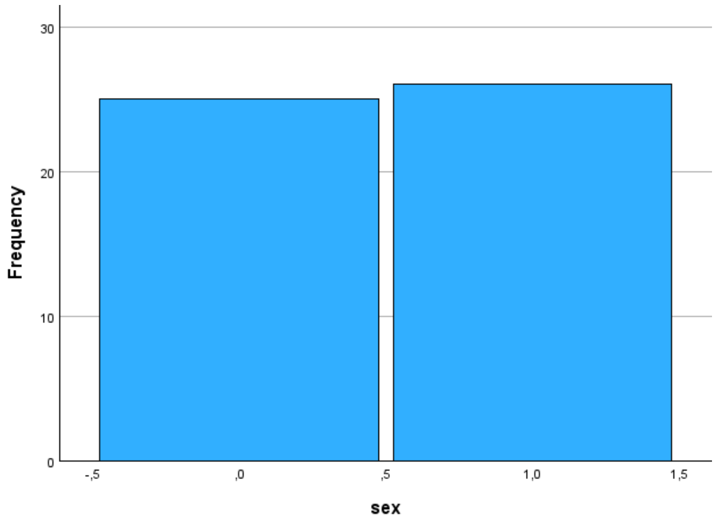



**Figure 4**

Distribution Pattern of No of spoken languages (n = 51)

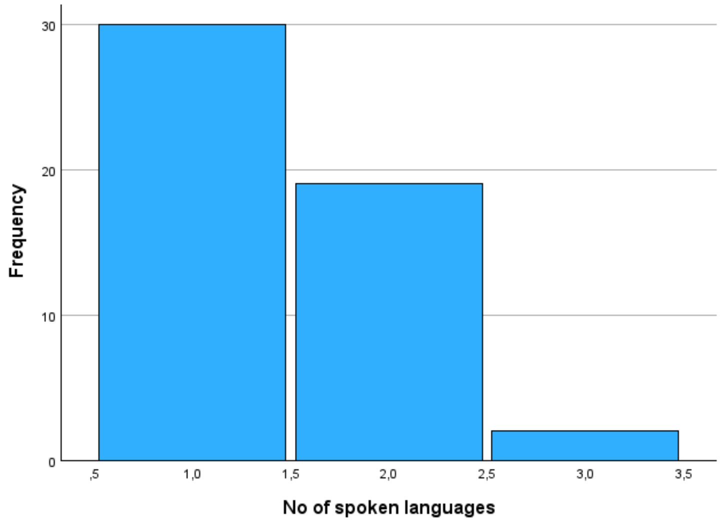



**Figure 5**

Distribution Pattern of Socioeconomic Status (n = 51)

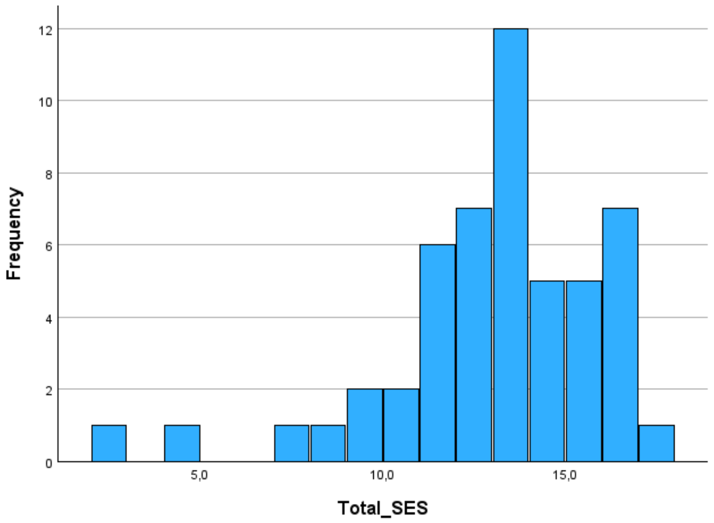



**Figure 6**

Distribution Pattern of Total Accuracy Animal (n = 51)

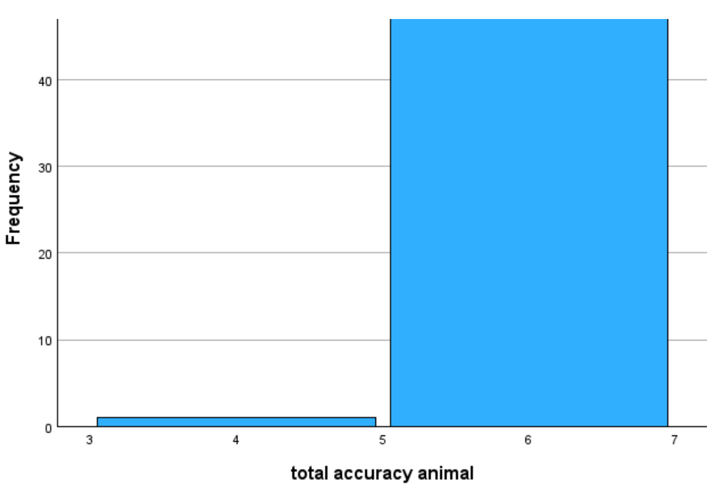


**Figure 7**

Distribution Pattern of Total Accuracy Colour (n = 51)

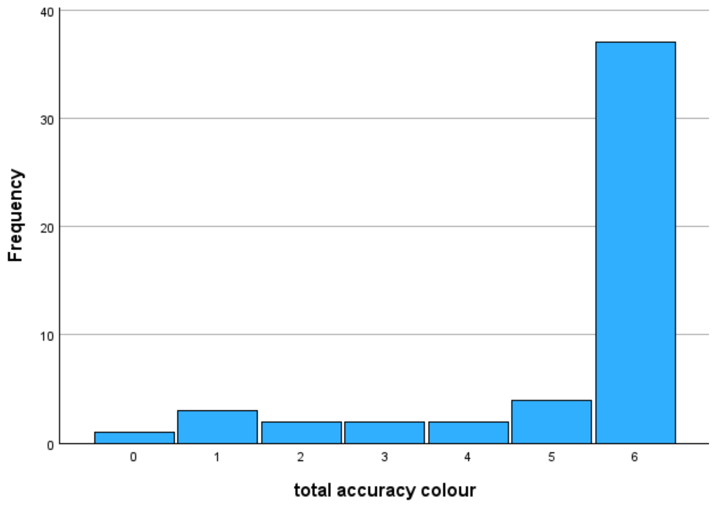



**Figure 8**

Distribution Pattern of Total Accuracy Size (n = 51)

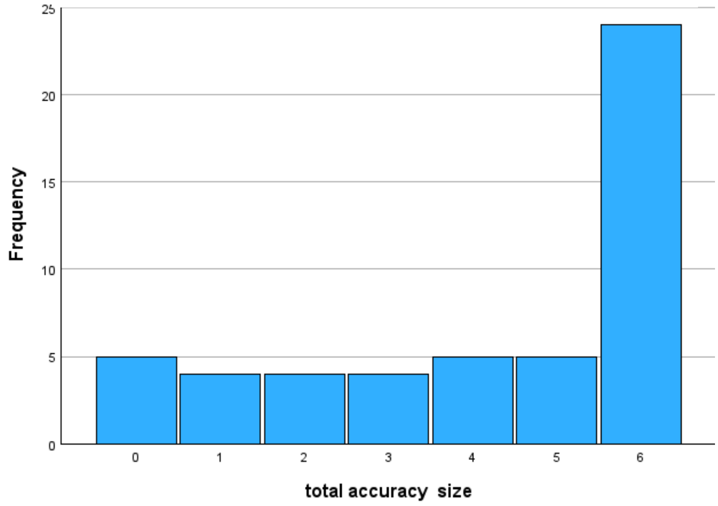



**Figure 9**

Distribution Pattern of Total Accuracy Score (n = 51)

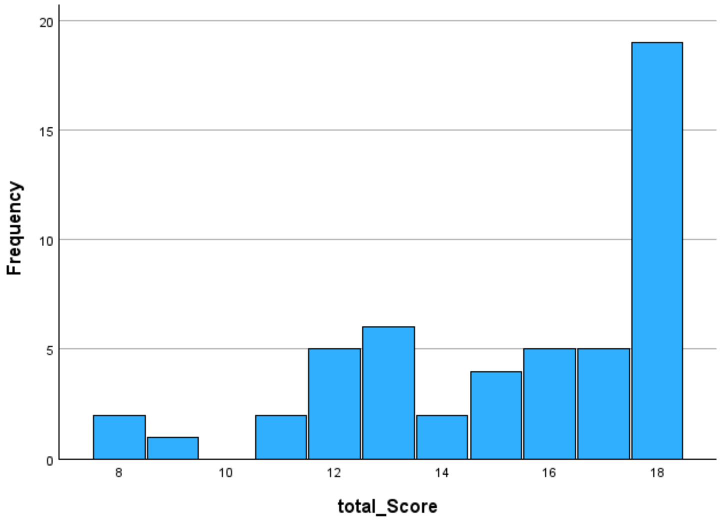
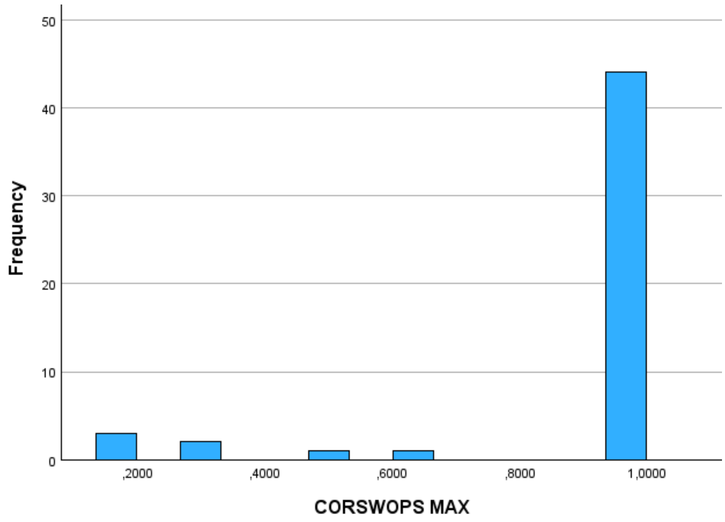



**Figure 10**

Distribution Pattern of CROSWOPS Scores (n = 51)



# Appendix I: Regression Assumptions

**Figure 1**

Homoscedasticity Scatterplot of demographic variables predicting 3DCCS Scores

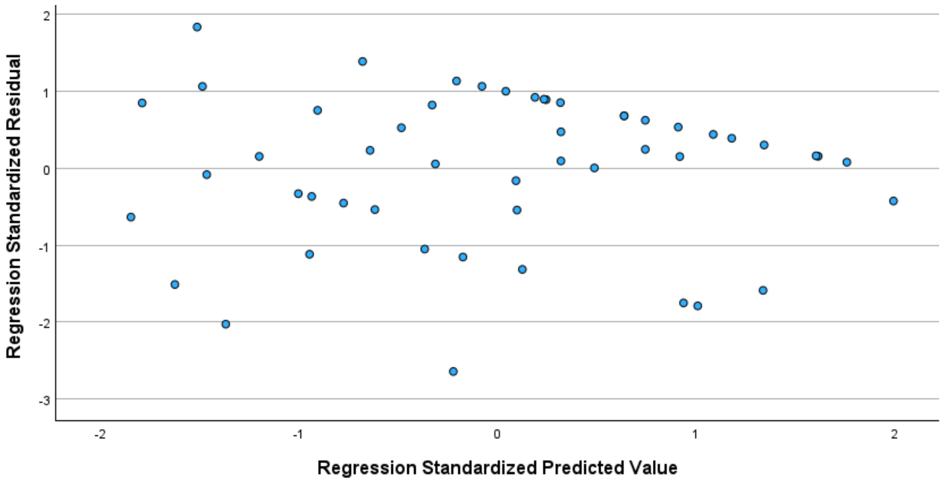



**Figure 2**

Residual Distribution of demographic variables predicting 3DCCS Scores

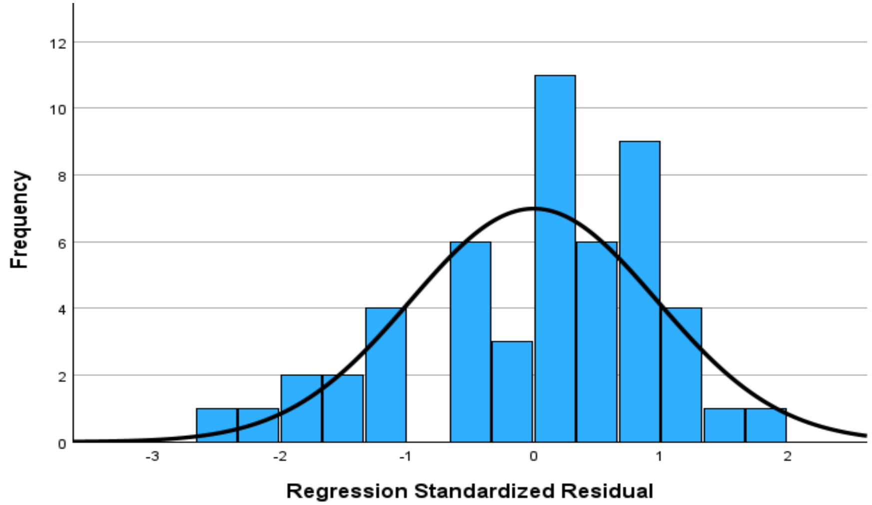



**Figure 3**

Homoscedasticity Scatterplot of demographic variables predicting CROSWOPS Scores

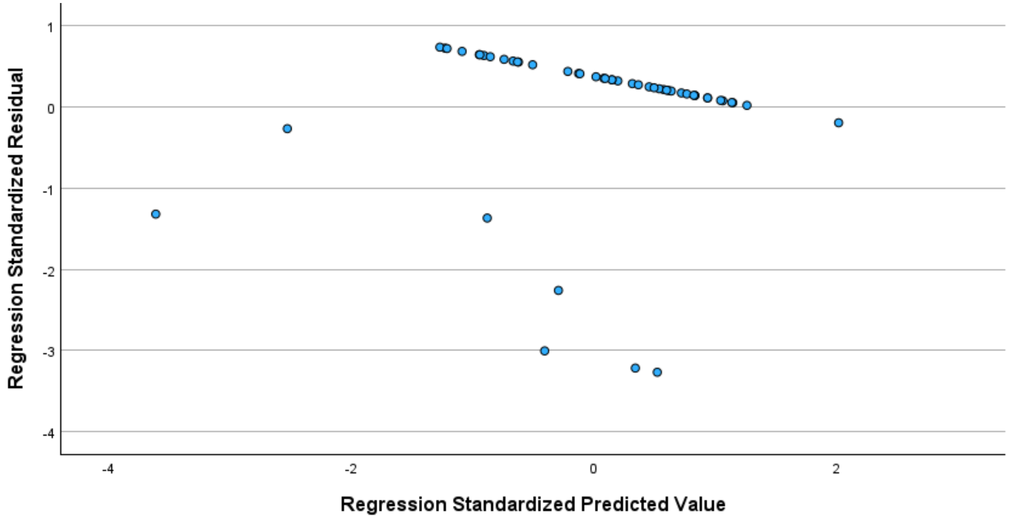



**Figure 4**

Residual Distribution of demographic variables predicting CROSWOPS Scores