The Impact of Siblings on Executive Functioning and Theory of Mind in Children

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Abstract. The impact of siblings on the executive functioning and theory of mind in children is a complex and multifaceted phenomenon. Siblings have the potential to influence each other's cognitive development through various forms of interaction, such as negotiation, cooperation, and conflicts. This paper summarizes the relationship between siblings, executive functioning, and theory of mind through reviewing previous research. It discusses whether siblings directly contribute to changes in executive functioning and theory of mind or if other factors, such as age difference and gender, play a role. This article discusses the importance of identifying the significant role of siblings in shaping executive functioning and theory of mind and provides an overview of research findings and potential influencing factors. By focusing on processes influenced by older siblings, this review article will provide a deeper understanding of how sibling interactions may impact younger children's cognitive functioning. Future research should encompass different cultural backgrounds, socioeconomic statuses, and family structures to increase generalizability and can help to understand the contexts of the correlation between siblings and cognitive functioning.

1 Introduction

Siblings play a major role in each other's development and have a significant influence in each other's cognitive and social development. In many cultures, siblings are considered to be as influential, if not more influential, than parents in shaping children's cognitive function. The impact of siblings on the executive functioning and theory of mind of each other is a complex and multifaceted phenomenon. Siblings have the potential to shape each other's cognitive development through various forms of interaction, including negotiation, cooperation, and conflicts.

Previous research in this area has primarily focused on understanding how older siblings contribute to the cognitive flexibility of their younger siblings. However, there are certain aspects that have been overlooked in these studies. For instance, most siblings share similar genetic components and growth environments, making it difficult to determine whether older siblings directly cause changes in younger children's cognitive flexibility or if other factors are at play.

Therefore, it is crucial to discuss whether siblings play a significant role in shaping executive functioning and theory of mind or if there are underlying factors, such as genetic components and growth environment, that contribute to these cognitive developments. To address this research gap, this review article will summarize the methodologies that specifically examine processes influenced by siblings to conclude their impact on each other. By providing an overview of the relationship between siblings, executive functioning, and theory of mind, this review will delve into how researchers have conducted tests, what they have discovered, and the potential influencing factors of siblings' contributions to each other's cognitive functioning.

2 Executive functioning

2.1 The concept of executive functioning

Executive Functioning is a series of cognitive processes that is associated with the regulation and control of behavior such as inhibition, working memory etc [1]. It plays a crucial role is human cognition and behavior including problem-solving and decision-making.

Having an older sibling can potentially foster younger children's executive control through either social modeling or sibling interaction. Sibling relationship often involves negotiation, cooperation, competition and conflicts. These interactions may require the use of executive control processes which can foster the younger children to learn executive control skills such as learning how to focus and adapt to demands of the environment.

However, an older sibling does not always bring positive effect to the younger children's executive function. Toxic sibling relationship that involves a lot of rivalry may even hinder the development of executive control depending on the relationship dynamics and other biological factors such as age and sex [1].

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2.2 Siblings and executive functioning

Impact of sibling interactions on executive control can vary on factors such as the dynamics of sibling relationship, age difference, sex and individual temperament [2]. Usually a healthy sibling relationship will foster the development of executive and cognitive control while conflict-ridden/toxic sibling relationship may have less of an impact or even hinder the development [2].

As Cole suggested, the presence of siblings promoted executive control [1]. Cole used 4 classic separate tasks to assess the executive control abilities of the children [1] .

The first one is route navigation designed two routes with 10 bends , with a character drawn at the end of the page leading to a wanted destination (a beach with ice-cream kiosk) at the top [1]. One route is obstacle free, one was blocked with three stickers [1]. Children received an instruction to choose the obstacle free path, and they were required to show the easy route with their finger [1]. This process had 4 trails and one point was given in each trial for a correct path choice [1] .

The second test was called Squirrel and Badger Game, which required children to resist instruction [1]. They were presented with two hand puppets, a squirrel and badger [1]. Before the task, children were instructed not to obey the badger's instruction by keeping still [1]. The puppets took turns asking the child to perform movements and the child earned points when they stand still when the badger puppet gave instructions [1]. The child is then presented with a 12 movement trials, with 6 trials per puppet [1]. After four trials (two per puppet), the researcher pauses and asks the participants to answer which puppet's instructions they should neglect [1] . The child's performance is coded based on their ability to resist moving when instructed to do so by the badger puppet, with a possible score range of 0-6 [1] .

The third test was the Bi-dimensional card sort, where the child is given a set of cards that vary along two dimensions, such as shape (e.g., round or rectangular) and category (e.g., boats or airplanes). Before the switch, the child is asked to sort the cards into two piles based on one dimension (e.g., color) [1]. The experimenter provides corrective feedback if the child makes sorting errors, reinforcing the correct sorting rule [1].

Once the child correctly sorts 5 consecutive cards according to the first dimension, the researcher proceeds to the post-switch phase [1] .In the post-switch phase, the experimenter explains that the game has switched to a different dimension (e.g., shape) and provides new instructions for sorting the cards [1]. The child is asked to sort five cards based on the new dimension without receiving corrective feedback [1]. One point is awarded for each correctly placed card, with a score range of 0-5 per card sort [1] .The child completes two card sorts: one based on color and shape, and another based on number and shape [1]. The combined score from both card sorts yields a total score range of 0-10 [1] .

The last classic test was called Building a Tower, where the child is shown a completed stacking rings toy, consisting of colored rings of different sizes arranged in ascending order on a center pole [1] . The experimenter removed the ring and mix the rings up [1]. They then asked children try to replicate the order of the rings [1] . To complete the task, the child use systematically select the largest remaining ring and place it at the base, followed by the next larges until the smallest ring is on the top [1]. One point is awarded for each correctly placed ring with a score range of 0-6 [1] .

The participants were classified into four sets: only child, child with younger siblings, child with older siblings and child with both older and younger siblings. There was an obvious advantage in resisting instructions for children with older siblings, showing higher Executive Function (EF) scores. There was also a mild correlation between EF scores and the presence of at least one sibling of the participant in the same household. Also, the relationship between car sorting and siblings implicates that sibling interactions can contribute to the development of some aspect of the executive system [1] .Therefore the data succeed to draw a complementary link between siblings and executive control [1] .

2.3 Potential influencing factors of siblings making contributions to each other's cognitive functioning

Researches in developmental psychology do suggests that sibling relationship can indeed influence the development of executive functioning in children [2].

As mentioned above, it is crucial to note that the impact of sibling interactions on executive control can be very dependent on the quality or dynamics of siblings' relationship may also bring different effects to children's executive function. Positive and supportive sibling relationship can provide opportunities for children to engage in social interactions, problem-solving and cooperation which can promote the development of executive functioning.

McHale and Whiteman highlighted the need to directly measure influence processes such as rivalry, different treatment, and resource allocation [3]. They also draw a conclusion that positive and supportive sibling relationships were found to be correlated with better executive control in children [3].

In addition, factors such as the gender combination of siblings affects their dynamics of sibling relationship for reasons like differential treatment based on gender and other direct interactions between siblings. McHale and Whiteman conducted a longitudinal study on sibling relationships in adolescence and found that sibling gender composition (e.g., having only same-sex siblings, having only opposite-sex siblings, or a mix of both) was associated with differences in sibling relationship quality [3]. They found that siblings of the same gender reported higher levels of intimacy and conflict compared to siblings of opposite genders.

Furthermore, the age gap is also a determinations factor. Siblings with a closer age gap often have more opportunities for shared activities and experiences. They may engage in similar hobbies, play together, and have common friends, which can foster the development of

executive function. But with wider age gaps there are less shared activities and interests, making it more challenging to find common ground or engage in activities that cater to both siblings' preferences. Also, rivalry and competition can occur regardless of the age gap but it may manifest differently depending on the age differences. Siblings with a smaller age gap may compete more direct for resources, attention and parental approval while larger age gaps might lead to less direct competition which involve less interaction.

Garon, Bryson and Smith conducted a study on preschool-aged children and found that having an older sibling was associated with better executive control skills [4]. They observed that children with older siblings showed more advanced inhibitory control and working memory abilities compared to children without older siblings [4]. This result suggested that older siblings may provide opportunities for the younger sibling to be at the exposure of more social experiences and practice that contribute to the development of executive functions [4].

2.4 Executive functioning and theory of mind

Cognitive functioning comprises various cognitive abilities such as attention, memory, problem-solving and reasoning while theory of mind refers to the the ability of understanding concepts such as believes and desires of oneself and others. The two concepts are very similar and the development of Theory of Mind is considered heavily relying on cognitive processes. To further analyze, language plays a vital role in the Theory of Mind development, cognitive skill such as comprehension is closely linked to Theory of Mind. It can help individuals to interpret others' thoughts and intentions.

Lecce et al. examined the relationship between cognitive perspective-taking and ToM (Theory of Mind) in school-aged children[5]. The researchers found a positive correlation between children's cognitive perspective-taking abilities and their ToM understanding[5]. The study suggested that executive functioning skills contribute to the development of ToM[5]. A meta-analysis published in Developmental Psychology in 2016 examined the relationship between executive functioning and theory of mind in both typically developing children and those with ASD[5]. The analysis found a moderate positive correlation between these two constructs, indicating that better executive functioning skills were associated with better theory of mind abilities [5].

3 Theory of mind

3.1 The concept of theory of mind

Theory of mind refers to the cognitive ability to understand and attribute mental state, such as beliefs, desires, intention, and emotion, to oneself and others, and to understand mental states such as beliefs emotions and recognizing mental states is different in every person [1], It is very crucial for social interactions and communication because it allows individuals to interpret and understand other's social behaviors, thoughts and feelings.

The concept of theory of mind is particularly important for empathy, ethical thinking and moral reasoning. The development of theory of mind can be devised in to 4 milestones: false belief understanding; Mental state attribution; Second order false belief understanding and advanced theory of mind.

The first milestone is where children understand that others can hold different or false view about the world. Following by mental state attribution where children recognize that people have desire, emotion that guides their behavior. This is when they start to understand that different mental state can influence actions. The second-Order false belief understanding suggest that around 6 to 8, children start to comprehend that someone can hold a false belief on someone else's false belief [1]. And as the children continue to grow, their theory of mind becomes more sophisticated where they start to understand concepts such as sarcasm, irony and deception. They also become better at accepting that people can hold different views and beliefs for the world based on their personal experiences.

3.2 The concept of theory of mind

Siblings play an influential role in the children. the relationship provides a unique opportunity where children have frequent and prolonged interaction with a peer that shares a common family environment through conversation, conflict solving, cooperation and older sibling modeling.

McAlister and Peterson aimed to measure Theory of Mind in children at two different time points: Time 1 (preschool) and Time 2 (Primary school) [6]. The testing occurred over two sessions at each time point, with a one-week gap between sessions. The order of tasks and trials within tasks was systematically varied [6].At Time 1, the children completed four ToM tasks, the ToM tasks included tasks assessing route navigation, appearance-reality understanding, false belief (unseen displacement and misleading container tasks), and pretend play [6].

At Time 2, additional and new challenging tests batteries were selected for ToM (four tasks). The Time 2 tasks were administered in two sessions (A and B) and included tasks such as the hand game, card sort tasks, appearance-reality tasks, false belief tasks (unseen displacement and emotion), resisting instructions task, real-apparent emotion task, and Tower of London task. The rationale for task selection was based on previous empirical evidence [6].To calculate a composite score for ToM, scores on the unseen displacement and misleading container false belief tasks were divided by 2 and averaged together to create a decimal false belief proportion score ranging from 0 to 1 [6].

The authors addressed two important research questions: How does having similar-aged siblings related to ToM performance at Time 1 and 2 and What do cross-lagged correlations suggest on how gains through time in ToM capacities related to earlier individual difference in

variables of age, language ability and number of siblings. The findings indicated that the presence of a greater number of child siblings was associated with the development of ToM in preschool children [6]. Even after controlling for age, the number of child siblings showed significant positive correlations with ToM at both Times 1 and Time 2 [6].

In another study from McAlister, McAlister and Peterson also conducted assessments of Theory of Mind in children at two time points [7]. At Time 1, the researchers used two ToM tasks: the changed location false belief test and the pretend representation test[7]. The changed location false belief test involved scenarios where a girl did not see the displacement of a marble, and children were asked questions about where the girl would look for the marble [7]. The pretend representation test involved children engaging in pretend play with objects like a carrot or a potato and being asked questions about the real and pretend identities of the objects[7].

The researchers assigned scores to each task based on children's correct responses, with a maximum score of 2 for each task [7]. These scores were then combined to create a composite score representing children's ToM understanding at Time 1 [7].

At Time 2, the researchers repeated the changed location false belief test and introduced a more advanced false belief test that required the inference of emotions based on false beliefs. They also included two appearance-reality (AR) tests. The AR tests involved objects that had a real identity and a different appearance, and children were asked questions to assess their understanding of the appearance-reality distinction[7].

Scores were assigned to each Time 2 task based on children's correct responses, with a maximum score of 2 for each task [7]. These scores were then combined to create a composite score representing children's ToM understanding at Time 2 [7].

The researchers found there was a significant correlation between the children's ToM and the number of child-aged siblings in their families at Time 1 [7]. Children with two or three child-aged sibings had significantly higher ToM scores compared to only-children. The age of the children was not a influential factor [7].

At Time 2, similar patterns were observed. The children's ToM scores were correlated with the number of child-aged siblings they had [7]. Only-children had significantly lower ToM scores compared to children with two or three child-aged siblings [7].

The regression analysis for Time 2 indicated that the number of child-aged siblings was a significant independent predictor of Time 2 ToM scores, even after controlling for age, verbal intelligence, and Time 1 ToM scores [7].

In sum, Children's ToM and EF scores were significantly correlated with the existence of their siblings, proving that sibling interaction can foster the development of cognitive functioning.

The presence of siblings can promote the development of executive control skills in younger children, including inhibition, working memory, and problem-solving abilities [8]. Positive and supportive sibling relationships tend to have a beneficial effect on executive functioning, while toxic or conflict-ridden relationships may hinder its development [8]. Positive and supportive sibling relationships are associated with better executive control in children [9]. Meanwhile, closer age gaps provide more opportunities for shared activities and experiences, which can promote the development of executive functions [9]. Furthermore, Azmitia concluded that executive functioning and theory of mind are closely related, as cognitive processes play a crucial role in the development of theory of mind [10]. The understanding of concepts such as beliefs and desires of oneself and others relies heavily on cognitive abilities [10].

Siblings can have a significant influence on the executive functioning and theory of mind in younger children [10]. Positive and supportive sibling relationships can foster the development of executive control skills, while negative or conflict-ridden relationships may impede it [10]. Factors such as the dynamics of the sibling relationship, gender combination, and age gap contribute to the varying effects of sibling interactions on cognitive functioning [10].

4 Conclusion

This review has shed light on the relationship between siblings, executive functioning and Theory of Mind in children. This paper can provide valuable insights of potential influencing factors of siblings making contributions each other's cognitive functioning.

Having siblings can have a positive impact on the development of executive control skills in younger children, which includes abilities such as inhibition, working memory, and problem-solving. When sibling relationships are positive and supportive, they tend to enhance executive functioning, while toxic or conflict-ridden relationships can hinder its development. Strong and supportive sibling relationships are associated with better executive control in children.

Additionally, having siblings who are closer in age provides more opportunities for shared activities and experiences, which can further promote the development of executive functions. Moreover, research suggests that executive functioning and theory of mind are closely intertwined, as cognitive processes play a vital role in the development of understanding others' beliefs and desires. Therefore, siblings can significantly influence the executive functioning and theory of mind in younger children. Positive and supportive sibling relationships facilitate the growth of executive control skills, while negative relationships may impede it. Various factors like the dynamics of the sibling relationship, gender combination, and age gap contribute to the diverse effects of sibling interactions on cognitive functioning.

Past researches may have low generalizability as the paper examined were mostly Caucasian children. which limits the generalizability of the findings to a broader population. Factors such as cultural differences, socioeconomic status, and family structures could

influence the dynamics of sibling relationships and their impact on cognitive functioning. Also, some of them only focused on the influence of siblings on executive functioning and theory of mind, neglecting other important aspects of cognitive development.

To address these limitations, further studies can investigate siblings relationship that encompass different cultural backgrounds, socioeconomic statuses, and family structures to increase generalizability and can help to understand the findings across different populations and contexts. Furthermore, future investigators can consider a broader range of cognitive processes and outcomes into research to give a more comprehensive result. This would enhance people's understanding of the complex relationship between siblings and cognitive functioning in children.

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