Proceedings of the 2nd International Conference on Interdisciplinary Humanities and Communication Studies
DOI: 10.54254/2753-7048/29/20231493

The Impact of Synesthesia on Cognitive Construction in Young Children

Bangting Ma[1,a,*]

[1]*School of Educational Sciences, Xinjiang Normal University, Urumqi, Xinjiang, China*
a. 571057709@qq.com
**corresponding author*

Abstract: Synesthesia is a special psychological sensory phenomenon that refers to a situation where one sensory stimulus can trigger another or more sensory stimuli. Currently, most scholars' research focuses on adult synesthesia, with few scholars focusing on the field of children. This study compared and distinguished the frequency differences between children's synesthesia and adult synesthesia by investigating the frequency of synesthesia in a group of 3-7 year-old children. And further explored the impact of synesthesia on children's cognitive development. The author's viewpoint is that the frequency of synesthesia in children is significantly higher than that in adults. Synesthesia has an impact on children's cognitive development, but this impact can be divided into positive and negative aspects. The impact of synesthesia on children's cognition varies in different situations. Afterward, the author proposed educational suggestions for children's synesthesia: activities such as multiple sensory teaching, situational teaching, natural games, and number and shape games can all have positive effects on children's cognitive development by enhancing synesthesia experiences. But at the same time, educators also need to reduce or avoid the negative impact of synesthesia on children through personalized teaching and other methods.

Keywords: synesthesia, childhood, cognition

1. Introduction

Synesthesia is a special sensory phenomenon that includes multiple types of associations [1]. It refers to the situation where various senses operate independently and a stimulus to one of them can trigger a response from another or more senses. For example, gunshots can trigger a blue synesthesia experience. In this case, synesthesia is additive, and the triggered perception is added to sensory perception rather than replacing it [2]. At present, over 60 types of synesthesia have been discovered, among which morpheme-color synesthesia is the most widespread type of synesthesia [3]. Which is characterized by the connection between letters or numbers and colors. In addition, the experience of synesthesia is predictable, and there is a correspondence between the stimuli in synesthesia and the reactions it triggers.

Synesthesia is a subjective conscious experience with sensory attributes, but not all types of synesthesia are caused by sensory factors. Many types of synesthesia are related to advanced cognitive abilities: Grossenbacher and Lovelace explained that the inducer of synesthesia is a concept rather than a sensory stimulus synesthesia experience: For example, in the time-space synesthesia type, the concept of time is presented in the spatial concept [4].

DOI: 10.54254/2753-7048/29/20231493

The historical background of synesthesia was established in John Locke's work in 1690 [4]. Afterward, as more and more scholars became interested in this phenomenon, synesthesia remained in a very popular position. Until the mid-1930s, the emerging behaviorist school prohibited the study of subjective psychological phenomena. In the following period, research on synesthesia decreased significantly. Afterwards, with the development of science and technology, the authenticity of synesthesia was confirmed, and empirical research that continues to this day was able to be carried out [2].

There is currently no clear conclusion on the origin of synesthesia. Asher et al. believe that it is related to genetics, while Hubbard et al. believe that neural development is the foundation of synesthesia, while Calkins et al. focus on the role of synesthesia in learning [1]. In addition, the vast majority of authors have reached a consensus that true synesthesia is not related to the use of certain drugs that can produce temporary synesthesia or certain specific mental illnesses. And there is no unified conclusion on how synesthesia develops. Scholars led by neuroscience believe that synesthesia is mainly determined by innate conditions, and babies are born with a certain degree of synesthesia response (such as pitch odor synesthesia, touch taste synesthesia, etc.), which only develops continuously as they age; Another common viewpoint emphasizes the role of learning in synesthesian [5]. Taking grapheme-color synesthesia as an example, although this type of synesthesia is the most common, it is usually not innate. Because graphemes are stimuli acquired through culture, although synaesthetes typically have a strong sense of this type of synesthesia throughout their lives, this does not mean that they have it from birth [6].

At present, although many scholars have researched synesthesia, research on the development of childhood is still relatively blank due to factors such as difficulty in recruiting children's synesthesia and subjective definitions of synesthesia. At present, it is widely believed in the academic community that synesthesia begins to develop from childhood, but research on children's synesthesia has stagnated since the end of the 19th century [7]. At present, with the gradual maturity of disciplines such as cognitive psychology, brain science, and physiological psychology, the understanding of the neural mechanisms of synesthesia is also becoming more and more perfect. On this basis, research on children's synesthesia will have a more scientific and physiological basis. The research by Hancock, Witthoft, and Winawer et al. shows that the formation of almost all synesthesia experiences in some adult synesthesia individuals comes from childhood [6], so research on children's synesthesia is of great significance. This study used methods such as literature review, interview survey, and research project analysis to investigate the frequency of synesthesia in children and its impact on their cognitive development. The aim is to enrich research on children's synesthesia and provide a reference for educators in the teaching application of synesthesia.

2. Results

2.1. Experiment 1

This experiment adopts an interview survey method, and the questions used in this study refer to the synesthesia battery designed by the University of Texas Health Science Center in the United States [8]. The content is optimized and the quantity is reduced based on the psychological characteristics of children. In the interview, the main focus was on children's grapheme-color synesthesia, time-color synesthesia, time-spatial synesthesia, sound-color synesthesia, lexical-taste synesthesia, and olfactory-visual synesthesia. A total of seven items of olfactory tactile synesthesia were investigated. Regarding the measurement of color-type synesthetes, reference was made to the revised Baron-Cohen et al.'s Test of Genuineness (TOG) [9]. The author adapted the method used to measure the synesthesia stability of subjects. Random tests were conducted on subjects with color-type synesthesia experiences from time to time within two weeks after the interview. Children who exhibit

DOI: 10.54254/2753-7048/29/20231493

reactions or memories to any type of synesthesia in the first round of interviews are considered to have a synesthesia experience. The following two weeks of random surveys mainly focused on color synesthesia, and children with more than one type of color synesthesia (totaling 4 types) whose test results were consistent with the interview results were considered color-type synesthetes.

The sampling school for this survey is Bohu Town Kindergarten in Bohu County, Bayingol Mongolian Autonomous Prefecture, Xinjiang Uygur Autonomous Region. The sampling target is children aged 4-7, including 46 in-depth interviews and 86 collective interviews, totaling 132 people. In this survey, there were 75 male children (56.82%) and 57 female children (43.18%).

As shown in Figure 1, a total of 119 young children in this interview described experiencing varying degrees of synesthesia, accounting for 90.15% of the total. Among them, 65 children, accounting for 54.62%, described only having one type of synesthesia experience; 41 young children described having two types of synesthesia experiences, accounting for 34.45%; 13 young children described having three or more types of synesthesia experiences, accounting for 10.92%.

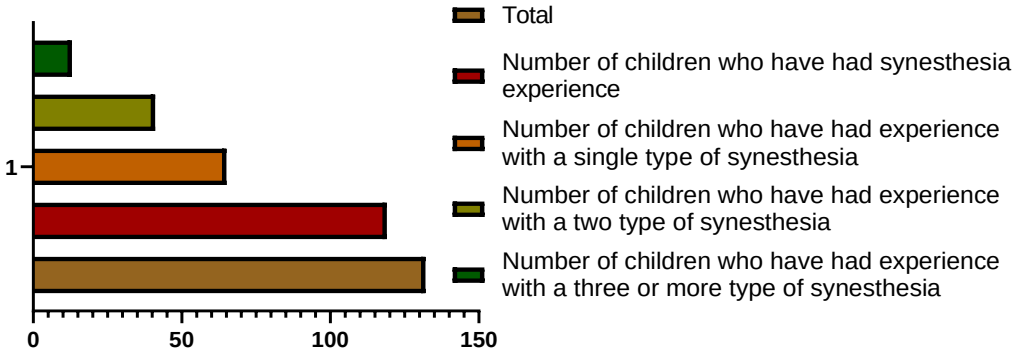

Figure 1: The proportion of children who may have had synesthesia experiences.

As shown in Figure 2, there is a significant difference in the number of children with different types of synesthesia experiences in this survey: among them, 99 children described have experience with letter-color synesthesia, accounting for 83.19% of the total number of children who may have experience with synesthesia; There are 96 children described have experience with time-color synesthesia, accounting for 80.67% of the total; There are 88 young children who described have experience with smell-color synesthesia, accounting for 73,95% of the total; 66 children, accounting for 55,46% of the total, described have experience with sound-color synesthesia; 58 children, accounting for 48.74% of the total, described have experience with letter-taste synesthesia; 50 children, accounting for 42.02% of the total, described have experience with time-position synesthesia; Only 26 young children, accounting for 21.85% of the total, described have experience with smell-taste synesthesia. During the interview, a total of 36 children, accounting for 30.25% of the total, were identified by the author as potentially possessing the conditions for color-type synesthetes.

DOI: 10.54254/2753-7048/29/20231493

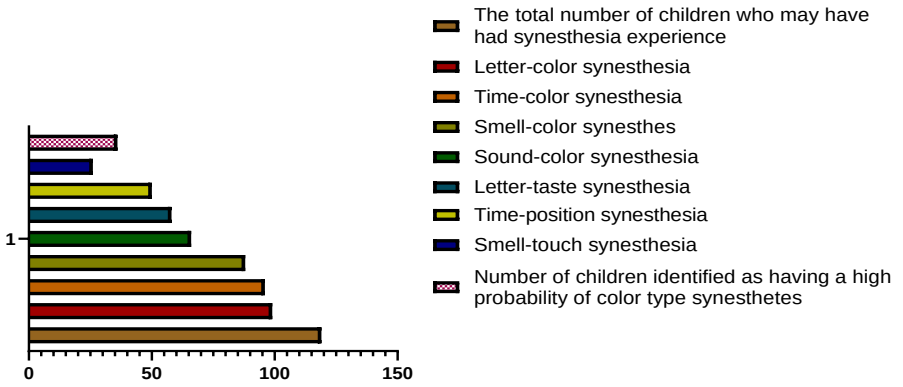

Figure 2: The proportion of children with various types of possible synesthesia experiences.

The results of Experiment 1 indicate that the vast majority of children have experienced varying degrees of synesthesia: children with single synesthesia experience the most, children with two synesthesia experience the second, and children with three or more types of synesthesia experience the least. In the group of children in this experiment, the top four types of synesthesia with the highest proportion were color-based synesthesia, color-based synesthesia experience is the most common type of synesthesia experience. Although most children have experienced mild synesthesia, the probability of being identified as a stable synesthete among children who have experienced synesthesia is 30.25%. These data may not seem surprising, but currently, the academic community generally believes that the probability of synesthetes appearing in the adult population is between 2% and 4% [10], the data in the children population far exceeds this value.

2.2. Experiment 2

Jennifer A.K. Green et al.'s experiment explored the impact of synesthesia on children's cognition by using numbers. The experiment adopted the matrix memory paradigm devised by Smilek, Dixon, Cudahy, & Merikle in 2002. Children who had been identified as synesthetes were given a piece of paper with a blank grid printed on it, and groups of numbers 3^3 or 4^4 were displayed on a computer screen. The number groups were displayed in three different ways: black (gray background), colors that matched the child's associative color, and colors that did not match the child's associative color. Afterward, the children were asked to compare the size of the displayed numbers.

As shown in Figure 3, both children with graphone-color synesthesia and children with phoneme-color synesthesia had slightly higher mean scores than children in the control group in both the neutral and congruent conditions. However, in the incongruent condition, the scores of the children in the phoneme-color synesthesia and control groups stabilized, whereas the scores of the children in the graphone-color synesthesia group very significantly declined.

DOI: 10.54254/2753-7048/29/20231493

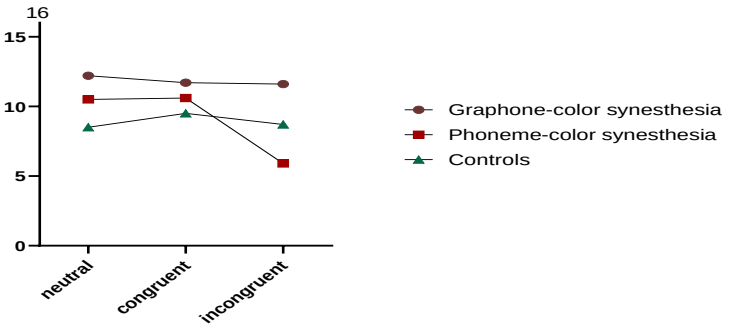

Figure 3: Average number of times the experiment was correct (16 points total) [11].

This result suggests that phoneme-color synesthesia and graphone-color synesthesia may have a small part of the increase in children's number cognitive ability in cases where synesthesia does not work and the color of the numbers matches the built-in colors of the synesthetically aware children; however, the number cognitive ability of children with the graphone-color synesthesia type may be disrupted to a greater extent if the color of the numbers does not match the built-in colors of the synesthetically aware children. This result suggests that there indeed be some degree of effect of synesthesia on children's cognitive abilities [11].

3. Discussion

3.1. The Experience of Synesthesia Widely Present in Children's Groups

The survey by Simner J, Sagiv N, et al. showed that in the adult population, the probability of stable synesthesia occurring is 2% -4% [10]. Chun&Hup é found in a 2013 study that the probability of common forms of synesthesia appearing in the general population is around 9-14% [12]. Ginsberg Simner et al. stated that 15% of people experience more pronounced synesthesia than the other 85% [13]. Although there is currently no consensus among scholars on the probability of synesthesia and synesthesia appearing in the general population, the probability of children's synesthesia and synesthesia appearing in this survey is much higher than these probabilities. Due to the subjectivity and uncertainty of synesthesia itself, as well as the limited language expression and cognitive level of children, there may be some errors in the data. But it can still explain the problem at a certain level: the probability of synesthesia in children is much higher than that in adults.

3.2. The Impact of Synesthesia on Children's Cognitive Development

Experiment 2 shows that synesthesia has an impact on children's cognition of numbers. In addition, many scholars have demonstrated the positive impact of synesthesia on various aspects of children's cognition: Simner and Bain hypothesize that there may be interference between synesthesia and cognitive performance in synesthetic children. However, in their actual experimental results, synesthetic children perform no worse than nonsynthetic and even perform better in certain aspects [11]. In a 2019 study, Smees et al. found that synesthetic children have significant advantages over nonsynesthetic peers in terms of academic self-concept and vocabulary in reading [11]. In the RAY H. SIMPSO study, it was found that there may be a connection between the music and color emotions of synesthetes [13]. Bouvet, L. et al. used the Wechsler Adult Intelligence Scale III to investigate the cognitive abilities of a synesthesia patient. The results showed that synesthesia patients exhibited high levels of language, working memory, hearing, and perception, which may indicate that academic abilities are related to synesthesia [3]. Chun&Hup é's research also suggests that synaesthetes have

DOI: 10.54254/2753-7048/29/20231493

higher language abilities than ordinary people [12]. Numerous studies have demonstrated the positive impact of synesthesia on children's cognition from different perspectives.

Some scholars have also researched the negative effects of synesthesia. Banissy, Tester, and others have found that the ability of synesthesia to detect coherent motion may be impaired. [12] Sinke et al. showed that synesthesia reduces the integration of auditory and visual cues. [12] In a large-scale survey conducted by Rich, Bradshaw, and Mattingley, synaesthetes showed significant weaknesses in the field of mathematics compared to the control group [7]. Yaro and Ward's research and Green and Goswami's research both show that synesthetes do not have a group advantage in memorizing numerical matrices [5].

In summary, synesthesia does have an impact on children's cognition, but this impact is not necessarily positive. Synesthesia has a significant positive effect on language, vocabulary, emotions, colors, music, hearing, and other aspects of cognition. It may have negative effects on the ability to quickly process information, visuospatial abilities, audio-visual integration, coherent motor detection, and mathematical abilities. So how to leverage the advantages of synesthesia and try to avoid the negative effects of synesthesia as much as possible?

4. Suggestions

As educators, the various teaching effects and conveniences brought by synesthesia are indeed worth applying in teaching, but caution should be exercised in choosing teaching methods.

4.1. Course Aspect

Educators can enhance the effectiveness of teaching by utilizing multiple sensory teaching, creative teaching, situational teaching, and other methods that can bring children a synesthetic experience [14].

Multiple sensory teaching can create a multi-sensory learning environment, allowing children to access and explore knowledge through different sensory channels. Moreover, multi-sensory teaching can enhance the initial synesthesia experience of some children without synesthesia, and may also lead to acquired synesthesia [14]. Creative activities such as storytelling, painting, and handcrafting can help children combine their imagination with their sense of connection [15]. Creating scenarios and role-playing activities can help children connect different elements [15].

4.2. Life and Game Aspect

Educators can help children connect different elements and explore connections and interactions in life through natural games, numbers and shapes games, and group collaboration.

Taking children outdoors for observation and exploration activities can help them discover the connections and interactions in nature. Through numbers and shapes games and activities, help children understand the relationships between numbers and the similarities and differences between shapes. During the game, children can learn to collaborate and establish relationships with others through collaboration and social activities.

4.3. Others

Educators also need to focus on creating complementary synesthesia experiences for children, integrating various disciplines with daily life, and continuously realizing them in children's various senses. At the same time, attention should also be paid to the teaching level of educators. Educators should fully understand children, use personalized teaching, and flexibly change teaching plans to eliminate or reduce the negative impact of synesthesia.

DOI: 10.54254/2753-7048/29/20231493

5. Conclusion

This study investigates the phenomenon of synesthesia and the frequency of various types of synaesthesia in a group of children aged 4-7 years and analyzes the impact of synaesthesia on children's cognitive abilities. The majority of children had various degrees of associative experiences: single-type associative experiences were the most frequent, double-type associative experiences were the second most frequent, three or more types of associative experiences were the least frequent, and color-type associative experiences were probably the most prevalent type of associative experiences. This study may provide some indication that associative phenomena may indeed be more prevalent in the child population than in the adult population.

Meanwhile, this study found that synesthesia has an impact on children's cognitive development, which can be divided into positive and negative aspects. When the content that children are about to recognize matches the patterns of built-in synesthesia types, synesthesia usually has a positive effect on children's cognition; When the content that children are about to recognize contradicts the patterns of built-in synesthesia types, synesthesia usually hurts children's cognition.

Due to the subjectivity of synesthesia itself, individual differences, as well as the weak language expression ability and difficulty in concentrating of children. The samples and survey data used in this project may have certain limitations due to the influence of such factors. Due to the ongoing development of research on children's synesthesia and the lack of consensus in the academic community, further research and exploration are needed on the changes in the impact of synesthesia on fields such as mathematics and art. Future research on synesthesia needs to further categorize the relationship between synesthesia experiences and synesthetes, clearly measure the connection between children's synesthesia and mathematics, and explore other potential applications of synesthesia in early childhood education.

References

[1] *Basirat, A. and Hupé, J. M. (2020) Synesthesia in children with difficulties in written language learning. Consciousness and Cognition, 82, 102951.*

[2] *Simner, J. (2012) Defining synaesthesia. British Journal of Psychology, 103(1), 1–15.*

[3] *Bouvet, L., Barbier, J. E., Cason, N., Bakchine, S. and Ehrlé, N. (2017) When synesthesia and savant abilities are mistaken for hallucinations and delusions: contribution of a cognitive approach for their differential diagnosis. The Clinical Neuropsychologist, 31(8), 1459-1473.*

[4] *Grossenbacher, P. G. and Lovelace, C. T. (2001) Mechanisms of synesthesia: cognitive and physiological constraints. Trends in cognitive sciences, 5(1), 36-41.*

[5] *Watson, M. R., Akins, K. A., Spiker, C., Crawford, L. and Enns, J. T. (2014) Synesthesia and learning: a critical review and novel theory. Frontiers in Human Neuroscience, 8, 98.*

[6] *Maurer, D., Gibson, L. C. and Spector, F. (2013) Synesthesia in infants and very young children. Oxford: Oxford University Press.*

[7] *Green, J. A. and Goswami, U. (2008) Synesthesia and number cognition in children. Cognition, 106(1), 463-473.*

[8] *Eagleman, D. M., Kagan, A. D., Nelson, S. S., Sagaram, D. and Sarma, A. K. (2007) A standardized test battery for the study of synesthesia. Journal of Neuroscience Methods, 159(1), 139-145.*

[9] *Asher, J. E., Aitken, M. R., Farooqi, N., Kurmani, S. and Baron-Cohen, S. Test of Genuineness - Revised. Neuropsychologia.*

[10] *Simner, J., Sagiv, N., Mulvenna, C., Tsakanikos, E. and Wetherby, S. A. (2006) Synaesthesia: the prevalence of atypical cross-modal experiences. Perception, 35(8), 1024-1033.*

[11] *Green, J. A. and Goswami, U. (2008) Synesthesia and number cognition in children. Cognition, 106(1), 463-473.*

[12] *Wheeler, K. L. (2013) Understanding Synesthesia and its Impact on Learning. Online Submission.*

[13] *Simner, J., Hubbard, E., Johnson, D., Allison, C. and Baron-Cohen, S. (2013) The prevalence of synesthesia: the Consistency Revolution. The Oxford Handbook of Synesthesia, 3-22.*

[14] *Ramachandran, V. S., and Hubbard, E. M. (2001) Psychophysical investigations into the neural basis of synaesthesia. Proc Biol Sci, 268, 979–983.*

[15] *Zheng, H. Y. (2009) The application of synesthesia psychology in music education in preschool teachers. Journal of Kashgar Normal University, 30 (04), 101-104.*