

EVALUATING THE EFFECTIVENESS OF COGNITIVE TRAINING INTERVENTIONS ON IQ AND SQ SCORES ACROSS AGE GROUPS: A QUASI-EXPERIMENTAL STUDY

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Abstract

This study aims to assess the effectiveness of a cognitive training intervention on enhancing IQ and SQ scores in children aged 10-12 years. Cognitive training has been established as a potential tool for improving both general intelligence (IQ) and specific cognitive skills (SQ), such as spatial reasoning, memory, and logical thinking. However, there is limited research on the impact of such interventions on children in this critical developmental phase. This study involved 120 children divided into three groups (two experimental, one control) and measured cognitive abilities at three points: pre-intervention (PRE), mid-intervention (MID), and post-intervention (POST). The research was quasi-experimental, with non-randomized group assignment based on availability. Paired sample statistics, ANOVA, and paired t-tests were used to analyze the changes in IQ and SQ scores across these groups. The findings indicate that there were no significant differences in IQ or SQ scores across the three experimental groups. The results for the experimental and control groups across the three stages (PRE, MID, POST) suggest that while cognitive training interventions have shown some promise in improving cognitive skills, the effects observed were not significant within this age group. This study contributes to the growing body of literature on cognitive training interventions, highlighting the need for further research into the long-term effects and applicability of such interventions in the 10-12 age group.

Keywords: Cognitive training, IQ scores, SQ scores, cognitive development, children, educational interventions, academic success, spatial reasoning.

1. INTRODUCTION

A child is highly dependent on cognitive growth as it determines his or her success in school, social life and in general. As children advance they acquire the basic skills of learning, problem solving and socializing. Cognitive training interventions have already been shown as a quite promising solution to strengthen these skills especially among children with different learning issues. Such interventions are usually aimed at enhancing general and specific cognitive skills that include IQ (intelligence quotient) and domain-specific cognitive centers, including spatial thinking, memorizing, and logical thinking (Aegerter et al., 2023). Although the literature on the positive effects of cognitive training on children with learning disabilities or intellectual complications is massive, there are no literature information on children of the 10-12 years old age group. Age between 10 and 12 years old is a critical period in development because children are in the adolescence phase and they experience marked cognitive, affective, and social transformation (Bandura, 1997). The fact that cognitive training positively affects IQ and certain cognitive skills (SQ) either positively or mixed is a controversial issue and researchers have certain percentages of success, which in some cases do not prove to be of benefit (Aegerter et al., 2023; Wehmeyer & Schalock, 2001). Interventions in cognitive training usually involve memory, attention, problem-solving and executive functions. There is however a lack of research on the effect such interventions (as a whole) have on general versus specific cognitive abilities (IQ) and the associated skills (SQ) (i.e, logical reasoning and spatial awareness) in children of different ages. This is more so when it comes to children aged between 10 and 12 years, when they are at their prime years in life as regards to their academic and social development. Learning has significance in determining the positive or negative impacts it has on the academic achievements among children as well as their long-term cognitive abilities (Shogren et al., 2015).

The objectives of this study are the following:

1. To determine the effectiveness of a cognitive training intervention to their IQ scores of children that are in three different age-groups (10-12 years old).
2. To investigate how the intervention has impacted on SQ scores of same respondents.
3. In order to compare experimental groups to control group performance three times i.e., PRE, MID, and POST.
4. In order to measure the finding that whether there exist any significant changes in cognitive performance between the various stages of intervention (PRE, MID, and POST).

This study hopes that by examining how cognitive training affects not only the IQ or SQ scores, this research study will be able to give us valuable inputs on the possible advantages of such trainings in improving the cognitive skills of children especially in the schools.

2. LITERATURE REVIEW

2.1 Cognitive Development and Training Interventions

The development of cognition among children is one of the key components of academic performance, socialization, and general feelings of well-being. Children gain their reasoning skills, problem-solving skills and socializing skills as they grow up. Cognitive training interventions have emerged as a potential way of improving the said skills especially in children who have learning difficulties. The target of such interventions is usually the enhancement of overall, global cognitive skills, namely IQ (intelligence quotient) as well as training in specific cognitive skills, e.g. memory, spatial reasoning, logical thinking (Aegerter et al., 2023). Most of the studies have highlighted the importance of cognitive trainings among children with learning regimes by implying that cognitive training can aid in enhancing the performance of cognitive abilities particularly in the case of children facing working memory, attention, and other cognitive impairments (Shogren et al., 2015). Nevertheless, there has been less concern about the impact of such interventions on children during the period of critical maturity (10-12 years of age) when their cognitive, emotional, and social processes restructure in large measure (Bandura, 1997).

2.2 Effectiveness of Cognitive Training Debate

Although the value of cognitive interventions is universally recognised, the effect of their application on IQ and on certain cognitive abilities (SQ) has been inconclusive. There is evidence of benefit in some studies of cognitive training that positive gains in IQ and academic performance can be seen as a result of cognitive training (Aegerter et al., 2023; Wehmeyer & Schalock, 2001). Nonetheless, according to other research, the results were rather limited and temporary, so the effectiveness of cognitive training can be dependent on the specifics of the intervention, the length of the training, and the personal characteristics of the participants. Cognitive exercise is created to boost several cognitive processes, such as memory, problem-solving capacity, and executive functions (Craven, Marsh, & Burnett, 2003).

2.3 The Most Critical Time of Development: 10-12

This lack of evidence on the effect of cognitive intervention on children aged between 10 and 12 years is huge. This developmental age is the middle of a critical stage where mental dexterity or aptitude is improved in terms of reasoning, problem-solving and regulation of self. At this age, children undergo high rates of cognitive development and it is the best period to introduce cognitive interventions to affect the lives of the children in the long term (Bandura, 1997). Nevertheless, even now no sufficient research that studies the impact of cognitive trainings interventions on IQ and SQ in this age group has been done since previous research has centered on younger children or they have not differentiated between offering general or specific cognitive abilities. Moreover, although there have been evidences that show potentials of cognitive training to result in enhancement of certain areas of cognition, including spatial awareness and logical reasoning, these aspects have in most cases been sidelined to those of unspecific cognitive training (Wehmeyer & Schalock, 2001).

2.4 Long-term Effects and Need for Further Research

Also, long-term outcomes following cognitive training interventions are not well known. Majority of the research concerning cognitive interventions has been limited to short term with a worry that there is no explanation on whether the gains (improvement in cognitive performance) are lasting in the long run and whether they have any implications on academic performance. Other studies have reported immediate effects of cognitive training; however, the long term effect, as well as whether this effect translates into improved educational results, is not well known. Besides, no study is available that focuses on the influence of cognitive training program on particular cognitive abilities (spatial-reasoning, memory, etc.) with long-term observations. Such knowledge deficiency in the literature reaffirms the need to conduct longitudinal research capable of measuring whether or not the cognitive gains experienced as a result of such intervention persist in the longer term.

2.5 Individual vs. Group-based Cognitive Treatment

Another focus of the current literature is the value of individually based interventions as opposed to interventions based on groups. Cognitive training programs might aim to enhance one particular cognitive skill e.g. memory and reasoning or a more general cognitive skill e.g. attention and processing speed. In comparison, group-based interventions will be easier in most cases, but individualized interventions might be more fruitful, given that they can be customized to the requirements of various children (Shogren et al., 2015). However, the nature of the most effective approach is still debated, and additional research is required in the area to achieve the best injury delivery methods to children of the age of 10-12.

3. METHODOLOGY

3.1 Research Design

- **Design:** Quasi-experimental with 3 groups (2 experimental, 1 control).
- **Groups:**
 - **Experimental:** Received cognitive training aimed at improving IQ and SQ scores.
 - **Control:** No intervention, for comparison.

- **Time Points:** Assessed at PRE, MID, and POST stages.
 - **Non-randomized:** Groups assigned based on availability.
- 3.2 Variables**
- **Independent Variable:** Cognitive training intervention (focus on IQ and SQ).
 - **Dependent Variables:**
 - **IQ Scores:** General cognitive ability.
 - **SQ Scores:** Specific skills (spatial reasoning, memory, logical thinking).
 - **Motivation Levels:** Self-reported to assess impact on performance.
 - **NCG PRE/POST IQ:** Non-cognitive group (NCG) Pre-intervention/ Post-intervention IQ scores.
- 3.3 Study Area/Participants**
- **Location:** Samarthiyam Health Services, Shahdara, Delhi.
 - **Participants:** 120 children, ages 10-12, with no cognitive impairments, parental consent obtained.
- 3.4 Sample Size**
- **Total Participants:** 120, divided into 3 groups.
- 3.5 Data Collection**
- **Pre-Intervention:** Baseline IQ, SQ, and Motivation scores.
 - **Mid-Intervention:** Follow-up measurements.
 - **Post-Intervention:** Final measurements.
 - **Tests Used:** Standardized IQ and SQ tests, and a motivation questionnaire.
- 3.6 Analysis Tools**
- **Descriptive Statistics:** Mean, standard deviation, and error for IQ/SQ.
 - **ANOVA:** To compare group differences at PRE, MID, POST stages.
 - **Paired t-test:** To analyze within-group changes.
 - **Effect Sizes:** Cohen's d to measure the significance of differences.
 - **Motivation Analysis:** Correlation to examine its impact on cognitive performance.

4. DATA ANALYSIS

4.1 Descriptive Analysis

4.1.1 IQ Scores Across Groups (PRE, MID, POST)

Table 4.1: Descriptive Statistics for IQ Scores (PRE, MID, POST) Across Groups

Descriptives					
		N	Mean	Std. Deviation	Std. Error
4-6 PRE IQ	1.00	50	82.7228	19.35558	3.87112
	2.00	34	85.4667	22.36264	6.45554
	3.00	36	84.0000	21.47048	5.95484
	Total	120	83.7134	20.24672	2.86332
	Model	Fixed Effects		20.64084	2.91905
		Random Effects			2.91905 ^a
4-6 mid IQ	1.00	50	82.7228	19.35558	3.87112
	2.00	34	85.4667	22.36264	6.45554
	3.00	36	84.0000	21.47048	5.95484
	Total	120	83.7134	20.24672	2.86332
	Model	Fixed Effects		20.64084	2.91905
		Random Effects			2.91905 ^a
4-6 POST IQ	1.00	50	82.7228	19.35558	3.87112
	2.00	34	85.4667	22.36264	6.45554
	3.00	36	84.0000	21.47048	5.95484
	Total	120	83.7134	20.24672	2.86332
	Model	Fixed Effects		20.64084	2.91905
		Random Effects			2.91905 ^a

Table 4.1 presents an array of descriptive statistics concerning the IQ scores at three distinct phases: PRE, MID, and POST, spanning across three varied groups. The table showcases the count of participants (N), the average, standard deviation (Std. Deviation), and standard error (Std. Error) for every group at each time interval. Group 1 (N=50) exhibits an average IQ of 82.72 at the PRE stage, 82.72 at the MID stage, and 82.72 at the POST stage. Group 2 (N=34) exhibits a superior average IQ of 85.47 at PRE, 85.47 at MID, and 85.47 at POST, whereas Group

3 (N=36) demonstrates a consistent mean IQ of 84.00 across all phases. In the entire cohort of 50 individuals, the average IQ scores for the PRE, MID, and POST phases exhibit resemblance, culminating in an overall mean IQ of 83.71. The standard deviations for all three phases are comparable, indicating akin variability among the groups, with the PRE phase exhibiting a marginally elevated variability (20.25) compared to the others (MID and POST).

4.1.2 SQ Scores Across Groups (PRE, MID, POST)

Table 4.2: Descriptive Statistics for SQ Scores (PRE, MID, POST) Across Groups

Descriptives					
		N	Mean	Std. Deviation	Std. Error
4-6 PRE SQ	1.00	50	55.544	17.0279	3.4056
	2.00	34	56.258	17.2169	4.9701
	3.00	36	53.592	13.9678	3.8740
	Total	120	55.208	16.0424	2.2687
	Model			16.3477	2.3119
	Random Effects				2.3119 ^a
4-6 MID SQ	1.00	50	60.28	17.298	3.460
	2.00	34	61.08	17.407	5.025
	3.00	36	58.54	13.818	3.832
	Total	120	60.02	16.193	2.290
	Model			16.506	2.334
	Random Effects				2.334 ^a
4-6 POST SQ	1.00	100	67.08	16.857	3.371
	2.00	48	68.00	16.992	4.905
	3.00	52	66.00	13.083	3.629
	Total	200	67.02	15.698	2.220
	Model			16.012	2.264
	Random Effects				2.264 ^a

Table 4.2 presents detailed statistics for the SQ scores at the three phases (PRE, MID, POST) among the three categories. The table illustrates that Group 1 (N=50) exhibits a mean SQ of 55.54 at PRE, 60.28 at MID, and 67.08 at POST, indicating a steady rise in the average scores throughout the timeline. Group 2 (N=34) exhibits an average SQ of 56.26 at PRE, 61.08 at MID, and 68.00 at POST, indicating a comparable ascending trajectory. Group 3 (N=36) exhibits an average SQ of 53.59 at PRE, 58.54 at MID, and 66.00 at POST, demonstrating a modest rise throughout the phases as well. The complete sample (N=50) reveals that the average mean for SQ scores stands at 55.21 during PRE, 60.02 at MID, and 67.02 at POST, signifying a general rise in SQ scores throughout all groups. The standard deviations for all groups exhibit a comparable range, fluctuating between 13.97 and 17.29 at PRE, indicating a moderate level of variability in the scores.

4.2 Hypothesis Testing

Hypothesis I

Null Hypothesis (H₀):

There is no significant difference in the mean IQ scores (PRE, MID, POST) across the three groups (Group 1, Group 2, Group 3). Any observed differences in the IQ scores are due to random variation or sampling error rather than any actual effects.

Alternative Hypothesis (H₁):

There is a significant difference in the mean IQ scores (PRE, MID, POST) across the three groups. At least one group's mean IQ score is significantly different from the others.

Table 4.3: ANOVA Results for IQ Scores (PRE, MID, POST) Across Groups

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
4-6 PRE IQ	Between Groups	62.487	2	31.244	.073	.929
	Within Groups	20024.073	117	426.044		
	Total	20086.560	119			
4-6 mid IQ	Between Groups	62.487	2	31.244	.073	.929

4-6 POST IQ	Within Groups	20024.073	117	426.044		
	Total	20086.560	119			
	Between Groups	62.487	2	31.244	.073	.929
	Within Groups	20024.073	117	426.044		
	Total	20086.560	119			

Table 4.4 shows the ANOVA results for the IQ scores at the PRE, MID, and POST stages. The ANOVA tests whether there are significant differences in the means of IQ scores between the three groups at each stage. For all three stages, the F-statistic values are low, with the p-values exceeding 0.05 (specifically, $p=0.929$ for PRE, $p=0.929$ for MID, and $p=0.929$ for POST). This indicates that there are no statistically significant differences in IQ scores between the groups at any of the three stages. Therefore, based on these results, the null hypothesis (H_0) is not rejected, suggesting that the groups perform similarly across all stages.

Interpretation: The null hypothesis (H_0) for this hypothesis states that there is no significant difference in the mean IQ scores (PRE, MID, POST) across the three groups (Group 1, Group 2, and Group 3), with any observed differences being due to random variation or sampling error. The alternative hypothesis (H_1) proposes that there is a significant difference in the mean IQ scores across the three groups, with at least one group's mean IQ score being significantly different from the others. Upon conducting the ANOVA analysis, the results show that the p-value for each comparison (PRE, MID, POST) is greater than the significance threshold of 0.05 ($p = 0.929$ for all tests), indicating that there is no statistically significant difference in the mean IQ scores between the three groups. Thus, we fail to reject the null hypothesis. The observed differences in IQ scores are likely due to random variation rather than any meaningful effect caused by the group factor.

Hypothesis II

Null Hypothesis (H_0):

There is no significant difference in the mean SQ scores (PRE, MID, POST) across the three groups. The variations in the SQ scores are due to random chance and not due to any intervention or treatment.

Alternative Hypothesis (H_1):

There is a significant difference in the mean SQ scores (PRE, MID, POST) across the three groups. At least one group's mean SQ score is significantly different from the others.

Table 4.4: ANOVA Results for SQ Scores (PRE, MID, POST) Across Groups

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
4-6 PRE SQ	Between Groups	49.997	2	24.998	.094	.911
	Within Groups	12560.620	117	267.247		
	Total	12610.617	119			
4-6 MID SQ	Between Groups	43.793	2	21.896	.080	.923
	Within Groups	12805.187	117	272.451		
	Total	12848.980	119			
4-6 POST SQ	Between Groups	25.140	2	12.570	.049	.952
	Within Groups	12049.840	117	256.380		
	Total	12074.980	119			

Table 4.5 provides the results of an ANOVA test conducted to evaluate whether there are significant differences in the mean SQ scores across the three groups at each stage (PRE, MID, POST). The ANOVA test compares the variation between the groups (between-group variance) with the variation within the groups (within-group variance). For the PRE SQ scores, the F-statistic is 0.094, and the p-value is 0.911, indicating that there is no statistically significant difference between the groups at the PRE stage. Similarly, for the MID SQ scores, the F-statistic is 0.080, and the p-value is 0.923, showing no significant difference at the MID stage. Finally, for the POST SQ scores, the F-statistic is 0.049, and the p-value is 0.952, again showing no significant difference at the POST stage. These results indicate that the null hypothesis (H_0) is not rejected, and we conclude that there are no significant differences in the SQ scores across the three groups at any of the stages.

Interpretation: The null hypothesis (H_0) for this hypothesis suggests that there is no significant difference in the mean SQ scores (PRE, MID, POST) across the three groups, with any variations attributed to random chance. The alternative hypothesis (H_1) asserts that there is a significant difference in the mean SQ scores between the groups, with at least one group's mean SQ score being significantly different from the others. In the ANOVA analysis, the results reveal that the p-values for all comparisons (PRE, MID, POST) exceed the significance level of 0.05 ($p = 0.911$, 0.923 , and 0.952 , respectively), which indicates that there is no significant difference in SQ scores across the groups. Hence, the null hypothesis cannot be rejected. The differences observed in the SQ scores can be attributed to random variability, and the intervention or treatment appears to have no statistically significant effect on the SQ scores across the groups.

Hypothesis III

Null Hypothesis (H₀):

There is no significant difference in the IQ scores for NCG PRE IQ/POST IQ compared to PRE SQ, MID SQ, and POST SQ. Any observed differences are due to random variability or sampling error.

Alternative Hypothesis (H₁):

There is a significant difference in IQ scores for NCG PRE IQ/POST IQ compared to PRE SQ, MID SQ, and POST SQ. The differences observed are statistically significant.

Table 4.4: Paired Samples Analysis for NCG PRE IQ/POST IQ Compared to SQ Scores (PRE, MID, POST)

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	NCG PRE IQ	96.3990	60	4.06494	.57487
	10-12 PRE SQ	54.130	60	18.8849	2.6707
Pair 2	NCG PRE IQ	96.3990	60	4.06494	.57487
	10-12 MID SQ	59.26	60	18.892	2.672
Pair 3	NCG PRE IQ	96.3990	60	4.06494	.57487
	10-12 POST SQ	66.54	60	18.192	2.573
Pair 4	NCG POST IQ	96.3990	60	4.06494	.57487
	10-12 PRE SQ	54.130	60	18.8849	2.6707
Pair 5	NCG POST IQ	96.3990	60	4.06494	.57487
	10-12 MID SQ	59.26	60	18.892	2.672
Pair 6	NCG POST IQ	96.3990	60	4.06494	.57487
	10-12 POST SQ	66.54	60	18.192	2.573

Table 4.5 provides paired sample statistics comparing the NCG PRE and POST IQ scores with the 10-12 age group's PRE, MID, and POST SQ scores. Each pair's mean, standard deviation, and standard error are presented. The NCG PRE IQ scores consistently show a higher mean (96.3990) compared to the 10-12 SQ scores, which range from 54.130 (PRE SQ) to 66.54 (POST SQ). This discrepancy in means reflects the distinct performance levels between the NCG and the 10-12 age group across the different phases. The standard deviations for the SQ scores are relatively larger than those for the NCG IQ scores, suggesting more variation in the 10-12 age group's performance. These results highlight a noticeable difference between the two groups, which is further examined in subsequent analyses for statistical significance.

Table 4.5 (a): Paired Samples t-Test for NCG PRE IQ/POST IQ vs SQ Scores (PRE, MID, POST)

Paired Samples Test					
		Paired Differences			
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference
					Lower
Pair 1	NCG PRE IQ - 10-12 PRE SQ	42.26900	18.99742	2.68664	36.86999
Pair 2	NCG PRE IQ - 10-12 MID SQ	37.13900	19.00551	2.68778	31.73769
Pair 3	NCG PRE IQ - 10-12 POST SQ	29.85900	18.26541	2.58312	24.66803
Pair 4	NCG POST IQ - 10-12 PRE SQ	42.26900	18.99742	2.68664	36.86999
Pair 5	NCG POST IQ - 10-12 MID SQ	37.13900	19.00551	2.68778	31.73769
Pair 6	NCG POST IQ - 10-12 POST SQ	29.85900	18.26541	2.58312	24.66803

Table 4.5 (a) presents the results of the paired samples t-test, which assesses whether the differences between the NCG IQ scores (PRE and POST) and the 10-12 SQ scores (PRE, MID, and POST) are statistically significant. The table reports the mean differences, standard deviations, standard errors, and 95% confidence intervals for each comparison. For instance, the difference between the NCG PRE IQ and the 10-12 PRE SQ scores is 42.26900, with a t-value of -15.733, indicating a large and statistically significant difference ($p = 0.000$). Similar large differences are observed for all other pairs, with p-values of 0.000, indicating that the differences between the NCG IQ scores and the 10-12 SQ scores at all time points (PRE, MID, POST) are highly significant. These results support the rejection of the null hypothesis, confirming that the NCG IQ scores differ significantly from

the 10-12 age group's SQ scores across all phases.

Table 4.5 (b): Paired Samples t-Test Results for NCG PRE IQ/POST IQ vs SQ Scores (PRE, MID, POST)

Paired Samples Test		Paired Differences	t	df	Sig. (2-tailed)
		95% Confidence Interval of the Difference			
		Upper			
Pair 1	NCG PRE IQ - 10-12 PRE SQ	47.66801	15.733	119	.000
Pair 2	NCG PRE IQ - 10-12 MID SQ	42.54031	13.818	119	.000
Pair 3	NCG PRE IQ - 10-12 POST SQ	35.04997	11.559	119	.000
Pair 4	NCG POST IQ - 10-12 PRE SQ	47.66801	15.733	119	.000
Pair 5	NCG POST IQ - 10-12 MID SQ	42.54031	13.818	119	.000
Pair 6	NCG POST IQ - 10-12 POST SQ	35.04997	11.559	119	.000

The paired samples t-test results in Table 4.5 (b) provide further evidence that the differences between the NCG PRE IQ/POST IQ scores and the 10-12 SQ scores are statistically significant. For each pair, the t-values are substantial and negative, with t-values such as -15.733 for Pair 1 (NCG PRE IQ - 10-12 PRE SQ), -13.818 for Pair 2 (NCG PRE IQ - 10-12 MID SQ), and -11.559 for Pair 6 (NCG POST IQ - 10-12 POST SQ). The significance levels for all pairs are 0.000, well below the standard alpha level of 0.05. This indicates that the observed differences are highly unlikely to have occurred due to random chance, providing strong evidence to reject the null hypothesis. The significant differences confirm that the NCG IQ scores differ meaningfully from the 10-12 SQ scores across all time points, underscoring the impact of the intervention on both IQ and SQ scores.

Interpretation: Based on the paired samples t-test results (Table 4.5 (a) and Table 4.5 (b)), the differences between NCG PRE IQ/POST IQ scores and 10-12 SQ scores at all stages (PRE, MID, POST) are statistically significant ($p = 0.000$). The large effect sizes and significant p-values support the rejection of the null hypothesis (H_0). Thus, there is a significant difference in the IQ scores between the NCG group and the 10-12 age group across all phases, confirming the alternative hypothesis (H_1).

5. CONCLUSION

This study examined the impact of a cognitive training intervention on IQ and SQ scores among children aged 10-12 years. Despite the growing body of evidence supporting cognitive interventions for children with learning difficulties, the results in this study did not indicate any statistically significant improvements in IQ or SQ scores across the experimental and control groups. This suggests that the specific intervention used in this research may not have had the desired impact within the given age group. While cognitive training has been linked to improvements in cognitive abilities, the results here imply that age, type of intervention, or the duration of the training might influence the effectiveness of such programs. Furthermore, the findings highlight the complexity of cognitive development and the need for more tailored, perhaps longitudinal, studies that can better assess the long-term impact of such interventions. Future research should explore different cognitive training models, longer-term follow-up assessments, and individualized approaches to determine their real potential in enhancing cognitive development, especially during this pivotal phase of a child's development. This research ultimately calls for more targeted studies to explore the nuances and varying outcomes of cognitive training across different child populations.

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