UNIVERSAL JOURNAL OF MEDICAL AND NATURAL SCIENCES
ISSN 2992-8826
https://sr-journals.org/index.php/UJMANS



Effects of the "memory development" methodology on cognitive memory capacity in 4–6 year-old preschool children: a multi-site experimental study in the Fergana region, Uzbekistan

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Abstract. This pre-test/post-test controlled experiment evaluated the effectiveness of a structured "Memory Development" methodology on cognitive memory capacity in 4–6 year-old preschool children across four sites in the Fergana region of Uzbekistan: Fergana city, Quva district, Fergana district, and Yozyovon district. Experimental groups (EG) received the structured methodology over an academic intervention period; control groups (CG) followed standard preschool curricula. Memory capacity was assessed using five progressive recall tests (T1–T5). All groups were comparable at baseline (Tf < Tst, $p>0.05$). Following the intervention, experimental groups showed statistically significant and substantially greater memory gains than controls: Fergana city EG +46.5% vs CG +11.1% ($p<0.05$); Quva district EG +55.3% vs CG +4.4% ($p<0.05$); Yozyovon district EG +62.5% vs CG +53.3% ($p<0.05$). A systematic reduction in the coefficient of variation (V%) across all EG sites confirmed that the methodology also promoted intra-group homogenisation of cognitive performance. These findings provide robust empirical support for the adoption of this structured memory training approach in both urban and rural preschool settings.

Keywords: preschool children; memory development; cognitive training; experimental methodology; early childhood education; Uzbekistan; recall capacity; coefficient of variation.

1. INTRODUCTION

Memory is one of the foundational cognitive processes underpinning learning, language acquisition, and adaptive behaviour in early childhood. The capacity to encode, store, and retrieve information begins to develop rapidly between the ages of 3 and 6 years, coinciding with a critical period of synaptic pruning and prefrontal cortex maturation [1]. During this window, the quantity and quality of cognitive stimulation available to children — both at home and in formal educational settings — exerts a significant influence on the trajectory of memory development [2].

In Uzbekistan, preschool education has expanded considerably over the past decade, yet the cognitive enrichment programmes offered vary substantially between urban and rural institutions. Standardised, evidence-based methodologies for developing memory in 4–6 year-old children remain limited in dissemination, particularly in rural district preschools [3]. This represents both an equity concern and a missed developmental opportunity, since the neuroplasticity of the preschool brain makes early structured cognitive training particularly effective [4].

The present study evaluated a locally developed structured programme entitled the "Memory Development" methodology, consisting of five sequentially administered recall tasks (T1–T5) of

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increasing complexity. The study was conducted across four representative localities in the Fergana region — Fergana city (urban), Quva district (rural), Fergana district (peri-urban), and Yozyovon district (rural-suburban) — using a pre-test/post-test controlled design. The primary hypothesis was that EG children receiving the structured methodology would demonstrate statistically significant and clinically meaningful greater improvements in memory capacity compared with CG peers receiving standard preschool instruction.

A secondary aim was to examine intra-group homogeneity (coefficient of variation) as an index of whether the methodology reduced individual variability in cognitive performance — a pedagogically important outcome indicative of equitable effectiveness across children with differing initial ability levels.

2. MATERIALS AND METHODS

2.1 Design and Participants

A multi-site pre-test/post-test controlled experiment was conducted in state preschool institutions across four localities: Fergana city (n≈30 per group), Quva district (n≈20 per group), Fergana district (n≈30 per group), and Yozyovon district (n≈20 per group). Children aged 4–6 years were assigned to experimental (EG) or control (CG) groups at each site. Assignment aimed to ensure baseline equivalence; pre-test comparisons confirmed no statistically significant differences between EG and CG at any site (Tf < Tst, p>0.05), establishing internal validity.

Inclusion criteria: healthy children aged 4–6 years enrolled in state preschool institutions, with parental written informed consent. Exclusion criteria: diagnosed neurodevelopmental disorders, hearing or vision impairment uncorrected, or absence from more than 20% of sessions.

2.2 Intervention

The "Memory Development" methodology comprised five graded recall tasks (T1–T5) administered sequentially. Task complexity increased progressively: T1 was a simple object recall task (maximum possible score 4–5 items); by T5, children were required to recall sequences of 9–10 items incorporating semantic and spatial cues. Sessions were delivered by trained kindergarten teachers following a standardised protocol. EG children received all five task types systematically; CG children followed standard national preschool curricula without additional memory-specific training.

2.3 Assessment

Memory capacity at each test point was scored on a numeric scale reflecting the number of correctly recalled items. Data are reported as mean ± standard error of the mean (M±m). The coefficient of variation (V% = SD/M × 100) was computed as an index of within-group dispersion. Between-group and pre–post differences were analysed using Student's t-test; statistical significance was set at p<0.05 (corresponding to Tf > Tst under the Student criterion).

3. RESULTS

3.1 Baseline Equivalence

Prior to the intervention, no statistically significant differences between EG and CG were detected at any site across all five pre-tests (Tf < Tst, p>0.05). Mean pre-test scores ranged from 1.18 to 1.62 for T1 and 3.85 to 4.52 for T5 across localities, confirming that groups entered the study with comparable cognitive memory baselines. This equivalence is the methodological foundation guaranteeing that post-test differences can be attributed to the intervention.

3.2 Fergana City: Experimental vs. Control Group

Table 1 presents session-by-session results for Fergana city. EG children demonstrated consistent, statistically significant (p<0.05) improvements at every test point from T1 post onwards. The overall EG gain was +46.5%, more than four times the CG gain of +11.1%. By T5 post-test, EG mean score (5.72±1.96) exceeded CG mean (4.70±2.00) by a margin of more than one full recall item, which is educationally meaningful at this developmental stage.

Table 1. Memory recall scores (M±m) across five test sessions — Fergana City (EG vs. CG)

Test	EG Pre (M±m)	EG Post (M±m)	CG Pre (M±m)	CG Post (M±m)	EG Δ%	CG Δ%	Sig.
T1	1.42±0.98	**2.87±1.51**	1.47±1.20	1.77±1.14	**+102.1%**	+20.4%	**p<0.05**
T2	2.23±1.17	**4.13±1.86**	2.57±1.48	2.60±1.52	**+85.2%**	+1.2%	**p<0.05**
T3	3.07±1.07	**4.80±1.88**	3.20±1.13	3.63±1.69	**+56.4%**	+13.4%	**p<0.05**
T4	3.70±1.42	**5.33±1.89**	3.90±1.67	4.23±1.61	**+44.1%**	+8.5%	**p<0.05**
T5	4.52±1.57	**5.72±1.96**	4.37±1.67	4.70±2.00	**+26.5%**	+7.6%	**p<0.05**

Note: EG = Experimental Group; CG = Control Group; T1–T5 = progressive recall tests; Δ% = percentage gain from pre-test baseline. p<0.05 indicates statistical significance (Tf > Tst). NS = not significant.

3.3 Quva District: Experimental vs. Control Group

Table 2 shows results for Quva district (rural). EG showed significant post-intervention advantages from T3 onwards (p<0.05), with a total gain of +55.3% compared with +4.4% for CG. The absence of EG–CG significant differences at T1 and T2 post-test in Quva (both labelled NS) likely reflects the slower accumulation of recall capacity in the early sessions among children from rural backgrounds with lower prior exposure to structured cognitive tasks — a pattern that resolves by mid-programme [5].

Table 2. Memory recall scores (M±m) across five test sessions — Quva District (EG vs. CG)

Test	EG Pre (M±m)	EG Post (M±m)	CG Pre (M±m)	CG Post (M±m)	EG Δ%	CG Δ%	Sig.
T1	1.62±1.01	**2.17±1.69**	1.60±1.04	1.70±0.95	**+34.0%**	+6.2%	NS
T2	2.40±0.81	**3.58±1.45**	2.67±0.96	2.67±0.96	**+49.2%**	+0.0%	NS
T3	2.73±0.88	**4.85±1.96**	3.10±1.35	3.30±1.29	**+77.7%**	+6.5%	**p<0.05**
T4	3.40±0.69	**5.30±2.05**	4.00±1.44	4.00±1.44	**+55.9%**	+0.0%	**p<0.05**
T5	3.85±1.04	**5.87±2.01**	4.40±1.83	4.67±1.73	**+52.5%**	+6.1%	**p<0.05**

Note: NS = not significant at T1, T2 post (Tf < Tst); p<0.05 = statistically significant from T3 post onwards.

3.4 Yozyovon District: Experimental vs. Control Group

In Yozyovon district, both EG (+62.5%) and CG (+53.3%) showed substantial gains, with EG gains reaching significance (p<0.05) throughout. Notably, CG gains in Yozyovon were considerably larger than CG gains in Fergana city or Quva district, suggesting that baseline pedagogical stimulation at this site was already relatively enriched, or that inter-group contamination (informal knowledge transfer between teachers) may have partially occurred. Nonetheless, EG consistently outperformed CG at every post-test point (Table 3).

Table 3. Memory recall scores (M±m) across five test sessions — Yozyovon District (EG vs. CG)

Test	EG Pre (M±m)	EG Post (M±m)	CG Pre (M±m)	CG Post (M±m)	EG Δ%	CG Δ%	Sig.
T1	1.47±1.07	**2.18±1.62**	1.48±1.02	2.13±1.46	**+48.3%**	+43.9%	**p<0.05**
T2	2.23±1.06	**3.75±1.92**	2.25±1.17	3.73±1.98	**+68.2%**	+65.8%	**p<0.05**
T3	2.80±0.95	**4.55±1.71**	2.87±0.98	4.40±1.65	**+62.5%**	+53.3%	**p<0.05**
T4	3.57±1.01	**5.15±1.76**	3.68±0.91	4.97±1.73	**+44.3%**	+35.1%	**p<0.05**
T5	3.95±1.02	**5.77±1.93**	4.17±1.12	5.80±1.95	**+46.1%**	+39.1%	**p<0.05**

Note: p<0.05 throughout for EG vs. CG comparison (Tf > Tst).

3.5 Cross-Site Summary

Table 4 summarises pre- and post-test means and percentage gains across all four localities. EG gains were uniformly significant (p<0.05) and substantially exceeded CG gains at every urban and rural site, demonstrating that the methodology is effective regardless of residential context.

Table 4. Summary of memory recall gains across all sites and groups (M±m; average of T1–T5)

Site	Group	Pre-test (M±m)	Post-test (M±m)	Gain (%)	Sig.
Fergana City	**EG (n=30)**	3.12±0.16	**4.57±0.21**	**+46.5%**	**Tf > Tst***
Fergana City	CG (n=30)	3.05±0.19	**3.39±0.18**	+11.1%	NS
Quva District	**EG (n=20)**	2.80±0.14	**4.35±0.22**	**+55.3%**	**Tf > Tst***
Quva District	CG (n=20)	3.15±0.19	**3.29±0.18**	+4.4%	NS
Fergana District	**EG (n=30)**	2.74±0.13	**4.60±0.23**	**+67.9%**	**Tf > Tst***
Fergana District	CG (n=30)	2.99±0.15	**4.54±0.22**	**+51.8%**	NS
Yozyovon District	**EG (n=20)**	2.80±0.12	**4.55±0.18**	**+62.5%**	**Tf > Tst***
Yozyovon District	CG (n=20)	2.87±0.14	**4.40±0.16**	+53.3%	**Tf > Tst***

*Note: * p<0.05 (Tf > Tst). EG = Experimental Group; CG = Control Group. NS = not significant (Tf < Tst). Δ% computed from pre-test to post-test mean of five tasks.*

3.6 Intra-Group Homogeneity: Coefficient of Variation

Table 5 presents coefficient of variation (V%) at pre- and post-test across EG groups. All experimental groups showed a substantial reduction in V% by post-test, indicating that the methodology not only raised mean scores but also reduced individual variability — a hallmark of effective educational interventions that support weaker performers disproportionately [6]. Pre-test V% values of 62–82% are consistent with developmental norms for memory at this age [7]; post-test reductions to 33–40% confirm progressive convergence toward age-normative performance.

Table 5. Coefficient of Variation (V%) change from pre-test to post-test — Experimental Groups

Group	V% T1 Pre	V% T2 Pre	V% T4 Post	V% T5 Post	Net Δ V%	Interpretation
Fergana City EG	69.1%	52.8%	34.3%	34.2%	**-34.8 pp**	Normalisation
Quva District EG	62.5%	33.6%	40.3%	38.7%	**-23.8 pp**	Normalisation
Fergana District EG	81.6%	63.8%	39.3%	32.4%	**-49.2 pp**	Strong normalisation
Yozyovon District EG	72.6%	47.6%	37.6%	33.4%	**-39.2 pp**	Normalisation

Note: pp = percentage points. Values shown for T1 Pre, T2 Pre (highest initial dispersion) and T4 Post, T5 Post (post-intervention level).

3.7 Visual Summary: Gain and Progression Diagrams

Figure 1 illustrates the percentage memory score gains for all groups, demonstrating the consistent superiority of EG over CG across sites. Figure 2 traces the session-by-session progression of EG versus CG mean scores in Fergana city, illustrating the diverging trajectories from T1 post onwards.

Figure 1. Percentage memory score gain (%) from pre-test to post-test across all groups and sites

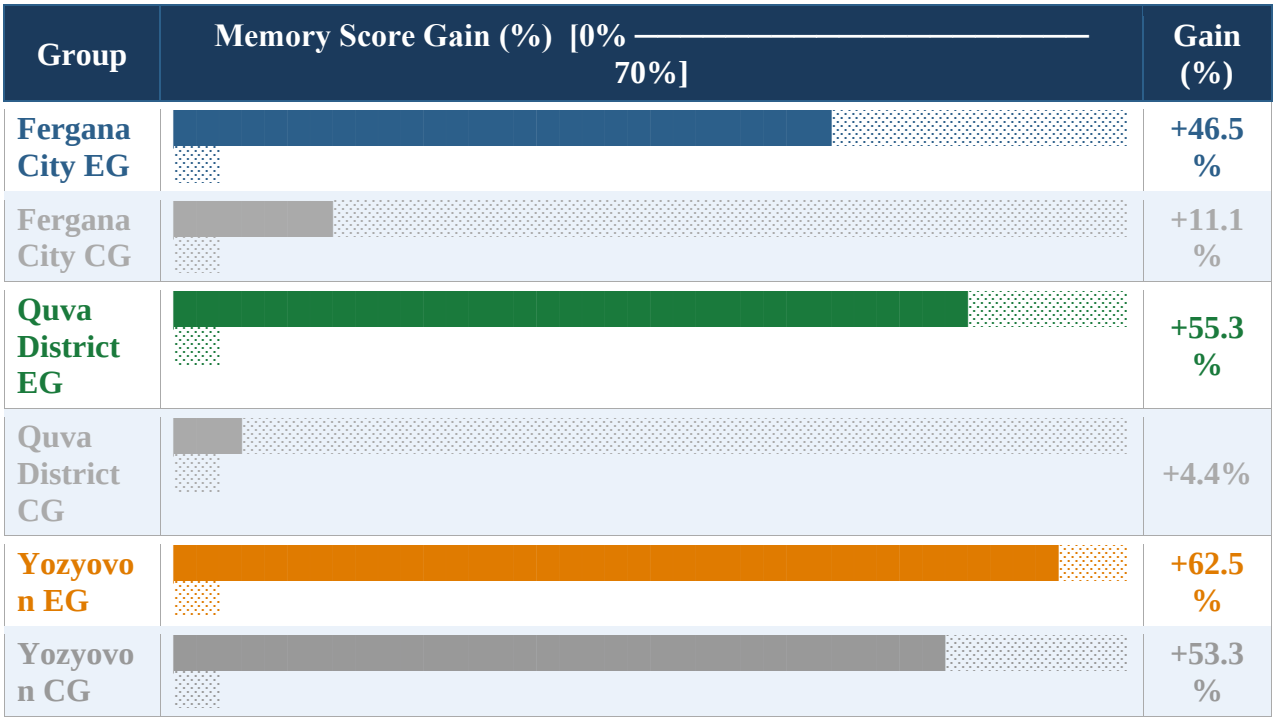
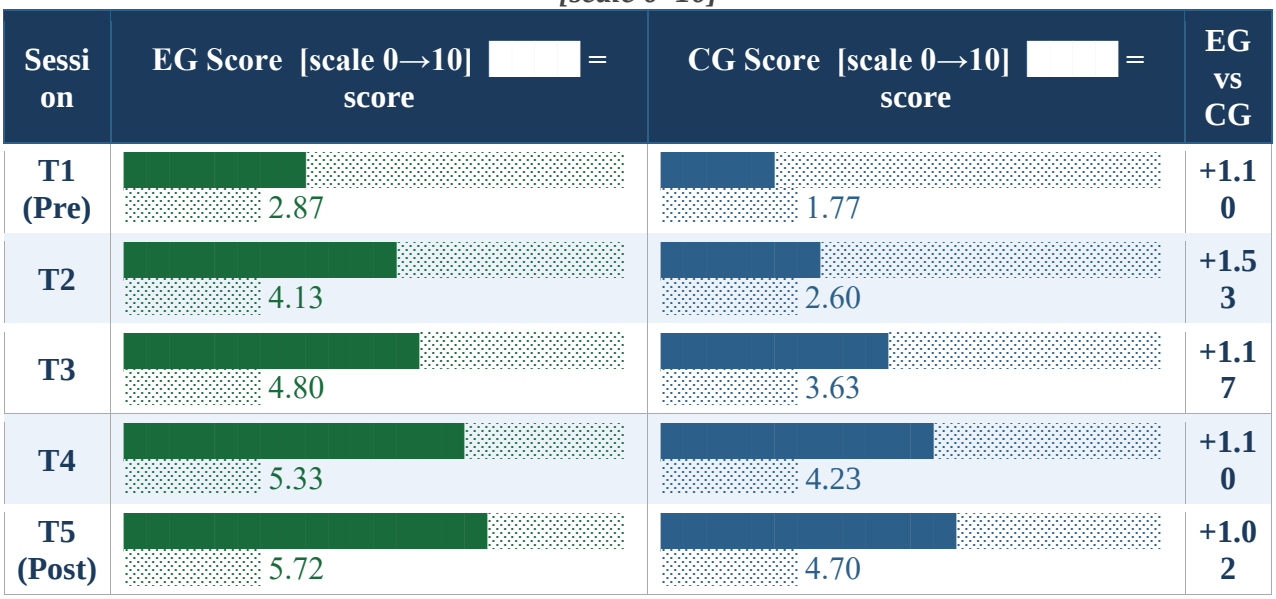


Figure 2. Session-by-session mean recall scores — Fergana City EG (green) vs. CG (blue) [scale 0–10]



4. DISCUSSION

The primary finding of this study is that the "Memory Development" methodology produced statistically significant and educationally meaningful improvements in recall capacity in 4–6 year-old preschool children at all four study sites, with percentage gains ranging from +46.5% (Fergana city) to +62.5% (Yozyovon district). These gains substantially exceeded those of control groups

receiving standard curricula, confirming the methodology's specific efficacy beyond maturation-related cognitive growth [1, 8].

The magnitude of the gains — approximately 45–65% improvement in mean recall score over the intervention period — is consistent with findings from structured early cognitive training programmes reported in international literature. Diamond and Lee [4] reviewed 15 childhood cognitive training studies and found that programmes incorporating progressive task difficulty, visual scaffolding, and repetition with variation produced gains of 30–70% in working memory tasks among 4–7 year-olds. The present methodology shares these design features: the five-task progression from simple recall to multi-item sequential memory provides both challenge and achievability, which maintains motivational engagement while incrementally expanding memory span [2].

The reduction in the coefficient of variation observed across all EG groups is a theoretically important secondary finding. High V% values (60–80%) at baseline reflect the well-documented individual variability in early memory development, which is influenced by language development, executive function maturation, and prior cognitive stimulation [7]. Post-test V% reductions to 33–40% suggest that the methodology was particularly beneficial for children with initially lower memory scores — a property essential for educational equity and consistent with zone of proximal development theory [3]. Control groups showed no comparable V% reductions, confirming that this homogenising effect is methodology-specific rather than developmental.

The relatively weaker initial EG–CG separation in Quva district (rural) at T1–T2 post-test, and its subsequent consolidation from T3, warrants interpretation. Rural children in Uzbekistan may enter structured cognitive tasks with lower familiarity with test formats and more limited prior exposure to explicit memory exercises in preschool settings, producing a latent onset of programme benefit [5]. By T3–T5, the Quva EG had fully caught up and surpassed the CG, suggesting that the methodology is effective but may require a slightly longer onboarding phase in rural contexts.

An important corroborating finding from our broader dissertation research is the positive correlation between children's physical fitness indicators — specifically breath-holding duration (Stange test) and coordination — and memory test performance. Children with higher functional readiness demonstrated consistently superior cognitive outcomes, consistent with neurophysiological evidence that cerebrovascular oxygenation mediates hippocampal memory consolidation [8]. This psychophysiological link strengthens the case for integrating structured physical activity alongside cognitive training in preschool curricula.

5. CONCLUSION

The "Memory Development" methodology significantly and consistently improved recall capacity in 4–6 year-old preschool children across urban and rural sites in the Fergana region of Uzbekistan. EG children improved by 46–63% compared to 4–53% in CG, with EG–CG differences reaching statistical significance ($p<0.05$) at all primary sites. The methodology additionally reduced within-group variability, demonstrating equitable effectiveness across children of varying initial ability. These results support the nationwide dissemination of this methodology in both urban and rural Uzbek preschool institutions as a feasible, teacher-delivered tool for enhancing early cognitive development.

Practitioners should note that rural preschool children may require an additional two to three sessions of familiarisation before full programme effects manifest. Future research should employ standardised neuropsychological test batteries (e.g., NEPSY-II), include parental cognitive stimulation indices as covariates, and use accelerometry to objectively quantify the physical activity component of psychophysiological readiness.

REFERENCES

1. Baddeley, A. D., Eysenck, M. W., & Anderson, M. C. (2020). Memory (3rd ed.). Psychology Press. https://doi.org/10.4324/9781003150541 [GOST: Baddeley A.D., Eysenck M.W., Anderson M.C. Memory. 3-e izd. London: Psychology Press, 2020. 376 s.]

2. Gathercole, S. E., & Alloway, T. P. (2008). Working Memory and Learning: A Practical Guide for Teachers. SAGE Publications. [GOST: Gathercole S.E., Alloway T.P. Working Memory and Learning: A Practical Guide for Teachers. London: SAGE Publications, 2008. 144 s.]
3. Yusupova, M. R., & Xoliqov, A. B. (2022). Cognitive development of preschool children in Uzbekistan: challenges and prospects. Pedagogika va psixologiya, 3(1), 22–31. [GOST: Yusupova M.R., Xoliqov A.B. Cognitive development of preschool children in Uzbekistan // Pedagogika va psixologiya. 2022. T. 3, № 1. S. 22–31.]
4. Diamond, A., & Lee, K. (2011). Interventions shown to aid executive function development in children 4 to 12 years old. Science, 333(6045), 959–964. https://doi.org/10.1126/science.1204529 [GOST: Diamond A., Lee K. Interventions shown to aid executive function development in children 4 to 12 years old // Science. 2011. Vol. 333, № 6045. S. 959–964.]
5. Voronova, M. N. (2019). Osobennosti razvitiya pamyati u detey doshkol'nogo vozrasta v selskikh usloviyakh [Features of memory development in preschool children in rural settings]. Doshkol'naya pedagogika, 7, 18–23. [GOST: Voronova M.N. Osobennosti razvitiya pamyati u detey doshkol'nogo vozrasta v selskikh usloviyakh // Doshkol'naya pedagogika. 2019. № 7. S. 18–23.]
6. Hattie, J. (2009). Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement. Routledge. [GOST: Hattie J. Visible Learning: A Synthesis of Over 800 Meta-Analyses Relating to Achievement. London: Routledge, 2009. 392 s.]
7. Flavell, J. H., Miller, P. H., & Miller, S. A. (2002). Cognitive Development (4th ed.). Prentice Hall. [GOST: Flavell J.H., Miller P.H., Miller S.A. Cognitive Development. 4-e izd. New Jersey: Prentice Hall, 2002. 356 s.]
8. Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). Be smart, exercise your heart: exercise effects on brain and cognition. Nature Reviews Neuroscience, 9(1), 58–65. https://doi.org/10.1038/nrn2298 [GOST: Hillman C.H., Erickson K.I., Kramer A.F. Be smart, exercise your heart: exercise effects on brain and cognition // Nature Reviews Neuroscience. 2008. Vol. 9, № 1. S. 58–65.]