

Improving Critical Thinking and Self-Confidence of Elementary Students through a Constructivist GASING Method Across School Levels

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ABSTRACT

Critical thinking and self-confidence are cognitive and affective competencies elementary students need, yet both remain underdeveloped in Indonesian mathematics classrooms. This study examined the effect of the GASING (Gampang, Asyik, Menyenangkan) method, integrated with a constructivist approach, on fifth-grade students' critical thinking skills and self-confidence in multiplication, and tested whether these effects differed across school levels. A quasi-experimental, one-group time-series design was used with 94 students purposively sampled from five public elementary schools in Kubutambahan District, Bali, representing high, medium, and low school levels. Students completed three repeated pretests, received treatment through GASING's concrete, abstract, and mental-arithmetic stages embedded in a constructivist sequence, and completed three repeated posttests using expert-validated instruments. Paired-samples t-tests showed statistically significant, very-large improvements in both critical thinking, $t(93) = 26.40$, $p < .001$, $d = 2.72$, $N\text{-Gain} = 0.57$, and self-confidence, $t(93) = 39.99$, $p < .001$, $d = 4.12$, $N\text{-Gain} = 0.69$. One-way ANOVAs revealed significant differences in gain across school levels for both outcomes: for critical thinking, medium-level schools gained significantly more than high-level schools, $F(2, 91) = 4.27$, $p = .017$; for self-confidence, both high- and medium-level schools gained significantly more than the low-level school, $F(2, 91) = 16.01$, $p < .001$. Non-parametric robustness checks corroborated all findings. These results confirm the effectiveness of the GASING-constructivist method for developing both competencies, while showing that the magnitude of benefit is moderated differently by school-level context, a nuance rarely examined in prior GASING research.

Keywords: GASING Method, Constructivism, Critical Thinking, Self-Confidence, Elementary Mathematics

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INTRODUCTION

Critical thinking and self-confidence are two foundational competencies elementary students need to navigate the complexity of twenty-first-century learning. Critical thinking equips students to analyze information logically, evaluate evidence, and make reasoned decisions rather than relying on memorized procedures (Wati et al., 2025; Susanti & Rohman, 2025; Solichin & Tyas, 2025; Latifah et al., 2024). Self-confidence, in turn, gives students the courage to participate actively, attempt new strategies, and voice their reasoning without excessive fear of being judged negatively (Hidayati, 2020; Sari & Wulandari, 2021; Hastuti, 2019; Rahmawati & Ningsih, 2022). The two competencies are theoretically intertwined: confidence gives students the courage to voice the results of their critical reasoning openly (Melyana & Pujiastuti, 2020), while confidence unsupported by sound reasoning can produce unfounded

beliefs (Rohmat & Lestari, 2019). Consistent with this view, students with stronger self-confidence have been found better able to articulate critical, reflective ideas (Safitri & Sutiarso, 2023).

Despite their importance, both competencies remain underdeveloped among Indonesian elementary students. The Programme for International Student Assessment (PISA) 2022 reported an average mathematics score of only 366 points for Indonesian 15-year-olds, well below the OECD average of 472 points in mathematics. Only 18% of Indonesian students reached minimum proficiency, compared with 69% across OECD countries (OECD, 2023). Indonesia's 2024 National Assessment similarly found that most students had not attained competence in tasks requiring conceptual understanding and logical reasoning (Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2024). Several studies confirm that Indonesian elementary students' critical thinking skills generally range from low to moderate (Diatmika & Sudirman, 2025; Sutrisno & Jazuli, 2022; Permana, 2018; Sariaman et al., 2021; Nurnaningsih et al., 2023). In parallel, low self-confidence has been linked to reduced classroom participation and reluctance to share ideas openly (Novita, 2021; Puspitasari et al., 2022; Hamama & Ratri, 2021).

A preliminary study conducted by the researcher, involving a questionnaire distributed to eight fifth-grade teachers representing eight school clusters in Kubutambahan District, Buleleng Regency, Bali, confirmed both problems locally. Every responding teacher reported that more than 20% of their students struggled with multiplication, with difficulty increasing sharply as problem complexity increased. Specifically, 50% of teachers reported that more than 80% of their students still struggled with two-digit-by-two-digit multiplication. Teachers also reported low scores for students' ability to explain their reasoning logically and to solve problems using more than one method. Half of the teachers (50%) further reported that students tended to avoid trying again after answering incorrectly in front of the class. Teachers attributed these problems primarily to weak mastery of basic multiplication concepts (62.5%) and fear of making mistakes (37.5%). They also noted that instruction remained dominated by drill and rote memorization (75%) rather than by opportunities for students to explain or evaluate their own reasoning.

This instructional pattern-emphasizing correct final answers over the exploration of reasoning, and right-or-wrong judgments over supportive risk-taking-has been identified as a barrier to both critical thinking and self-confidence development (Sanjaya, 2021; Fauziah, 2019; Sulaiman & Hasanah, 2020; Hidayati & Susanto, 2020). One instructional approach with growing empirical support for addressing both gaps simultaneously is the GASING method (Gampang, Asyik, Menyenangkan-Easy, Fun, and Enjoyable), developed by Yohanes Surya and grounded in constructivist principles (Surya, 2013; Suyudi, 2022). GASING guides students through three sequential stages-concrete, abstract, and mental arithmetic (*mencongak*)-so that students come to understand why a mathematical procedure works, building understanding progressively rather than through memorization. Prior studies report that GASING improves mathematics learning outcomes. It has also been found to foster critical thinking, abstract reasoning, and analytical skills (Agusfian & Pratiwi, 2022; Amtiran et al., 2024; Hidayah et al., 2024; Maharudin et al., 2026; Sihombing et al., 2026; Gusmara et al., 2025), and to help students feel more confident attempting problems and participating actively in class (Devi, 2024; Matahelumual, 2025; Widodo & Turmudi, 2017). A systematic review of 26 GASING studies (2019-2025) found that its enjoyable learning climate strengthens students' mathematics-related confidence and self-efficacy, though GASING's integration with critical thinking outcomes remains comparatively limited (Tartillah et al., 2025).

In this study, GASING was combined with a constructivist approach grounded in Piaget's (1970) and Vygotsky's (1978) view that knowledge is actively built through direct experience, exploration, and social interaction. Constructivist instruction has been shown to foster critical thinking through active engagement with problems (Firdaus et al., 2023) and to nurture confidence, initiative, and responsibility in learning (Mutiarawati, 2019). However, most prior research examines GASING's cognitive benefits and constructivism's role in building confidence as separate strands, addressing critical thinking and self-confidence in isolation from

one another (Marini & Hamidah, 2020). Such research also typically treats samples as homogeneous rather than examining whether treatment effects differ across schools with differing numeracy achievement levels (Gesiradja et al., 2025; Moan et al., 2026). Pratiwi et al. (2026) further cautioned that the structural alignment between GASING and constructivist, critical pedagogy does not automatically guarantee genuine critical thinking transformation, underscoring the need for direct empirical verification rather than theoretical assumption.

The novelty of this study lies in its joint examination of both a cognitive competency (critical thinking) and an affective competency (self-confidence) within a single constructivist GASING intervention, and in testing whether the resulting gains are moderated by school-level context—a comparison largely absent from prior GASING literature, which has treated samples as homogeneous. Building on this gap, the present study investigated the effect of the GASING method based on a constructivist approach on fifth-grade elementary students' critical thinking skills (H1) and self-confidence (H2) in multiplication, and examined whether the improvement in each competency differed across school levels—high, medium, and low (H3 for critical thinking; H4 for self-confidence). Four hypotheses were tested: H1, the GASING-constructivist method significantly improves students' critical thinking skills; H2, the GASING-constructivist method significantly improves students' self-confidence; H3, critical thinking improvement differs significantly across school levels; and H4, self-confidence improvement differs significantly across school levels.

Critical thinking in mathematics is commonly operationalized through indicators such as interpreting a problem, analyzing information, drawing logical inferences, evaluating the reasonableness of a solution, and explaining the strategy used (Ennis, 1985; Fisher, 2008). Self-confidence, meanwhile, is commonly understood through indicators such as the courage to share opinions without hesitation (Puspitasari et al., 2022) and belief in one's own capability to complete tasks successfully (Yuliati & Susianna, 2023). On the cognitive side, GASING has improved mathematics learning outcomes generally (Kusuma et al., 2018; Lestari & Hardini, 2022; Maulida et al., 2024), improving conceptual understanding of two-digit multiplication among sixth-grade students by 17.7% relative to conventional instruction (Lestari & Hardini, 2022), producing a high normalized gain ($N\text{-Gain} = 0.77$) in arithmetic skills (Sihombing et al., 2026), and significantly predicting numeracy competence ($R^2 = 0.688$) across 203 students in four Indonesian regions (Gusmara et al., 2025). On the affective side, GASING combined with the traditional Balinese game Megowak-gowakan reduced students' mathematics anxiety with a moderate effect (Mahendra & Dewi, 2026), and a systematic review confirmed that GASING's enjoyable climate strengthens mathematics-related self-efficacy (Tartillah et al., 2025). Constructivism, grounded in Piaget's (1970) and Vygotsky's (1978) accounts of active, experience-based, and socially mediated learning, provides the theoretical scaffold connecting GASING's stepwise pedagogy to both outcomes, having been shown to build critical thinking through active exploration of problems (Firdaus et al., 2023) and to strengthen self-confidence, initiative, and responsibility for learning (Mutiarawati, 2019).

METHOD

This study used a quantitative approach with a quasi-experimental, one-group time-series design. Unlike randomized experiments, quasi-experimental designs do not involve full randomization of subjects to conditions. They still incorporate a treatment, an outcome measurement, and a defined experimental unit, which makes them well suited to authentic classroom settings where full randomization is rarely feasible (Hastjarjo, 2019; Abraham & Supriyati, 2022). In the time-series variant used here, an intact group was measured repeatedly before treatment to establish the stability of the baseline, received the treatment, and was then measured repeatedly again afterward (Arib et al., 2024), which helps rule out common threats to internal validity such as history and maturation. Participants were 94 fifth-grade students drawn from five public elementary schools in Kubutambahan District, Buleleng Regency, Bali Province, out of a population of fifth-grade students across 45 schools in the district. Schools were selected using purposive sampling on the criteria that students had already studied whole-number operations (multiplication and division) and that schools varied in numeracy

achievement level, allowing the study to examine whether treatment effects differed by school context. Based on each school's numeracy score in the 2025 Asesmen Nasional Berbasis Komputer (ANBK, Indonesia's national computer-based assessment) report, the five schools were grouped into three levels-high ("baik"), medium ("sedang"), and low ("kurang")-yielding 38 students from two high-level schools, 36 students from two medium-level schools, and 20 students from one low-level school (total N = 94).

Critical thinking skills were measured using a written essay test comprising ten contextual multiplication problems, developed based on Ennis's (1985) and Fisher's (2008) critical thinking indicators-interpreting the problem, analyzing information, drawing logical conclusions, and evaluating or explaining the solution strategy used. Self-confidence was measured using a closed-ended questionnaire employing a five-point Likert scale comprising 20 statements across five indicators: courage to express opinions, confidence in one's own ability, readiness to face learning challenges, a positive attitude toward criticism and feedback, and consistency in pursuing learning goals. Three parallel forms of each instrument were used across the repeated sessions. Critical thinking raw scores were converted to a 0-100 scale; self-confidence used the total raw Likert score (range 20-100). Content validity for both instruments was established through expert judgment: two validators rated every critical thinking item as fully appropriate following revision (content validity index = 100%), and the self-confidence questionnaire's validator rated all 20 statements as relevant without revision (content validity index = 100%). The internal consistency of the critical thinking instrument was estimated from field-test data (n = 40 students, 15 trial items) using Cronbach's (1951) alpha coefficient, yielding a value of .995, with corrected item-total correlations ranging from .90 to .98; based on this field test, the instrument was refined to the ten items used in the main study. A readability trial with an independent group of 40 students indicated that the self-confidence questionnaire's language was well understood, with a mean readability score of 2.49 out of 3.00 across 800 item-responses.

The study proceeded through six stages, illustrated in Figure 1. First, instruments were developed and validated by experts; second, instruments were piloted with a group outside the main sample; and third, three repeated pretests were administered on both constructs to establish baseline stability. Fourth, in the treatment stage, students received mathematics instruction on multiplication using the GASING method integrated with a constructivist approach, progressing through the concrete, abstract, and mental-arithmetic (mencongak) stages while emphasizing active knowledge construction, low-stakes exploration, peer collaboration, and reflection. Fifth, three repeated posttests were administered using indicators identical to the pretest; and sixth, the resulting data were analyzed and reported. For each construct, each student's three repeated pretest scores and three repeated posttest scores were averaged into a single pretest and posttest score. Descriptive statistics were computed, and the normality of each gain-score distribution was assessed using the Shapiro-Wilk test, with homogeneity of variance across school-level groups assessed using Levene's test. Paired-samples t-tests were used to test H1 (critical thinking) and H2 (self-confidence), with effect sizes expressed as Cohen's d and normalized gain scores (N-Gain) interpreted following Hake's (1998) categories (low < 0.3, medium 0.3-0.7, high > 0.7). One-way ANOVAs were used to test H3 and H4, followed by Tukey's HSD post hoc tests where significant. Non-parametric Wilcoxon signed-rank and Kruskal-Wallis tests were additionally computed as robustness checks given modest deviations from normality. All analyses were conducted using Python (SciPy and statsmodels libraries).

Figure 1. One-Group Time-Series Research Procedure.

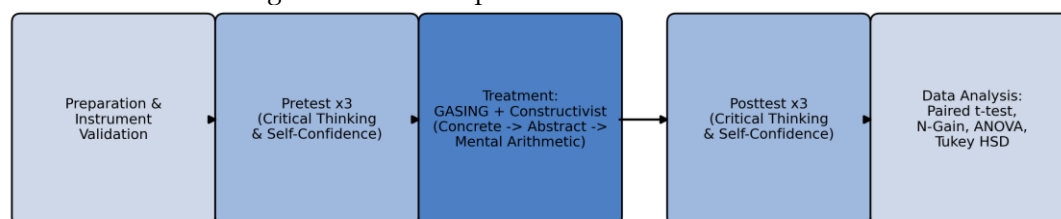


Table 1 and Figure 2 present the descriptive statistics for students' critical thinking and self-confidence scores before and after the GASING-constructivist treatment. Critical thinking scores rose from a pretest mean of 25.78 (SD = 5.80) to a posttest mean of 67.64 (SD = 16.18), while self-confidence scores rose from a pretest mean of 49.55 (SD = 8.15) to a posttest mean of 84.69 (SD = 4.45).

Table 1. Descriptive Statistics of Critical Thinking and Self-Confidence Scores

Measure	N	Mean	SD
Critical thinking - Pretest (0-100)	94	25.78	5.80
Critical thinking - Posttest (0-100)	94	67.64	16.18
Self-confidence - Pretest (20-100)	94	49.55	8.15
Self-confidence - Posttest (20-100)	94	84.69	4.45

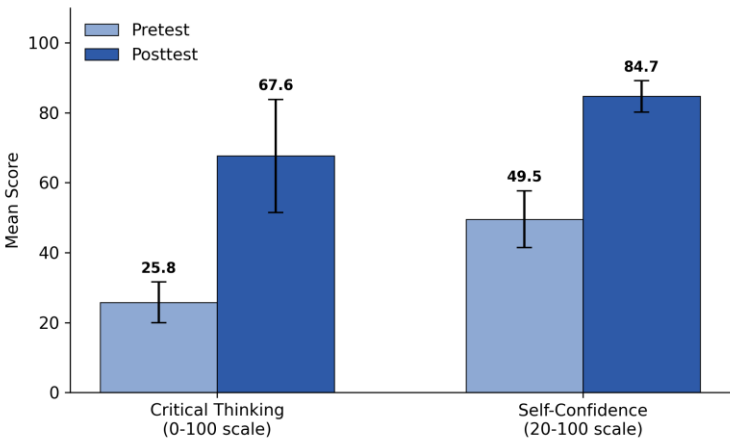


Figure 2. Pretest and Posttest Means for Critical Thinking and Self-Confidence (Error Bars = SD).

The Shapiro-Wilk test indicated a modest deviation from normality in the critical thinking gain-score distribution ($W = 0.972$, $p = .041$) and a clearer deviation for self-confidence ($W = 0.957$, $p = .004$); given the adequate sample size ($N = 94$), paired-samples t -tests were nonetheless used and cross-checked with non-parametric equivalents. The paired-samples t -test showed a statistically significant increase in critical thinking scores, $t(93) = 26.40$, $p < .001$, with a mean gain of 41.86 points and a very large effect size (Cohen's $d = 2.72$); the average normalized gain was 0.57 (Hake's medium category), and the Wilcoxon signed-rank test corroborated this result ($p < .001$). H1 was therefore supported. Similarly, the paired-samples t -test showed a statistically significant increase in self-confidence scores, $t(93) = 39.99$, $p < .001$, with a mean gain of 35.14 points and a very large effect size (Cohen's $d = 4.12$); the average normalized gain was 0.69, at the upper end of Hake's medium category. The Wilcoxon signed-rank test again corroborated this result ($p < .001$), and H2 was supported.

These findings are consistent with, and extend, prior research that has generally examined GASING's cognitive and affective benefits separately (Kusuma et al., 2018; Lestari & Hardini, 2022; Devi, 2024; Widodo & Turmudi, 2017; Tartillah et al., 2025). A plausible shared mechanism is GASING's stepwise progression from concrete manipulation to abstract representation to mental computation. This progression may scaffold the reasoning processes underlying critical thinking-analyzing structure, testing strategies, evaluating answers-while giving students repeated, incremental experiences of success that build confidence in their own capability, consistent with constructivist emphases on active exploration and reflection (Firdaus et al., 2023; Mutiarawati, 2019).

Table 2. Normalized Gain by School Level for Critical Thinking and Self-Confidence

School Level	n	Critical Thinking N-Gain (SD)	Self-Confidence N-Gain (SD)
High	38	0.495 (0.190)	0.714 (0.091)

Medium	36	0.629 (0.224)	0.720 (0.071)
Low	20	0.590 (0.175)	0.595 (0.099)

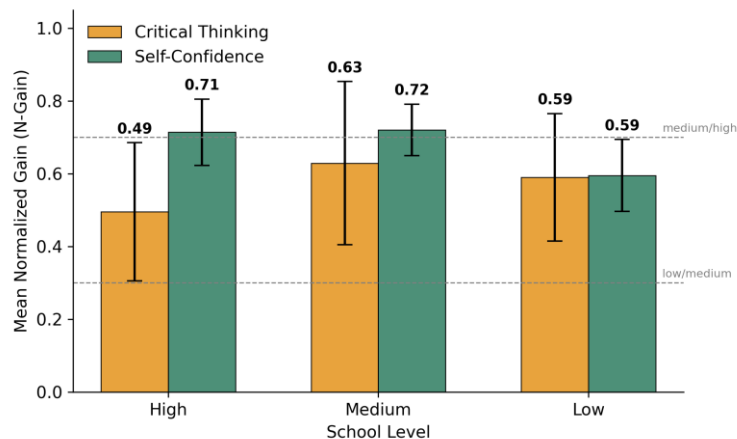


Figure 3. Mean Normalized Gain by School Level for Critical Thinking and Self-Confidence.

Table 2 and Figure 3 summarize normalized gain by school level for both constructs, and Figure 4 displays the full distribution of individual gains. Levene's test indicated homogeneity of variance for critical thinking gain ($F = 1.34$, $p = .268$). A one-way ANOVA showed a statistically significant difference in critical thinking normalized gain across school levels, $F(2, 91) = 4.27$, $p = .017$. Tukey's HSD post hoc comparisons indicated that students from medium-level schools achieved significantly higher gains than students from high-level schools (mean difference = 0.134, $p = .014$), while the low-level school did not differ significantly from either group ($p = .211$ and $p = .761$, respectively). The Kruskal-Wallis test confirmed this group difference ($H = 8.10$, $p = .017$), supporting H3.

For self-confidence, Levene's test again indicated homogeneity of variance ($F = 0.88$, $p = .419$), and a one-way ANOVA showed a statistically significant difference across school levels, $F(2, 91) = 16.01$, $p < .001$. Tukey's HSD comparisons indicated that both high-level schools (mean difference = 0.119, $p < .001$) and medium-level schools (mean difference = 0.125, $p < .001$) achieved significantly higher gains than the low-level school, while high- and medium-level schools did not differ from each other ($p = .942$). The Kruskal-Wallis test confirmed this difference ($H = 23.84$, $p < .001$), supporting H4. Table 3 summarizes the decisions for all four hypotheses.

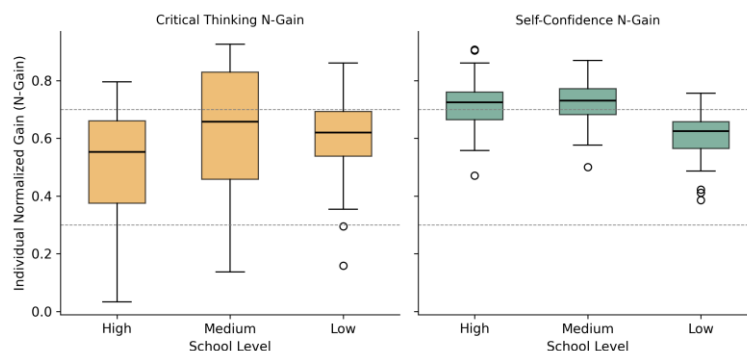


Figure 4. Distribution of Individual Normalized Gains by School Level.

Table 3. Summary of Hypothesis Testing Results

Hypothesis	Test	Statistic	P	Decision
H1: GASING-constructivist improves critical thinking	Paired t-test	$t(93) = 26.40$	$< .001$	Supported
H2: GASING-constructivist improves self-confidence	Paired t-test	$t(93) = 39.99$	$< .001$	Supported
H3: Critical thinking gain differs by school level	One-way ANOVA	$F(2,91) = 4.27$	.017	Supported

H4: Self-confidence gain differs by school level	One-way ANOVA	$F(2,91) = 16.01$	$< .001$	Supported
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The pattern of school-level differences diverged between the two outcomes. For critical thinking, medium-level schools gained significantly more than high-level schools, plausibly reflecting a ceiling effect in which academically stronger students began closer to the instrument's upper bound, leaving proportionally less room for measurable gain. For self-confidence, by contrast, both high- and medium-level schools outgained the low-level school, plausibly because students in the low-level school entered the study with more substantial gaps in foundational multiplication concepts-consistent with the preliminary teacher survey identifying weak conceptual mastery as the most frequently cited cause of low confidence-so that a comparable dose of treatment translated into a smaller confidence gain within the same intervention period, even though a clear positive gain was still observed. This divergence suggests that critical thinking and self-confidence, while both responsive to the GASING-constructivist intervention, are moderated by school-level context through partly different mechanisms. Treating them as a single undifferentiated outcome package, as much prior GASING research implicitly does, may therefore obscure practically important differences in how and for whom the intervention works best. These results should be interpreted within the bounds of the study's design. As a one-group time-series design without a comparison group, the study cannot fully rule out alternative explanations for the observed gains, such as maturation or general classroom practice effects, although the use of three repeated pretest and three repeated posttest administrations with parallel instrument forms offers some protection against testing-effect artifacts (Hastjarjo, 2019; Abraham & Supriyati, 2022). The study was also confined to a single mathematical topic (multiplication) over a relatively short intervention window, and the low-level group was represented by a single school ($n = 20$), so school-level and individual-level variance cannot be fully disentangled. Consistent with Pratiwi et al.'s (2026) caution, a significant quantitative gain in test or questionnaire scores does not by itself confirm that students' critical thinking or self-confidence was transformed in a deep and durable sense; qualitative or longitudinal follow-up would be needed to substantiate this further.

CONCLUSION

This study provides quasi-experimental evidence that the GASING method, implemented with a constructivist approach, significantly improved fifth-grade elementary students' critical thinking skills and self-confidence in multiplication, both with very large effect sizes. The magnitude of improvement in each competency, however, was moderated differently by school level: medium-level schools benefited most for critical thinking, whereas high- and medium-level schools both outperformed the low-level school for self-confidence. These findings matter because they show that teachers can reasonably expect the GASING-constructivist approach to strengthen both competencies, while also indicating that support may need to be calibrated differently depending on which competency is prioritized and on students' starting school context-particularly through additional conceptual scaffolding for students in lower-performing schools. Future research using a randomized or matched-control design across a broader range of mathematical topics, together with process-level data, would help confirm and explain the differential effects observed here.

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