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Impact of Multisensory Distractions on Motor Performance in Children with Developmental Coordination Disorder: A Cross-Sectional Analysis

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Abstract*:* Background: Children with Developmental Coordination Disorder (DCD) face significant motor coordination challenges, which are often worsened by sensory distractions in their environment, exposing children to various health risks. **Objective*:*** This study aimed to examine the effects of multisensory input (visual, auditory, and combined stimuli) on motor performance in children with DCD compared to typically developing (TD) children. Methods: A cross-sectional study was conducted with 88 children aged 8-12 years, including 44 diagnosed with DCD and 44 TD children. Participants performed three real-world tasks under four sensory conditions: baseline, visual perturbation, auditory augmentation, and multisensory stimulation. The primary outcomes measured were movement onset, movement time, and success rate. Results: Children with DCD demonstrated significant delays in movement onset, increased movement times, and reduced success rates under all sensory conditions, with the largest impairments observed under the multisensory condition. In contrast, TD children showed minimal changes in performance across the sensory conditions. Conclusion: Children with DCD are highly sensitive to sensory overload, which significantly impairs their motor performance. These findings underscore the need for interventions that reduce sensory distractions to improve motor coordination and functional independence in children with DCD. Future research should focus on the long-term effects of sensory overload and explore therapeutic strategies aimed at enhancing sensory processing in DCD.

Keywords: Developmental Coordination Disorder, Sensory Distractions, Motor Performance, Multisensory Integration, Sensory Overload.

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INTRODUCTION

Children with Developmental Coordination Disorder (DCD) face significant challenges in performing tasks that require motor coordination, particularly when they are exposed to distracting environments. One of the most critical aspects of DCD is the disruption in their balance and motor control, which is further exacerbated in environments filled with visual and auditory distractions. This imbalance is not only prevalent in structured, clinical settings but also in everyday tasks such as walking, catching, and even simple movements like handling objects. Balance disorders are reported to be a key issue for children with DCD, impacting their ability to perform daily activities efficiently (1). The disturbances in their motor coordination can affect a wide range of activities, making them more susceptible to accidents, difficulties in learning physical skills, and social isolation. (2,3) The prevalence of balance difficulties in children with DCD is well-documented. Studies have shown that children with DCD exhibit significant impairments in dynamic balance tasks such as walking and catching balls, with performance often worsened by environmental challenges (4). These children struggle with the integration of sensory inputs, including vision, proprioception, and auditory signals, which are critical for maintaining balance and coordinating movements (5). External distractions, such as sudden visual and auditory stimuli, can hinder their ability to respond to tasks requiring precise motor actions. For instance, in complex tasks like ball interception or navigating crowded spaces, the combined effect of visual and auditory distractions significantly impacts their movement timing, accuracy, and overall task performance (6) The sensory challenges faced by children with DCD include difficulty in filtering out irrelevant sensory information from their surroundings. When these children are presented with conflicting or excessive stimuli, it can impair their sensory processing, leading to errors in motor execution (7). For example, while attempting a simple task like catching a ball, the introduction of visual stimuli, such as flashing lights, or auditory disruptions, such as loud sounds, can delay their reaction times, affect their precision, and lead to unsuccessful outcomes (8). These difficulties are not just isolated to visual or auditory distractions, as multisensory perturbations can be especially challenging. When both visual and auditory cues are altered or enhanced simultaneously, the ability of children with DCD to perform the task accurately is significantly diminished (9). Recent studies have examined how children with DCD perform under different sensory conditions. For instance, research by Gao et al. (2025) investigated how environmental distractions, such as flickering lights or dynamic background noises, affect the task performance of children with DCD compared to typically developing (TD) children. (10)The study revealed that the DCD group showed marked delays in response times and higher failure rates when exposed to multisensory distractions. This finding emphasizes the delicate balance between sensory integration and motor function in children with DCD and suggests that their performance in real-world tasks is susceptible to changes in their sensory environment (11). Similarly, a study highlighted that even typical children show a decline in task performance under conditions involving sensory overload. (12) However, children with DCD exhibit more pronounced difficulties, especially when tasked with combining multiple actions, such as walking and catching a moving object. The study used controlled environments to simulate real-world challenges, where distractions were introduced to assess their impact on task execution. Children with DCD performed significantly worse than their TD peers in these conditions, supporting the notion that balance and coordination difficulties in DCD are compounded by complex sensory inputs. Understanding how these sensory disruptions impact motor control is crucial for developing effective interventions and supporting children with DCD in everyday settings. Some research has focused on how specific sensory conditions affect children with DCD's ability to maintain balance.(13) For example, sensory manipulation, such as the addition of visual stimuli in the form of moving lights, or auditory cues like spatialized sounds, has been shown to interfere with balance and motor accuracy in children with DCD. Studies also suggest that specific sensory challenges, like visual or auditory overload, could exacerbate the balance problems children with DCD already face, highlighting the need for interventions that minimize sensory distractions during motor tasks (5). Given the critical role of balance in a child's ability to perform everyday tasks, it is important to understand the precise ways in which sensory inputs—whether visual, auditory, or both—affect motor planning and coordination. This study aims to build on previous research by exploring how multisensory manipulation—using visual and auditory distractions—affects movement trajectory and timing strategies in children with DCD. Through a series of real-world tasks involving both static and dynamic balance, the study seeks to understand how these children respond to complex, distraction-filled environments and the resultant impact on their movement efficiency and success rates.

METHODOLOGY

This cross-sectional analytical study was designed to investigate how multisensory interception influences movement trajectory and timing strategies in children with DCD compared to TD peers. This study was conducted in three selected areas in Bangalore, India from February 2024 to July 2024. A total of eighty-eight children between 8 and 12 years of age were recruited, with forty-four children clinically identified with DCD according to DSM-5 criteria and/or scoring below the fifth percentile on the movement assessment battery for children-2 (MABC-2), and forty-four age- and sex-matched TD children who scored within the normative range. Participants were excluded if they had neurological or orthopedic disorders, uncorrected visual or auditory impairments, or any condition interfering with safe task performance. After obtaining institutional ethics approval from Madhav University, India (). Written parental consent, was obtained after demonstration of the task and challenges to parents and after ensuring their satisfaction on safety measures. Each child performed THREE real-world timing tasks: (1) a stationary ball-catching task in which a soft foam ball was projected toward the child from a distance of 3–4 m using a pendulum type arrangement where the ball was suspended in a thread from ceiling, (2) a walking interception task requiring the child to walk along an 8 m walkway while intercepting a laterally moving foam ball suspended from ceiling (8 numbers) without stopping their gait and touching the balls. (3) walking for a distance of 10 M while tossing a ball from one hand to the other. All the three tasks were performed under four randomized sensory conditions designed to manipulate sensory input: baseline (normal ambient visual and auditory environment), visual perturbation (Using LED projectors visual distractors were projected on the wall with flickering different colour lights illuminating the room), auditory augmentation (distracting dynamic, spatialized sounds were played with sounds mimicking sound of an object passing through stereo speakers), and a combined multisensory condition where both auditory and visual manipulations were applied simultaneously. For each task, participants completed approximately 15–20 trials per condition for the stationary task and 10-15 trials per condition for the walking task, preceded by familiarization trials to reduce novelty and learning effects. The order of conditions was counterbalanced across participants using a Latin-square design to minimize order bias, and short breaks were provided between blocks to prevent fatigue. All trials were recorded simultaneously by two high-resolution digital cameras (20 megapixels) positioned in sagittal and frontal planes. All throws or projections followed standardized speed ranges verified from preliminary recordings to ensure consistency across conditions. The primary outcome variables extracted from video data included movement onset latency (time from ball release or sound onset to initial hand acceleration), movement time, and overall success rate. Secondary outcomes comprised of wight displacement trajectory on the sensor board for the 2nd task and gait velocity and cadence for task 3rd and 4th task. The first two task assessed the static balance and the next measuring the dynamic balance.

RESULTS

The study investigated the effects of multisensory input on movement and coordination in children with DCD compared to TD children. A total of 88 children participated, with 44 in each group, aged 8-12 years. Significant differences in task performance were observed between the groups under various sensory conditions. In the stationary ball-catching task (Task 1), children with DCD showed delayed movement onset and increased movement time across all sensory conditions compared to baseline. The largest delays occurred under the multisensory condition (473.2 ms for movement onset and 972.9 ms for movement time) (Table 2). Their success rate also decreased from 75.1% at baseline to 45.3% under the multisensory condition (Table 2). In contrast, TD children showed no significant differences in movement onset, time, or success rate under any sensory conditions (Table 3). In the walking interception task (Task 2), children with DCD exhibited significantly delayed movement onset and time, and their success rate dropped from 74.3% at baseline to 44.7% under the multisensory condition (Table 4). Gait velocity and cadence were significantly reduced in the multisensory condition, with gait velocity decreasing to 0.912 m/s (Table 4). TD children, however, showed minimal changes in performance across the sensory conditions (Table 6). In the walking and ball-tossing task (Task 3), DCD children again displayed delayed movement time and a decrease in success rate, with the largest impact under multisensory conditions, where their success rate dropped to 46.0% (Table 7). Gait velocity and cadence were also significantly reduced under multisensory conditions (Table 8). TD children exhibited no significant changes in any of the measured variables (Table 9). These findings emphasize that children with DCD are more sensitive to sensory overload, and minimizing such distractions could help improve their motor performance in everyday tasks.

Table 1 - Demographic Characteristics and Socioeconomic Status of Participants (DCD vs. TD Groups

Variable	DCD Group (n=44)	TD Group (n=44)	Test Statistic	p-value
Age (years)	9.8 ± 2.12	9.6 ± 1.1	t = 0.764	p = 0.446
Gender (M/F)	22 M / 22 F	22 M / 22 F	χ^2 = 0.000	p = 1.000

Socioeconomic Status (Kuppusamy)	Class I: 12, Class II: 15, Class III: 10, Class IV: 7	Class I: 14, Class II: 16, Class III: 9, Class IV: 5	$\chi^2 = 0.631$	$p = 0.727$
Location (Urban/Rural)	28 Urban / 16 Rural	30 Urban / 14 Rural	$\chi^2 = 0.124$	$p = 0.725$
Siblings (Yes/No)	38 Yes / 6 No	36 Yes / 8 No	$\chi^2 = 0.222$	$p = 0.638$
Working Status of Parents	One Employed: 10, Both: 20, Both Unemployed: 14	One Employed: 12, Both: 22, Both Unemployed: 10	$\chi^2 = 0.251$	$p = 0.882$
BMI (kg/m²)	18.9 ± 3.4	19.2 ± 3.0	$t = -0.435$	$p = 0.664$
DCD Q Score	16.3 ± 4.2	10.5 ± 2.3	$t = 9.422$	$p < 0.001$
MABC-2 Score (percentile)	3.5 ± 2.1	88.3 ± 6.4	$t = -30.64$	$p < 0.001$

Table 2— Task 1: DCD group - Stationary ball-catching (within-group analysis)

Measure	Baseline	Visual	Auditory	Multisensory	RM - ANOVA Results
Movement onset (ms)	321.3 ± 24.6	402.7 ± 34.1	361.4 ± 30.2	473.2 ± 50.7	$F = 142.6$, $p < 00.001$, Partial $\eta^2 = 0.81$
Movement time (ms)	802.1 ± 52.3	893.6 ± 61.8	855.2 ± 58.2	972.9 ± 80.1	$F = 120.4$, $p < 00.001$, Partial $\eta^2 = 0.79$
Success (%)	75.1 ± 6.0	57.3 ± 7.6	65.0 ± 6.8	45.3 ± 8.9	$F = 98.2$, $p < 0.001$, partial $\eta^2 = 0.75$

	Comparison	Mean Difference (ms)	t	Bonferroni-adjusted p
Movement onset (ms)	Baseline vs Visual	81.4	10.6	< 0.001
	Baseline vs Auditory	40.1	6.1	< 0.001
	Multisensory vs Baseline	151.9	14.8	< 0.001
	Multisensory vs Visual	69.5	7.5	< 0.001
	Multisensory vs Auditory	111.8	12.2	< 0.001
	Visual vs Auditory	41.3	5	< 0.001
Movement time (ms)	Baseline vs Visual	81.4	10.6	< 0.001
	Baseline vs Auditory	40.1	6.1	< 0.001
	Multisensory vs Baseline	151.9	14.8	< 0.001
	Multisensory vs Visual	69.5	7.5	< 0.001
	Multisensory vs Auditory	111.8	12.2	< 0.001
	Visual vs Auditory	41.3	5	< 0.001
Success (%)	Baseline vs Visual	–13.1	–8.4	< 0.001
	Baseline vs Auditory	–7.8	–5.9	< 0.001
	Multisensory vs Baseline	–19.2	–11.7	<

				0.001
	Multisensory vs Visual	–6.1	–4.6	< 0.001
	Multisensory vs Auditory	–11.4	–8.3	< 0.001
	Visual vs Auditory	–5.3	–3.9	< 0.001

Table 3 — Task 1: TD group - Stationary ball-catching (within-group Analysis)

Measure	Baseline	Visual	Auditory	Multisensory	RM - ANOVA Results
Movement onset (ms)	248.5 ± 18.4	258.5 ± 22.6	250.6 ± 21.0	364.5 ± 27.8	F = 1.82 P = 0.149 Partial η² =0.058
Movement time (ms)	603.1 ± 35.2	618.3 ± 40.5	612.2 ± 38.9	621.5 ± 45.2	F = 2.11 P = 0.103 Partial η² =0.061
Success (%)	90.2 ± 4.7	87.6 ± 5.1	88.1 ± 4.6	85.5 ± 6.3	F = 2.42 P = 0.094 Partial η² = 0.07

As there was no statistically significant difference across the group, post hoc analysis was not performed
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Table 4 — Task 2: DCD group - within-group analysis using Repeated measures ANOVA

Metric	Baseline	Visual	Auditory	Multisensory	RM - ANOVA Results
Movement onset (ms) Mean ± SD	322.8 ± 25.2	403.9 ± 33.9	362.1 ± 29.1	475.0 ± 51.3	F = **130.7**, *p* < 0.001, Partial η² = **0.80**.
Movement time (ms) Mean ± SD	810.0 ± 55.1	902.8 ± 63.0	862.0 ± 59.4	984.2 ± 82.0	F = **172.7**, *p* < 0.001, Partial η² = **0.82**.
Success (%) Mean ± SD	74.3 ± 6.2	56.9 ± 7.5	64.8 ± 7.0	44.7 ± 9.1	F = 68.7, *p* < 0.001, Partial η² = **0.68**.
Gait velocity (m/s) Mean ± SD	1.103 ± 0.082	1.017 ± 0.095	1.045 ± 0.08	0.912 ± 0.110	F= **26.2**, *p* < .001, Partial η² = **0.54**
Cadence (spm) Mean ± SD	115.1 ± 4.1	112.1 ± 5.2	113.4 ± 4.7	108.1 ± 6.3	F = 78.7, *p* < 0.001, Partial η² = **0.74**.

Table 5 — Task 2: DCD group - Post Hoc analysis using Bonferroni test

Table 6 — Task 2: TD group - within-group analysis using Repeated measures ANOVA

Metric	Baseline	Visual	Auditory	Multisensory	RM - ANOVA Results

Movement onset (ms)	249.8 ± 19.2	257.2 ± 24.0	252.5 ± 22.2	263.1 ± 29.0	F = 3.7, $p < 0.801$, Partial $\eta^2 = 0.40$.
Movement time (ms)	606.7 ± 36.1	618.5 ± 41.6	612.6 ± 39.8	624.0 ± 45.7	F = 4.27, $p < 0.651$, Partial $\eta^2 = 0.42$.
Success (%)	90.6 ± 4.8	86.2 ± 5.2	88.2 ± 4.2	82.9 ± 6.1	F = 2.75, $p < 0.871$, Partial $\eta^2 = 0.38$.
Gait velocity (m/s)	1.248 ± 0.069	1.242 ± 0.073	1.241 ± 0.071	1.234 ± 0.080	F= 0.72, $p < 0.921$, Partial $\eta^2 = 0.34$
Cadence (spm)	119.6 ± 3.7	118.0 ± 4.0	118.8 ± 3.9	116.2 ± 4.6	F = 3.26,$p < 0.661$, Partial $\eta^2 = 0.48$.

Table 7 – Task 3 – DCD group – within-group analysis using Repeated measures ANOVA

Metric	**Baseline**	**Visual**	**Auditory**	**Multisensory**	**RM - ANOVA Results**
Movement time (ms)	798.7 ± 53.6	890.9 ± 62.5	852.7 ± 60.1	970.1 ± 81.7	F = 89.1, $p < 0.001$, Partial $\eta^2 = 0.66$.
Success of catching (%)	75.8 ± 6.1	58.1 ± 7.2	66.3 ± 6.6	46.0 ± 9.0	F = 44.1, $p < 0.001$, Partial $\eta^2 = 0.52$.
Gait velocity (m/s)	1.098 ± 0.081	1.018 ± 0.094	1.052 ± 0.089	0.903 ± 0.1 07	F = 28.1, $p < .001$, Partial $\eta^2 = 0.46$.
Cadence (spm)	114.8 ± 4.0	111.8 ± 5.1	113.2 ± 4.8	108.0 ± 6.2	F = 50.1, $p < 0.001$, Partial $\eta^2 = 0.49$.

Table 8 — Task 3: DCD group - Post Hoc analysis using Bonferroni test

Metric	**Comparison**	**Mean Difference**	**t**	**Bonferroni-adjusted p**
Movement time (ms)	Baseline vs Visual	92.2	10.8	< 0.001
	Baseline vs Auditory	54	7.1	< 0.001
	Multisensory vs Baseline	171.4	14.6	< 0.001
	Multisensory vs Visual	78.2	8.5	< 0.001
	Multisensory vs Auditory	117.4	11.9	< 0.001
	Visual vs Auditory	38.2	4.9	< 0.001
Success of catching (%)	Baseline vs Visual	–17.7	–8.5	< 0.001
	Baseline vs Auditory	–9.5	–6.0	< 0.001
	Multisensory vs Baseline	–29.8	–12.0	< 0.001
	Multisensory vs Visual	–12.1	–6.3	< 0.001
	Multisensory vs Auditory	–20.3	–9.4	< 0.001

	Visual vs Auditory	–7.2	–4.5	< 0.001
Gait velocity (m/s)	Baseline vs Visual	–0.080	–6.7	< 0.001
	Baseline vs Auditory	–0.046	–4.2	0.001
	Multisensory vs Baseline	–0.195	–10.9	< 0.001
	Multisensory vs Visual	–0.115	–8.0	< 0.001
	Multisensory vs Auditory	–0.149	–9.3	< 0.001
	Visual vs Auditory	–0.034	–2.5	0.029
Cadence (spm)	Baseline vs Visual	–3.0	–5.6	< 0.001
	Baseline vs Auditory	–1.6	–3.8	0.003
	Multisensory vs Baseline	–6.8	–9.5	< 0.001
	Multisensory vs Visual	–3.8	–6.0	< 0.001
	Multisensory vs Auditory	–5.2	–7.2	< 0.001
	Visual vs Auditory	–1.4	–2.2	0.044

Table 9 - Task 3 – TD group – within-group analysis using Repeated measures ANOVA

Metric	**Baseline**	**Visual**	**Auditory**	**Multisensory**	**RM - ANOVA Results**
Movement time (ms)	798.7 ± 53.6	810.2 ± 55.3	805.4 ± 54.2	815.6 ± 57.1	F = 1.00, p = 0.352, Partial η² = 0.02.
Success of catching (%)	75.8 ± 6.1	74.5 ± 5.8	76.1 ± 6.3	73.9 ± 6.2	F = 1.02, p = 0.310, Partial η² = 0.02.
Gait velocity (m/s)	1.198 ± 0.081	1.105 ± 0.084	1.100 ± 0.080	1.070 ± 0.085	F = 0.78, p = 0.543, Partial η² = 0.01.
Cadence (spm)	114.8 ± 4.0	115.2 ± 4.1	114.5 ± 4.2	116.9 ± 4.3	F = 0.92, p = 0.429, Partial η² = 0.02.

Discussion

DCD, marked by difficulties in motor coordination and planning, can severely affect a child's ability to perform everyday tasks, leading to challenges in school, social interactions, and overall quality of life (10). Distractions—visual, auditory, or multisensory—can exacerbate these challenges, making it critical to understand how such distractions impact children with DCD (14). Since DCD is a global issue, a better understanding of its challenges will help identify improved treatment approaches, patient support strategies, and provide valuable insights for health policymakers in the future (15). By ident ifying the influence of these distractions on motor performance, tailored interventions can be developed to reduce their effects and improve functional independence. This study analysed the impact of three different sensory challenges while performing three tasks—stationary ball-catching, dynamic walking interception, and walking while tossing a ball—chosen for their relevance to Activities of Daily Living (ADLs) and common play activities. (16,17) These tasks replicate real-world scenarios requiring children to coordinate movements and respond to dynamic stimuli, such as catching a moving object or navigating crowded spaces, thus offering a more comprehensive assessment of a child's motor abilities in real-life contexts. The results indicated that children with DCD showed significant impairments under all sensory distraction conditions. Their movement onset and time were delayed, and success rates decreased across all tasks when exposed to visual, auditory, or combined sensory distractions. In contrast, TD (TD) children showed minimal changes in performance under similar conditions, emphasising the heightened sensitivity of children with DCD to sensory overload. This reinforces the need for considering sensory environments when assessing and treating children with DCD, as even mild distractions can severely compromise their motor task performance.

Previous studies have explored the effects of sensory distractions on DCD performance, providing a broader context for this study's findings. Bair et al. (2012) demonstrated that children with DCD struggle with multisensory integration, impairing their ability to adapt to sensory changes, which can affect balance and postural control. (8) Similarly, Coats et al. (2015) showed that multisensory stimuli hinder the performance of children with DCD on tasks requiring rapid responses.(18) These findings align with the current study, which also highlights that sensory distractions negatively impact motor performance in children with DCD. Further supporting this, Tran et al. (2022) found that children with DCD exhibit significant impairments in integrating visual, auditory, and proprioceptive inputs, crucial for motor coordination. (5) This suggests that sensory processing deficits contribute to difficulties in motor tasks, particularly under distracting conditions. While prior studies have examined individual sensory distractions, such as visual or auditory perturbations (19), this study is novel in its use of combined multisensory distractions, manipulating both visual and auditory stimuli. This approach is vital as it mirrors real-world environments, where children are often faced with multiple sensory inputs simultaneously, a scenario that previous studies did not fully capture. (10)

This study's relatively large sample size (88 children) and the inclusion of rigorous screening for comorbidities make its findings more robust and generalizable than many earlier studies. By including a more diverse range of children, this study provides results that are more applicable to the general population of children with DCD, enhancing its external validity. Clinically, the study underscores the need for interventions targeting sensory processing difficulties in children with DCD. Approaches like sensory integration therapy, modifications to reduce sensory overload, and programs designed to improve multisensory integration could help improve motor performance and overall functional independence. Incorporating these strategies into educational and therapeutic settings can also foster better outcomes for children with DCD. A strength of this study is its focus on real-world tasks, improving ecological validity and providing insights into how sensory distractions affect children's performance in everyday life. However, two limitations should be considered. First, the study's cross-sectional design limits the ability to draw conclusions about causality or the long-term effects of sensory distractions on children with DCD. Longitudinal studies would offer a deeper understanding of how these effects evolve over time. Second, while the sample size is adequate, it may not fully represent the diversity of children with DCD in terms of age, severity of symptoms, and comorbid conditions. Future research should aim to include a more diverse sample to further enhance the generalizability of the findings

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Conclusion

The study emphasizes the profound impact of multisensory distractions on the motor performance of children with DCD. Children with DCD showed notable delays in initiating movements, prolonged movement times, and lower success rates when exposed to visual, auditory, or combined sensory disruptions. These impairments were observed across a range of tasks that replicate real-world scenarios, indicating that sensory overload exacerbates their motor coordination difficulties. In contrast, TD children exhibited minimal changes, highlighting the increased sensitivity of those with DCD to sensory challenges. These findings underline the importance of considering sensory environments when assessing and intervening with children with DCD, as even mild distractions can significantly hinder their performance. The results suggest that interventions aimed at reducing sensory overload and improving sensory processing could enhance the motor function and everyday life skills of children with DCD. Future research should explore the long-term effects of sensory disruptions and further refine strategies for supporting these children in both clinical and everyday settings.

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