Imitation performance in toddlers with autism and those with other developmental disorders

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Abstract

The present study sought to examine the specificity, developmental correlates, nature and pervasiveness of imitation deficits very early in the development of autism. Subjects were 24 children with autism (mean age 34 months), 18 children with fragile X syndrome, 20 children with other developmental disorders, and 15 typically-developing children. Children with autism were found to be significantly more impaired in overall imitation abilities, oral-facial imitation, and imitations of actions on objects than children with developmental disorders and typically-developing children. Imitation skills of young children with fragile X syndrome were strongly influenced by the absence or presence of symptoms of autism. For children with autism, imitation skills were moderately correlated with autistic symptoms and joint attention, independent of developmental level. For comparison groups, imitation was related to general developmental abilities including play, language, and visual spatial skills. Neither motor functioning nor social responsivity accounted for a significant amount of variance in imitation scores, when controlling for overall developmental level.

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Introduction

Difficulty with imitation of other people's movements appears to be particularly affected in autism. Autism is defined by the presence of three main symptom sets involving abnormalities of social reciprocity, communication and language function, and the presence of abnormally restricted and repetitive behaviors and/or interests (American Psychiatric Association, 1994). Problems with imitation discriminate children with autism from those with other developmental disorders as early as age 2 (Charman et al, 1997; Stone et al, 1997), and continue into adulthood (Rogers et al. 1996). Given the theoretical importance of early imitation to social –emotional development (Stern, 1985) and its impoverishment in autism, Rogers & Pennington (1991) suggested that an imitation deficit may be fundamental to the social deficits involved in autism and raised questions about the mechanisms that may be involved. Several major review papers (Meltzoff & Gopnik, 1993; Smith & Bryson, 1994) further developed ideas about the role of imitation in autism. The field has moved beyond asking whether imitation is deficient in autism and is exploring more complex questions involving underlying mechanisms. Two potential mechanisms that have some preliminary support involve motor functions, particularly praxis related functions, and social aspects.

The Purpose of the Present Study

The present study, carried out as part of a larger longitudinal study of early development in autism, was designed to answer several of the questions remaining from earlier studies. The main hypotheses are:

1. Imitation deficits are pervasive in children with autism compared to both typical and clinical control groups with their primacy reflected by relationships with key developmental areas also affected by autism: language, play, and main symptoms of autism.

2. Children with autism will demonstrate greatest impairments in oral-facial imitations and least impairments in actions on objects relative to comparison groups. Specific imitation skills will be related to specific developments in other areas (e.g. oral imitation will be related to speech development; imitations on objects will be related to play development).

3. Both motor function and social responsivity will affect imitation ability in young children with autism and othr developmental disorders.

Methods

Subjects

Table 1
Subject Characteristics by Diagnosis (n = 77)

	Autistic Disorder (n =24)	Developmental Delay of Mixed Etiologies (n = 20)	Fragile X Syndrome (n = 18)	Typically-Developing Children (n = 15)
Chronological Age				
M (SD)	34.17 (3.6)	34.15 (6.5)	34.35 (8.3)	21.27 (1.5)
Range	26 - 41	24 - 45	21 - 50	18 - 24
Nonverbal MA				
M (SD)	23.67 (6.3)	23.58 (5.6)	21.16 (4.9)	24.13 (3.4)
Range	12 - 44	16 - 35	14 - 35	20 – 31
Verbal MA				
M (SD)	16.58 (6.7)	20.53 (5.7)	18.44 (6.8)	26.47 (4.2)
Range	5 - 33	11 - 30	8 - 33	19 – 34
Overall Mental Age				
M (SD)	20.09 (6.1)	22.04 (5.4)	19.73 (5.8)	25.3 (3.5)
Range	10 - 38	14 - 31	11 - 34	20 – 32
Gender (%)				
Male	83	45	89	40
Female	17	55	11	60
Ethnicity (%)				
Caucasian	88	80	83	86
African-American	8	0	0	0
Hispanic	0	10	11	7
Biracial	4	10	6	7
Socioeconomic Status				
M (SD)	48.3 (12.4)	53.55 (8.9)	50.74 (12.9)	48.49 (14.6)
Range	22 - 66	40 - 66	15 - 66	22 – 66

All clinical subjects were recruited from various health and early education agencies, as well as parent support groups (e.g., Fragile X Foundation and Autism Society of America). There were no significant differences between the children with autism and those with mixed DD on chronological age, nonverbal, verbal or overall mental age. The children in the typically-developing group were significantly younger than the clinical groups, and had significantly higher verbal skills than the clinical groups $F(3, 74) = 8.72$. $p < .01$.

The children with autism were free from any other medical condition, had been diagnosed with autism by an outside agency, received current clinical diagnoses of autism, and met criteria for autism on at least two of three diagnostic systems: DSM-IV, ADI-R and ADOS-G. Within the DD group, there were 8 subjects with Down Syndrome, 2 subjects with other genetic abnormalities and 10 subjects with idiopathic DD. None had autism. All subjects in the FXS group had DNA verification of fragile X status. Five of these children met criteria for autism. Correlational analysis within the FXS group between Total Imitation Score and ADOS algorithm scores was significant ($r^2 = -.53$, $p < .01$), suggesting that autism symptoms were strongly related to imitation abilities. Therefore, subjects in the FXS group were treated as comprising two subgroups, fragile X syndrome without autism (FX/DD; $n = 13$), and fragile X syndrome with autism (FX/AD; $n = 5$). Due to the small number of subjects per group, these children were included in the regression and correlational analyses, but were not included in the group comparisons by diagnosis.

Measures

Autism Diagnostic Interview – Revised (ADI-R). (Lord, Rutter, & Le Couteur, 1994). The ADI-R is a structured, standardized parent interview developed to assess the presence and severity of symptoms of autism in early childhood across all three main symptom areas involved in autism: social relatedness, communication, and repetitive, restrictive behaviors. The ADI-R has been carefully psychometrically validated across a wide range of ages and severity levels in autism. Reliability was maintained at 80% for 20% of subjects.

Autism Diagnostic Observation Schedule – Generic. (ADOS-G; Lord, Rutter, & DiLavore, 1998). The ADOS-G is a semi-structured standardized interview using developmentally appropriate social and toy-based interactions in a 30-45 minute interview to elicit symptoms of autism in four areas: social interaction, communication, play, and repetitive behaviors. Reliability was maintained at 80% and checked for 20% of participants. The total score on the ADOS was used as a measure of symptom severity.

Mullen Scales of Early Learning. (MSEL; Mullen, 1989). The MSEL is a standardized developmental test for children ages 3 months to 60 months consisting of five subscales: gross motor, fine motor, visual reception, expressive language, and receptive language. Overall developmental age equivalents were used in most analyses.

Merrill-Palmer Scale. Two pegboards and the Seguin form board were used from the Merrill-Palmer (Stutsman, 1948) to assess the child's visual-spatial problem-solving abilities. A developmental age equivalent was calculated by averaging the developmental level of the child's performance according to test norms across three the tasks.

Vineland Scales of Adaptive Behavior, Interview Edition. The Vineland (Sparrow, Balla, & Cicchetti, 1984) is a standardized parent interview designed to assess adaptive behavior across four domains: social, communication, daily living, and motor skills.

Imitation Battery. The Imitation Battery appears in Table 2. The test battery was split in half and administered on two separate days using a counterbalanced, randomized order of items. A specific administration procedure was employed throughout imitation trials based on Meltzoff & Moore (1977). With the child looking directly at the adult, the examiner said "(Name), do this" and repeated the action three times rapidly in a burst of three actions each (thus demonstrating 9 rapid repetitions of the action). The child was rewarded for any attempt with social, and sometimes tangible, rewards. If the child made an imitative response to the first burst, the next task was given. If the child did not respond to the first burst, a second burst was provided (9 more repetitions in 3 sets of three). Up to three bursts were administered for each item. First scores were used throughout the analyses. Scores of 0 reflected no action at all, 1 reflected a contingent movement that appeared unrelated to the target movement, and higher scores 2-4 reflected increasingly more accurate imitation. Inter-rater reliability was established prior to scoring and maintained throughout the study by having two coders independently rate 20% of the tapes. Inter-rater reliability assessed via weighted kappas ranged from .86-.88.

Praxis Battery. The praxis battery of seven tasks listed in Table 2 was developed for this study in consultation with two expert occupational therapists. These tasks were designed to challenge motor planning and execution abilities. Scoring criteria for each item were established based on the number of errors involved in the child's performance. It was scotred similarly to the imitation battery. Inter-rater reliability was established prior to scoring and maintained throughout the study by having two coders independently rate 25% of the tapes. Inter-rater reliability calculated via weighted kappa ranged from .86 to .89.

Table 2

Imitation Battery
Manual Items
Open and close both hands (simultaneous)
Pat chest with one hand
Pat elbow
Imitation: Actions on Objects
Pull duplos apart and bang them together
Turn car upside-down and pat it
Pat squeaky toy with elbow
Imitation: Oral-Facial Movements
Extend tongue and wiggle sideways
Blow cotton ball across table
Make a "noisy kiss"
Praxis Battery
Remove a nerf ball from inside a fishbowl
String three large beads

Put a several coins in a bank with one hand
Place a rod in a hole vertically
Place a long necklace in a tall cup
Climb out of a cardboard box on the floor
Walk forward, pulling a pulltoy

Social Responsivity Score. This score was the sum of 6 ratings on ADOS that tapped dyadic social orienting and responsiveness to a partner. Items included ratings of a child's ability to direct facial expressions to others, direct vocalizations to others, share enjoyment in an interaction, integrate eye contact with other behaviors, smile responsively, and to initiate social overtures towards others. Cronbach's alpha on the scale of 6 items was computed on a large sample of children with autism and other developmental disorders ($n = 68$), yielding an alpha coefficient of .93.

Revised Early Social and Communication Scales. (ESCS, Seibert, Hogan, & Mundy, 1982; Mundy, Hogan, & Doehring, 1996). These procedures involved a 20-minute semi-structured, toy-based interaction designed to elicit nonverbal communicative behaviors involving joint attention, requesting, and turn-taking. The interaction is videotaped and coded using a micro-analytic approach. Inter-rater reliability was established at 85% and maintained throughout the project by having two raters code 30% of all tapes. The frequency of high-level Initiates Joint Attention acts (i.e., child directs the attention of the adult for the purpose of commenting by coordinating eye gaze with a distal point or other gesture to an object or event) was used in these analyses.

Modified Fewell Play Scales. The Play Assessment Scale, 5th edition (Fewell, 1992) is a developmentally-sequenced, semi-structured assessment of a child's play in both spontaneous and prompted conditions. A modified version of this assessment, including items covering play skills from 4-30 months, was used in this study and administered across two lab visits. The total number of items in which the child exhibited spontaneous play was used in these analyses, with higher scores indicating more mature play. In this study, inter-rater agreement was examined for over 20% of the sample and was maintained at higher than 85% item by item agreement.

Spatial Reversal Task. (Kaufman, Leckman, & Ort, 1989). This task assesses perseverations and set-shifting in a series of visual-spatial search tasks. The examiner sets up the task by hiding a reward under each of two identical cups behind a screen. After four successful searches under the same cup, the side of hiding is reversed. The child's responses from this point forward are either correct (i.e., adjusting to the change, the child chooses the correct cup) or perseverative (i.e., the child continues to choose the incorrect cup after the initial failure trial). The examiner administers twenty-three trials (potential range of correct responses is 0-20) and up to four sets, reversing the side of hiding after 4 correct consecutive searches. The number of correct searches was used in these analyses.

Results

Development of Summary Scores for Imitation Battery

Consistent with previous findings on imitative ability, three subscales of imitative behavior were constructed as a function of form: Manual (acts with the hands, 3 items, alpha = .86),), Object (manual actions on objects, 3 items, alpha = .74),), and Oral-facial (actions with the mouth, 3 items, alpha = .86). Subscales were combined into a total imitation score (9 items, alpha = .87). Partial correlations among the three subscales (controlling for overall developmental age were moderate: manual with object ($r = .46$, $p<.01$); manual with oral-facial ($r = .63$, $p = .01$); object with oral-facial ($r = .45$, $p< .01$). Thus, the different types of imitation were not independent of each other.

Subject Participation in Imitation Battery

Zelazo (2001) proposed that the imitation deficit in autism is due to interfering behaviors and lack of participation. Therefore, we examined subject participation by group. Scores were collapsed into two categories: No response (i.e., a score of 0, indicating a failure to respond to the examiner's model) vs. Attempted Response (i.e., a score of 1 or higher, indicating a contingent response to the examiner's model, regardless of the accuracy of the imitation). Using a chi-square analysis, the groups did not differ on frequency of responding to 7/9 items; however, children in the AD and FXS group responded less frequently than children with DD on two items (Elbow on toy, $x^2 = 8.51$, $p < .05$; Blow cotton ball, $x^2 = 9.01$, $p < .05$). Examination of performance on these two items revealed that these were the most difficult tasks within the battery for children in all groups, and it was felt that poor responses to these two items reflected the level of task difficulty rather than poor cooperation.

Next, we compared the four groups on the number of modeled bursts required to elicit the first imitative response. Differences in the number of bursts might indicate difficulty encoding or processing the adult model or planning and executing the response. There were no significant group differences in the number of bursts given on manual imitations, (F (3, 73) = 1.19, p=.32) or oral-facial subscales,(F (3, 73) = 1.10, p=.36); however, there were group differences in the number of models given in the object imitation subscale by group, F(3,73) = 3.71, p<.05. Specifically, children with FXS required more models to imitate items on this subscale than children with DD. Children with AD did not differ from the DD or typical groups.

Specificity of Imitation Deficits to Autism

The following analyses were conducted by comparing the group of 24 children with autism with the group of 20 children with DD and 15 children with typical development. A one-way analysis of variance on total imitation score revealed that children with autism performed more poorly on the imitation battery than children with DD and the typically-developing children, F (2, 57) = 6.02, p < .05. Children with autism were more impaired than both of the other groups on oral-facial imitation, F (2, 57) = 5.31, p < .01, and object imitation, F (2, 57) = 5.76, p < .01, but not on manual imitation, F (2, 57) = 2.24, p = .12.

Table 3
Means and Standard Deviations of Imitation, Motor and Social Functioning By Group (n = 59)

	Autism (n = 24)	DD (n = 20)	Typical (n = 15)	F	P	Post-hoc
Imitation Total						
Mean (SD)	12.63 (8.2)	19.80 (7.7)	20.00 (7.6)	6.02	.004	Aut < DD,Typ
Manual Imitation						
Mean (SD)	4.58 (4.2)	6.46 (4.2)	7.27 (4.0)	2.24	.16	ns
Object Imitation						
Mean (SD)	4.75 (2.2)	6.58 (2.2)	6.67 (1.8)	5.76	.005	Aut <DD, Typ
Oral Imitation						
Mean (SD)	3.29 (2.9)	5.33 (2.9)	6.07 (2.6)	5.31	.008	Aut <DD, Typ
Fine Motor Age						
Mean (SD)	22.88 (4.6)	23.3 (5.1)	23.4 (3.6)	.08	.93	Ns
Gross Motor Age						
Mean (SD)	24.37 (5.2)	20.78 (5.8)	21.07 (3.7)	3.03	.06	Ns
Praxis Total Score						
Mean (SD)	17.71 (5.3)	16.45 (5.7)	18.11 (2.0)	.47	.63	Ns
Social Responsivity						
Mean (SD)	10.91 (2.5)	3.05 (2.5)	2.35 (1.7)	81.34	.00	Aut >DD, Typ

Correlations Among Imitation Abilities and Other Skills

The next question concerned a replication of the findings of Stone et al. (1997) involving the roles of oral-facial imitation and imitations on objects in predicting language development and play, respectively. Partial correlations were conducted to control for overall developmental age for all 29 subjects with autism (24 from the autism group and 5 from the FX/AD group) and for 30 subjects with other developmental disorders (20 from the DD group and 10 from the FX/DD group). See Table 4.

Table 4
Partial Correlations Among Imitative Skills and Other Developmental Skills Controlling for Developmental Age in Children with Autism (n = 29)

	Play	Express. Language Raw Score	Severity of Autism (ADOS)	Initiates Joint Attention	Executive Function	Merrill-Palmer	Vineland ABC
Manual	.03	.12	-.27	.14	.15	-.25	-.03
Object	.07	.12	-.49**	.36*	.06	-.11	-.07
Oral	.34	.10	-.60**	.30*	.12	-.12	- .004
Total	.18	.06	-.54**	.16	.11	-.21	-.04

Partial Correlations Among Imitative Skills and Other Developmental Skills Controlling for Developmental Age in Children with Developmental Disorders (n = 30)

	Play	Express. Language	Severity of Autism (ADOS)	Initiates Joint Attention	Executive Function	Merrill-Palmer	Vineland ABC
Manual	.89**	.27**	.07	.03	.11	.27	.06
Object	.50**	.08	.05	-.33*	.18	.40*	.11
Oral	.15	.42*	.05	.18	.04	.20	.02
Total	.39*	.34	.08	.003	.002	.23	.09

Possible Motor and Social Mechanisms involved in Imitative Ability

Further exploration of the potential contributions of motor and social functioning on overall imitative ability was conducted using analyses of variance, correlation and regression analyses. The first analysis examined group differences on the motor and social variables. No significant group differences were found on the motor variables: fine motor functioning, $F\ (2, 56) = .08$, $p=.93$; gross motor functioning, $F\ (2, 56) = 3.03$, $p = .06$, and praxis, $F(2,50) = .47$, $p=.63$ (see Table 3). However, as expected, there were significant group differences in social responsivity, $F(2, 53) = 81.24$, $p < .00$, with children with autism significantly more impaired than children in the other groups. To examine whether these group differences influenced the differences in imitation ability, partial correlations controlling for developmental age (as measured by the verbal mental age, due to independence from the motor variables) were computed for children with autism ($n = 29$) and children with other developmental disorders ($n = 30$) separately. See Table 5.

Table 5
Partial Correlations Among Motor, Social, and Imitation Ability by Diagnostic Group Controlling for Developmental Age

	Imitation Total Score	
	Autism ($n = 29$)	DD ($n = 30$)
Gross Motor Age Equivalent	-.08	.17
Fine Motor Age Equivalent	.39*	.18
Praxis Total Score	.18	.11
Social Responsivity	-.24	-.23

$p < .05$

A model was constructed to test the relative contributions of social and motor functioning to imitative ability, above and beyond overall developmental functioning. The Fine Motor Age Equivalent was used as the index of motor functioning. The child's verbal developmental age from the Mullens' was entered in step 1, followed by the Fine Motor Age Equivalent score and then the Social Responsivity Score in Step 2. The verbal developmental quotient was included in the model because it was independent of fine motor scores on the MSEL, and yet was strongly correlated with nonverbal developmental ages across both groups of children ($r = .73$, $p<.01$). For children with autism, verbal developmental ages accounted for 53% of the variance in the total imitation score. The Fine Motor Age Equivalent and Social Responsivity score added little to the model (4%), $F(2, 26) = 1.67$, $p = .21$. Results for the DD group were similar. These results suggest that overall developmental functioning as measured by the MSEL plays a strong role in imitation ability, while motor functioning and social responsivity do not play independent roles in imitation, above and beyond overall developmental functioning.

Discussion

Specificity of the imitation deficit

The findings from this study replicate previous reports by Charman et al 1997; Sigman & Ungerer, 1984; Stone, 1997 and others in reporting robust differences in imitation performance of very young children with autism. The apparent specificity of the imitation difficulty to autism was further demonstrated by the performance of the children with FXS. The performance of children with FXS who did not have autism closely resembled the imitation performance of the mixed DD group, while the performance of the FXS group with autism closely resembled the imitation performance of the idiopathic autism group. This was not due to a confounding of imitation performance with diagnostic criteria. Of the autism diagnostic procedures that were used in this study, none of the 28 algorithm items on the ADOS involved imitation, and only 2 items out of 38 on the ADI algorithm involved imitation. Thus, imitation appeared to "follow" autism into FXS, further demonstrating the specificity of imitation problems to autism.

Relationships between imitation performance and key developmental skills

We did not find dissociations between forms of imitation, nor did we find independent relationships between oral-motor imitation and speech development, nor between manual or object imitations and play skills. Our lack of replication of relative independence in object imitations and body imitations may be due to our use of novel actions on objects that contradicted the affordance of the objects. For all groups of children, imitation ability was highly related to overall developmental status. For the children with autism, imitation abilities were strongly associated with joint attention abilities and severity of autism symptoms. Imitation skills were not related significantly to level of play skills, visual-spatial abilities, language development, or adaptive behavior. A very different pattern was found for children with other developmental disabilities. In the DD group, imitation was closely related to other key developmental skills as well as overall intellectual ability, demonstrating the inter-dependence of various developmental skills that are rapidly developing in the 12-24 month period (the developmental ages of the children involved.) In contrast, for the children with autism in the same developmental period, imitation clusters with the social disabilities in dyadic and triadic relations that mark early autism, and overall developmental status, rather than with the social-cognitive cluster involving language and play.

Does a general motor dyspraxia underlie the imitation difficulties in early autism?

We tested the hypothesis that an underlying, general difficulty with motor planning and execution might be the mechanism responsible for early imitation problems, an hypothesis that we shared with several other groups (Adams, 1998; DeMyer, 1981; Page & Boucher, 1998). However, this hypothesis was not supported in the present study. These unexpected findings raise several questions. First concerns the nature of the praxis battery. The tasks were developed by a group of occupational therapists expert in early motor development and in early autism; however, it remains possible that the battery may not reflect a valid measurement of this construct. Second, motor and praxis skills correlated with imitation performance equivalently in all three groups. Thus, a very thorough examination of motor functioning in this study did not yield evidence supportive of an autism-specific difficulty or a different type of relationship between imitation and motor performance in autism than in other groups. This suggests a mechanism other than a generalized dyspraxia lies behind the motor imitation difficulty in autism. However, it does not rule out a more specific motor mechanism. Our motor tasks focused on manual and body movements. The question of oral dyspraxia was not well addressed by these findings and needs further exploration.

Social mechanisms involved in imitation

Social responsivity correlated significantly with imitation performance in children with autism, but did not add to the regression model above and beyond overall developmental functioning. While we were able to establish that the children with autism appeared to participate in the battery as actively as other children, it is important to acknowledge the strong scaffolding for imitation provided by our procedures. It is well established that, in ongoing daily life, children with autism do not imitate others as frequently as other children and thus do not as frequently practice imitation skills. It is possible that at least some of the autism difference in imitation reflects lack of practice and resulting lack of refinement of the movements. The discrepancy between amount of imitation in scaffolded and natural situations may be due to lack of social rewards, lack of social attention to others, lack of attention shifting, or other factors. The relation between social responsivity and imitation may reflect the importance of dyadic interaction in the development of imitation abilities in young children, thus adding support to the growing number of studies demonstrating that social impairments in autism involve dyadic as well as triadic engagement (Dawson et al 1998; Hobson, 1993; Osterling & Dawson, 1994). Thus, the imitation deficit in autism may more properly be classified as part and parcel of the broader social impairment in dyadic relations and emotional responsivity seen in autism (a position best represented by Nadel's program of research; Nadel & Peze, 1993; Nadel et al, 2000; Nadel et al, 1999).

Future Directions

While published studies on imitation in the past decade have firmly established the autism-specific differences, we have only begun to explore possible underlying mechanisms. The clinical and empirical evidence suggests that there may be several functions of imitation in development Trevarthen et al, 1999; Uzgiris, 1999), perhaps with differing mechanisms. An early function of imitation involves social communication (Nadel et al, 1999) and highlights oral-facial and vocal exchanges. A candidate process for this imitative function could involve an affective mechanism modulating social exchanges. Another function of imitation involves apprenticeship, allowing one to learn instrumental means-end relations involving actions on objects from others. This function may involve a different underlying process, one akin to the findings from the mirror neuron studies, involving intentional acts on objects. It is possible that children with autism are impaired in one type of imitative ability more than another. Future studies are planned to test these predictions.

There are other pressing questions regarding imitation in autism. We do not know how early the imitative difficulty is observable in autism. Retrospective videotape studies measuring early imitative movements (i.e., facial expressions or emotional contagion) will be informative in this regard. We do not know the course of imitative development in autism, or how these abilities relate to the growth of other capacities. Few studies have examined imitative performance within the natural environment; thus it is not known whether imitation performance in the lab reflects imitation skills used in daily life. Given that imitation skills may be related to important outcomes for children with autism, research concerning treatment approaches for improving imitation skills, and the effect of such an approach on other areas of functioning is relevant. Difficulties with imitation appear to be part and parcel of autism, and pursuing a deeper understanding of imitation may lead us to a deeper understanding of the social core of autism.

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