Original Article

Inter-Intra Rater Reliability, Construct and Discriminative Validity of Iranian Typically Developing Children Handwriting Speed Test (I-CHST)

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Objectives: The purpose of this study was to develop an Iranian Hand writing Speed Test (I-CHST) for testing of Iranian students aged 8-12. To date, no norms of handwriting speed have been published for hand-writing speed of the Iranian students.

Methods: A sample of 400 typically developing Iranian students across four age cohorts was recruited. Among those 400 students 50% were girls and 50% were boys. 73% were studding at government schools and 27% were from the private schools. 79% were right handed and 11% were left handed. The results showed that the handwriting speed assessment test has excellent inter-rater reliability (r=1, p=0.000) and construct validity (r=0.798, p=0.000).

Results: The findings showed that handwriting speed increases with age and the rate of increase was found to be greatest among Iranian children aged 8-12. It is also found that the girls aged 11-12 wrote faster than boys of the same age.

Discussion: Based on this research, I-CHST was a valid and reliable test for testing the hand writing speed in Iranian children and it could be used for testing or intervention purposes by the therapists at clinics.

Key words: Handwriting speed, Typically Developing Children, Occupational Therapy, Test Development

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Introduction

The Iranian Children's Handwriting Speed Test (I-CHST) was developed in 2011, as an inexpensive and easy-to-use tool for Occupational Therapists or Educational Psychologists in Iran to refer to when assessing Farsi writer children with handwriting difficulties. At the time of doing this study there was not any published Iranian standard handwriting speed assessment test available for the primary children's handwriting speed aged 8-11. The purpose of this study was to document handwriting speed performance of Iranian children in aged 8-11. To design the pilot edition of the I-CHST, a number of tests were examined and critiqued and the literature related to handwriting and standardized test development were reviewed. Because at the time of doing this research, all of the existing handwriting speed tests and assessments were from the other languages and no norms of hand writing speed test was published in Farsi. The research team in this study decided to develop a new test especially for Iranian children with considering the culture and language. In Farsi the writing is from right to left and there are 32 letters in the language.

In Iran, due to a lack of standardized evaluation tools, the occupational therapist and teachers often

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determine either subjectively or by clinical judgment whether the child's written productivity is adequate within the given time constraints. All the writers of this research are Paediatrics Occupational Therapist who has some few years of experience in Iran's special children's clinics or schools. Based on their investigation and researches, the paediatric occupational therapists or the teachers who are working closely with the families and the school children in Iran, need are liable and valid assessment of handwriting speed that could get information about the Farsi writer children. Throughout history and in all cultures, handwriting has been a means for children and adults to communicate ideas and information. Despite the advent of many mechanical and electronic means of communication handwriting still remains a common mode of communication (1-3). Handwriting is a complex human activity that entails an intricate blend of cognitive, kinaesthetic and perceptual-motor components (2,4). Functional handwriting involves complex interactions among physical, cognitive and sensory systems which are referred to higher level functions in brain (5-8). Handwriting is the process of forming letters and symbols, generally on paper (9). Children are expected to acquire a level of handwriting proficiency that enables them to make skilful use of handwriting as a tool to carry out their work at school. It is an important function task used in an every grade beginning in kindergarten. At school, children are expected to copy numbers and mathematical computation, reproduce spelling words, compose creative stories and take notes (10). They are also asked to have handwriting fluency in a written examination which requires the writer to maintain sufficient speed. Studies showed that 31–60% of the children's school day consisted of fine motor activities (3) and of these fine motor tasks, 85% of the time was employed in paper and pencil tasks. Amundson and Weil pointed out that children spend a quarter to a half of their classroom time involved with paper and pencil tasks each day at school (11). In addition, the majority of these tasks have time constraints; therefore, an efficient writing speed is critical if the students are to accomplish an acceptable amount of work in the classroom and meet the standards of the teacher and the curriculum (11). Slow handwriting speed is one of the major problems encountered by school-aged children having handwriting difficulties. Research consistently shows that speed increased with increasing age (12). Although handwriting is an essential skill that enables students to express their knowledge, studies have shown that 10% to 20% of school-aged children have difficulty with this task (13). Hand writing difficulties can have implications for a child's successful participation in school and play activities and potentially leading to lowered self-esteem (14), thus limiting their participation in every tasks that require handwriting.

Factors known to influence handwriting include age, gender and type of text written. Gender-related differences also exist; women write faster than men (15-17) Prevalence of handwriting difficulties has been estimated to range between 5% and 27% depending on grade, selection criteria, and instruments used (18-21) Children who try to write faster to keep up with class work may compromise legibility (22). Typical handwriting difficulties for these children are illegibility, inability to keep up with written class assignments, and the lack of automaticity of handwriting (11,23-25). These children are often referred to occupational therapists for assessment and intervention and it is one of the most common reasons for school-aged children to refer to occupational therapy (25, 26). A reliable and valid assessment of handwriting speed could help the paediatric occupational therapists or the teachers who are working closely with the families and the school children (14). As to overall handwriting performance, speed is probably the simplest overall measure of proficiency in writing. Research has indicated that children who can write well have improved confidence and self-esteem, increased concentration, improved academic performance and an increased ability to express them creatively. Handwriting quality is reportedly correlated with various aspects of fine motor control including, manual dexterity (27), grip (1,28), in-hand manipulation (29), muscle tone (27), praxis (27) movement isolation, grading, and timing (1,20,30).

Hand writing difficulties are widespread in children with neuro-developmental disorders such as Attention Deficit Hyperactivity Disorder (ADHD) (31) and Developmental Coordination Disorder (DCD) (32,33). There is also evidence of handwriting difficulties in children with Autism Spectrum Disorders (ASD) (34), but the specific nature of these difficulties remain unknown. Handwriting difficulties could lead to academic underachievement and poor self-esteem. Perhaps because of its complexity, poor handwriting in the early years has also been correlated with later academic difficulty (35,36). Speed, in terms of fluency of movement, is one factor

considered to affect written output in examinations. A method commonly employed to assess writing speed is to use a short duration handwriting speed test that requires repeated copying of either a simple sentence (22) or a written passage (37).

Handwriting speed is depending on the strength of the fine motor skills. Fine motor skills enable finely graded and fluent manipulation of the writing implement, allowing production of letters with specific form and size at a specific position on the writing surface (38). Handwriting speed is also influenced by task demands (13). Writing self-generated text such as a diary entry involves complex cognitive processing and is more demanding than copied text (39). Ideas need to be generated and long-term memory used in order to sequence letters, spell words and construct a sentence (39). Based on the results from the previous researches, the texts which need more cognitive engagement of the children, would write it up with less speed. Thus, note taking, compositions, and essay tests are increasingly frequent and prove frustrating for those who struggle with the skill of handwriting. Fatigue is also thought to have a significant effect on handwriting speed, letter formation, spatial organization, and ergonomics (40). In one study, when children were asked to write long texts, fatigue had a significant effect on handwriting performance in children with both poor and good handwriting (41). Another study with children aged 8 to 9 years old showed that the quality of handwriting decreased as more was written (32). Writing long texts caused letter formation to deteriorate and the speed of handwriting to increase. In addition, writing long texts caused the children's posture to worsen. Due to poor posture, children with poor handwriting also had worsened spatial organization and increased pencil pressure (41). Thus the effects of fatigue on handwriting performance are complex and may have more serious implications for children who have already been identified as poor hand writers. Assessing handwriting skills is a controversial field. Research concerning the development of handwriting evaluation scales was conducted the early decades of the twentieth century. The primary aim of researchers who composed the various handwriting evaluation scales was to develop standardized evaluations. Their dilemma was how to define the "quality of handwriting" or "readability" in specific, measurable terms (6). During the following years, additional attempts were made to produce an improved handwriting scale with more accurate scoring criteria. One of the tests that have been developed for this purpose is the Test of Legible Handwriting(TOLH) to evaluate the overall readability of manuscript (print) and cursive writing of children from the 2nd to 12th grade (42). The authors of the TOLH constructed a scale of writing samples graded from 1 to 9 (from "least" to "most readable"). Although this scale is unique in its capacity to evaluate three types of writing, further research is necessary to determine its psychometric properties (13). In a recent study, the TOLH was used by classroom teachers to select experimental groups of poor and proficient hand writers for research (43). The Evaluation Tool of Children's Handwriting (ETCH) is another handwriting assessment which was developed by an occupational therapist for the purpose of evaluating the readability and handwriting speed generated on written tasks that are similar to those expected in the classroom (11). One part of the tool tests manuscript (print) writing (ETCH-M) and the other tests cursive handwriting (ETCH-C). The time needed to administer each part of the ETCH is 20-30 min (44). The writing tasks include writing uppercase and lowercase letters from memory, writing numbers from memory, copying a near-point text, copying a text from a distance, dictation, and composing a sentence. Scoring focuses on overall readability, writing speed, component features of readability, and biomechanical aspects of writing. The evaluator counts occurrence of various readability components (such as shape, size, and spacing). The mechanical aspects of the child's writing, such as pencil grasp, pencil pressure, and in-hand manipulation, are observed during task performance and noted on the evaluation sheet (45). The inter-rater reliability studies for the ETCH completed by the test developer showed moderate-to-high results for different parts of the ECTHM and the ECTH-C (11). Test retest reliability for readability, according to studies of the ETCH-M that were conducted on first- and second-grade children, was moderate (45). These results did not demonstrate that the ETCH scales had better reliability than previous scales, a disappointing finding for its authors (44,46-49). However, Shneck points out that in contrast to the reliability studies done for prior assessment scales, the ETCH-M was researched among children who have handwriting difficulties, which would tend to reduce its reliability (44). Diekma et al. suggest that therapists take into account the limited reliability of a writing assessment tool (i.e., its subjectivity and absence of studies applicable to children with handwriting difficulties) when planning to use it for assessing the efficacy of

treatment (45). In fact, no significant relationship was found between the ETCH scores and teacher questionnaire scores in either general legibility or task-specific legibility (50). Thus, it has been suggested that further changes for scoring criteria are warranted before the ETCH scores are considered related to actual performance in the classroom as determined by teachers (50).

Another handwriting speed scale is the Scale of Rubin and Henderson which was developed to enable teachers to identify children with handwriting difficulties (51). Following a few trials, six assessment criteria were chosen: readability, accuracy of letter formation, unity of letters size and letters tilt, spaces between letters and words, and straightness of the written line. Systematic Screening for Handwriting Difficulties (SOS test) is another test of handwriting. A 4-point scale was developed for each SOS test. A child is asking to copy a sample of writing within 5 min. Handwriting quality is evaluated using six criteria and writing speed is measured. The Dutch SOS test was administered to 860 Flemish children (7-12 years). Inter- and intra-rater reliability was excellent. Test-retest reliability was moderate. A correlation coefficient of 0.70 between SOS and 'Concise Assessment Methods of Children Handwriting' test (Dutch version) confirmed convergent validity. The SOS allowed discrimination between typically developing children and children in special education, males and females, and different age groups (52). There are so many researches about the handwriting speed and the children within the last few decades but none of them is about handwriting assessment of the Farsi writer children.

In a variety of studies, handwriting speed has been found to increase steadily during the school years, with most studies reporting a levelling off at about age 13 to 14 (13,53). Girls tend to be faster writers than boys throughout childhood (46,54) and right-handers faster than left-handers(13). Tseng and Chow tested thirty-four slow hand writers and 35 normal speed hand writers (7 to 11 years of age) attending elementary schools in Taiwan (55). The participants were given three perceptual-motor tests and a vigilance task to assess sustained attention. Their results showed that there is a significant difference between slow and normal hand writers in upper-limb coordination, visual memory, spatial relation and form constancy, visual sequential memory, figure ground, visual-motor integration, and sustained attention. The three significant predictors of handwriting speed for the slow hand writers were age, visual sequential memory, and visual-motor integration. For the normal speed hand writers, age and upper-limb speed and dexterity were the only two significant predictors. Slow and normal speed hand writers responded to handwriting demands through different perceptual- motor systems. Whereas upper-limb speed and dexterity seems to play an important role in normal speed hand writers, slow hand writers seem to rely more on visually directed processes, including sequence memory and visual-motor integration. In another study Ziviani and Watson-Will's measured the writing speed and readability of 372 typical children aged 7-14 years in Australia (9) Unlike the methods used previously by Ziviani and Elkins, (46), this scale evaluates the global readability of handwriting, measuring the written product on a 7-point scale. No significant differences were found between boys and girls in mean writing speed. However, the readability of the girls' handwriting was significantly better than that of the boys. A low correlation was found between writing speed and readability (9), but reliability studies were not found in the literature. Compared the writing speeds of left- and right-handed children (53). No significant differences were found between the writing speeds of left-handed and right-handed Students from either the matched or the general study populations. It is concluded that the left to right direction of Latin script does not hinder the development of writing ability in left-handed children.

In a different study Connelly et al. measured the handwriting and typing speeds of 312 UK children aged 4 to 11 years, using the task devised by Wallen et al (22,56). From age 7 onwards, handwriting speed increase was found to be near linear and broadly consistent with the findings of Wallen et al., from 33 letters per minute (lpm) (8.48 wpm) at age 7 to 65 lpm (16.71 wpm) at age 11 (22). When typing the same task, performance also increased linearly with age, but speeds were considerably below those of handwriting: 28 lpm (7.20 wpm) at age 7 to 46lpm (11.23 wpm) at age 11. A significant correlation between the two modes of text reproduction was found ($r=0.70$; $p<0.001$). As shown in table (1), unfortunately, there is a dearth of studies in the resent years. The majority of previous studies have been done in the last two decades and it seems that the interest to assess the handwriting speed in primary school children has been inconspicuous. While the widespread use of computer at schools may influence the handwriting speed of the children in the last few years.

Table 1. The results from previous studies of hand writing speed in different countries

Researchers	Country	Language	Tool	Boys	Girls	Total	Results
Tseng, Mei Hui, Hsueh, I-Ping, 1997	Taipei, Taiwan	Chinese	Copy a specified text in 5 minutes	825	700	1525	7.27- 18.10 characters per minute
Ziviani & Elkins, 1984	Australia	English	copying of symbols, letters and words	279	296	575	40.68 Letters per minute
Ziviani & Watson 1998	Australia	English	The speed subtest of the Handwriting Performance Test (HPT; Ziviani & Elkins, 1984)	183	189	372	69.4 letters per minute
Graham, Berninger, Weintraub and Schafer 1998	America	English	Copying a paragraph	450	450	900	17-117 words in 1 minute
Hamstra-Bletz&Blote, 1990	Netherland	Dutch	BHK scale	----	----	127	24-66 words

Methods

This study was designed to examine the reliability and validity of the newly developed handwriting speed test for Iranian children (I-CHST) at elementary schools. The Descriptive-analytic survey with the technique of cluster sampling was carried out on 19 suburbs in Tehran. The number of student age 8-12 who were studding in great Tehran in 2007- 2008 was 379786. Among those 194073 were boys and 185713 were girls. The sampling selection was multistage cluster method. Based on the method of sampling, the population of the students from Tehran were divided into 4 sub-population which were from the northern, eastern, western or southern areas. These four areas were identified from the department of education in Tehran. Then from each of the areas one suburb chose randomly. Inside the selected suburbs the boys' and girls' school were disported and from each suburbs 2 girl's school and 2 boy's school systematically selected which were 20 schools all together. Then after recognizing the volume of the students in each of the schools in different grades, the students' names were listed with systematic sampling. The reason for the selected age was because of the Iranian teaching method. In Iran the students start to write Farsi in grade 1 when they are 7 and they finish all of the alphabets when they are 8. So in grade 2 when the students are 8, they could recognise the letters and they could copy a text with familiar words.

Subject were excluded if they had a documented learning disability, developmental delay, pervasive developmental disorder (autism, ADHD, DCD or intellectual disability), neurological deficits, were born prematurely (<37 weeks) or had repeated a grade.

Approval to carry out the study was obtained from the Shahid Beheshti University of Medical Sciences, research committee, for doing the research. Written consent was gained from the school principle, teachers, parents and children (over 10 years of age). After collecting the results, the students with low performance were selected and some consultations to the parents were given. No names were required on handwriting sample page and anonymity and confidentiality of responses were guaranteed. In this study the research team created a text that contains all of the 32 Farsi alphabets. For the 'criterion validity" of the Iranian Children Hand writing Speed Test (I-CHST),the text were approved as an appropriate text for the selected age student. For that reason 30 elementary expert teachers grade 2 to 5 wrote their comments about replacing the repeated words or deleting the unfamiliar words. After many changing all of the teachers reached the consensus of the appropriate text for the selected age students. Time for copying the text by the students was estimated 5 minutes based on the pilot study was performed before the big study. It was being considered that if any of the students had some extra time, he/she could start from the beginning of the text again.

Also the teachers provided demographic data for each student using a student information form. The form included the students' names, date of birth, year at school, sex, hand use for writing, and the student's classification as either a 'fast' or 'slow' hand-writer. Other materials were a 2B pencil for each student, a test manual, and a stopwatch. The outcomes of measurement were the 'speed of copying" a text. 400 students aged 8-12 completed the I-CHST in groups within each school according to the administration procedure. Subjects were withdrawn from the classroom and assessed individually in a quiet room at their schools. The participants were asked to re-write a Farsi text that was printed at the top of A4 size paper on the

writing lines below with a BH black pencil on with their normal speed. Because the child's posture is thought to influence both the efficiency of the writing process and the final handwritten product, authors described the 90-90-90 seating posture as the most ideal position for children. The children were asked to sit upright and copy the explained position and also ensure that their ankles, knees, and hips are all aligned at 90 degrees. To provide further support, the child's feet should be planted firmly on the floor, the trunk should be aligned against the back of the chair, the head should be aligned with the trunk, and the shoulders and wrists should be stabilized. It is also suggested that the child's elbows should be slightly off the edge of the desk and that the table surface should be two inches above the flexed elbows when the child is seated.

It described that the students were not allowed to use the eraser and if they made any mistake they could just crossed over the word with their pencils. If any of the students could finish the text earlier should start to write the text again from the beginning. After finishing the test the examiner asked the children to hold their pencils up and one of the assistants collected the peppers. Then the papers were collected and numbers of letters written were counted down. The students could not use all of the given time for reasons such as sharpening their pencils or talking were excluded. The data collectors administered the (I-CHST) during the middle of the education year 2011 and the teachers were asked to provide the demographic form at the end of the education year. This time frame was chosen as teachers would be sufficiently familiar with students to select fast and slow hand writers, and to allow collection of data from the required number of schools. Then the research assistants started to count down the letters written by the students in 5 minutes. The data collectors were 2 Occupational therapists with some few years of paediatrics experiences who were blind to students' age, sex and years at school. The data collectors did not trained in test administration.

For intra-rater reliability, the papers collected from the students were scored two times. Re-scoring was done 4 to 5 weeks following initial scoring. To measure intra-rater reliability, each rater also re-scored a random half of the samples that another rater had scored. All the letters written by the students were counted including the crossed over words and punctuations. For construct validity of the test, the teachers were asked to score the children based on their hand writing speed for example 'slow writer', 'normal writer' or 'fast writer'.

Results

Statistical analysis was performed with SPSS17.o software descriptive statistics were used to summarise demographic data and writing speed. Then the correlation between the children's score in I-CHST from 2 data collectors and the teachers score was given with Pearson Correlation Coefficient and Spearman Correlation Test (table 2and 3). For getting the mean of the letters the students could re-write per minute, the counted word per 5 minutes divided to 5. Intra-class correlation coefficients (ICC) for the letters per minute scores were used to determine interrater and intra-rater reliability. Frequency distribution of students based on their handwriting shows in table (2).

Table 2. Frequency distribution of students based on their handwriting speed

students	Letters per minutes	N	%	Mean SD
	Undergraduate			
Age8	24-36 (slow hand writer)	37	37	38.4
	36-50 (normal hand writer)	44	44	38.4
	51-63 (fast hand writer)	19	19	38.4
	Total	100	100	
Age 9	20-42 (slow hand writer)	29	29	46.7
	43-66 (normal hand writer)	48	48	46.7
	67-90 (fast hand writer)	23	23	46.7
	Total	100	100	
Age 10	24-51 (slow hand writer)	30	30	53.2
	52-80 (normal hand writer)	61	61	53.2
	81-108 (fast hand writer)	9	9	53.2
	Total	100	100	
Age 11	30-57 (slow hand writer)	36	36	60.7
	58-85 (normal hand writer)	48	48	60.7
	86-113 (fast hand writer)	16	16	60.7
	Total	100	100	
All ages		400		49.75

Results from testing the correlation between the scores given to the students from 2 data collectors shows that there is a strong relationship between them (r= 1, p= 0.0001) (Table 3).

Table 3. Correlation between the student's score form two data collectors in I-

	Writing speed score (1)	Writing speed score (2)
Hand writing speed test score(1)		
r	1	1
p		0.0001
n	400	400
Hand writing speed test score(2)		
r	1	1
p	0.0001	
n	400	400

And the result from testing the correlation between the scores given by the teachers and the scores given by the examiners by Spearman's Coefficient Test, shows that there is a strong relationship between variables (r = 0.798, p = 0.0001) (Table 4).

Table 4. Correlation between examiner's score and teacher's score in I-CHST

	Examiner Score	Teacher's Score
Examiner Score		
r	1	0.798
P		0.0001
n	400	400
Teacher's Score		
r	0.798	1
P	0.0001	
n	400	400

The results show that the students rated as fast hand writers by teachers scored higher on the I-CHST and the students rated as slow hand writers scored lower on the I-CHST in any of the grades and across boys and girls. Results from this study revealed that (I-CHST) is a useful tool that is applicable to a wide age of Farsi speaker's children. It was standardized and norm- referenced on a large sample of 400 Iranians students aged 8-12 in Tehran.

The results showed that (I-CHST) has a good discriminative validity and inter-rater, intra-rater reliability. This study also provided construct validity; that is, the ability to statistically discriminate between three known groups of students, the ones who are fast, normal or slow hand writers. Obviously, the (I-CHST) should be used with other standard assessments and clinical observations.

Discussion

Mastering handwriting skills is one of the primary goals of elementary school education. A student's ability to write not only legibly but also at an efficient speed is important for functional written communication as well as for educational development (27,48,57). Various Hand writing difficulties affect the academic performance and participation of many school-aged children, and intervention programs are offered to treat these difficulties. Slow handwriting speed is one of the major problems encountered by school-aged children having handwriting difficulties (26). This paper is about stages of the development a new handwriting speed test for Farsi speakers. Iranian Children Handwriting speed Test (I-CHST) is a new developed handwriting speed test and the only handwriting test available for Farsi speaker children age 8-12, at the time of writing this journal article. This study evaluated aspects of reliability and validity of the (I-CHST) with 400 Iranian school students. This study also provided preliminary support for one aspect of construct validity; that is, the ability to statistically discriminate between three known groups of students those designated fast, normal or slow hand writers by their teachers. Both inter-rater and intra-rater reliability were high and were consistent across school year and teachers' rating of fast, normal or slow hand writers. The development of norms for handwriting speed were mainly based on the school-aged children draw from a specific geographic location only limited to the Tehran area, which is the capital of Iran. Thus, the norms may not be applicable to school-aged children

in other areas of Iran, especially the rural area. Future studies may need to expand the sample size to incorporate participants from different geographic locations in Iran in order to be reflective of the entire population of school-aged children. I-CHST evaluates only one small aspect of handwriting speed; that is, performance on copying a short text without other variables playing a substantial part. Teachers' ratings may, therefore, be more realistic of overall handwriting speed performance than the I-CHST.

Further research is warranted, in which teachers are given more specific instructions for rating students as fast and slow hand writers. Comparison of I-CHST scores to students' speed in completing various writing tasks, including dictated samples, tests, and self-generated compositions, also would be informative. These writing tasks require a more complex integration of requisite abilities, such as executive function, motivation and motor skills. Our study found a difference between different school years in terms of speed of handwriting, as did the normative study. I-CHST should be used as a part of a multifaceted assessment of handwriting, which includes other standardized assessments and clinical observations. It also should be used with its limitations in mind; that is, the need for more research on its validity, ability to predict handwriting speed in other situations, and its responsiveness to changes in children's handwriting speed following intervention.

There is a need for more research on (I-CHST) for its validity its ability to predict handwriting speed in other situations and other Farsi speaker countries, and using it in the intervention situations. This study's baseline data on handwriting speed for the Iranian hand writing system provide further substantial information for future research and clinical practice.

Conclusions

The findings showed that handwriting speed increases with age and the rate of increase was found to be greatest among Iranian children aged 8-12. It is also found that the girls aged 11-12 wrote faster than boys of the same age

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