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Disorder of attention, motor control and perception in Grade 1 boys and girls

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Background: Researchers continue to investigate the predictive validity of motor assessment in learners with disorder of attention, motor control and perception (DAMP).

Aim: Determine the prevalence of attention-deficit hyperactive disorder (ADHD) and developmental coordination disorder (DCD); assess their association in Grade 1 children.

Setting: Two primary schools located within 30 km of the University of the Free State, Bloemfontein.

Methods: Attention deficit disorder or attention deficit hyperactive disorder (ADD/ ADHD) was assessed using the strength and weaknesses of ADD/ADHD symptoms normal behaviour rating scale (SWAN) and DCD using the Movement Assessment Battery for Children – 2 (MABC-2).

Results: One-hundred-and-ninety-five children (97 girls; 98 boys) aged 6 years to 8 years participated. MABC-2 and SWAN data were available for 195 and 182 children, respectively. Across both genders, 180 participants (92.3%) had no, 10 (5.1%) had moderate and 5 (2.6%) had severe motor difficulties. No statistically significant association (p = 0.1537) between gender and DCD was found. Similarly, 31 (17.0%) participants had ADHD subtype ADHD-I, 21 (11.5%) ADHD-H and 11 (6.0%) ADHD-C; no significant associations between gender and ADHD-I (p = 0.5579), ADHD-H (p = 0.4938) or ADHD-C (p = 0.7654) were found. There were no significant associations between DCD and the ADHD subtypes ADHD-I (p = 0.2956), ADHD-H (p = 0.7570) and ADHD-C (p = 1.000).

Conclusion: Prevalence of DCD in the current study is higher than elsewhere in the world. No significant association between DCD and ADHD was found.

Contribution: The relatively high prevalence of DCD in this South African population and its significance in the motor development of young children.

Keywords: Movement Assessment Battery for Children – 2; Strength and Weaknesses of ADD/ADHD Symptoms Normal Behaviour rating scale; disorder of attention; Motor Control and Perception; Developmental Coordination Disorder; Attention-deficit hyperactive disorder.

Introduction

Neurodevelopmental disorders such as attention-deficit hyperactivity disorder (ADHD) and developmental coordination disorder (DCD) are commonly seen in children (Kaiser et al. 2015; Pila-Nemutandani, Pillay & Meyer 2018; Villa, Barriopedro & Ruiz 2020). Villa, Ruiz and Barriopedro (2019) found that a variety of studies estimated that between 30% and 50% of children had ADHD in conjunction with DCD. An overlap of ADHD and DCD in the same child (Blank et al. 2019) has been called a deficit in attention, motor control and perception (DAMP) (Henderson, Sugden & Barnett 2007). In Scandinavian countries, the concept of DAMP emphasises the notion of motor deficits within the ADHD spectrum. Disorder of attention, motor control and perception can be described as an assortment of motor control and perceptual problems in unification with attentional problems among children without mental retardation or cerebral palsy being present (Pila-Nemutandani et al. 2018).

According to the American Psychiatric Association (APA) – *Diagnostic and Statistical Manual of Mental Disorders*, 5th Text Revised™ [DSM-5-TR™] (2022), ADHD is seen as a persistent pattern of inattention and/or hyperactivity impulsivity that interferes with the functioning or the development of the child, and DCD is defined as a serious and persistent impairment in the motor coordination

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development, but not because of intellectual retardation, pervasive developmental disorders or any other neurological disorders. Both disorders represent a heterogeneous condition (Lust et al. 2022; Meyer & Sagvolden 2006) and can manifest early during the developmental phase of children, even before the child enters formal education, namely at 7 years for ADHD (DSM-5-TR™ 2022; Villa et al. 2020) and at age 3 for DCD (Cantell, Smyth & Ahonen 1994). For ADHD, the following subtypes are described by the DSM-5 (2022), namely attention-deficit hyperactive predominantly inattentive (ADHD-I), attention-deficit hyperactive predominantly hyperactive-impulsive (ADHD-H) and attention-deficit hyperactive disorder combined (ADHD-C). Developmental coordination disorder, too, is thought to consist of subtypes and can be differentiated on the basis of more severe difficulties in both gross-motor performance and fine-motor performance (Lust et al. 2022).

The DSM-5-TR™ (2022) states that ADHD and DCD have a prevalence, respectively, of 7% and 5% worldwide. The DSM-5-TR™ (2022) and Schellack and Meyer (2016) are of the opinion that the fluctuation in ADHD prevalence in various regions might be because of the different diagnostic and methodological practices used to diagnose ADHD. For example, De Milander et al. (2020) report a study on 382 participants between the ages of 6 to 8 in Bloemfontein, South Africa, and found that 95 participants (24.9%) had ADHD symptoms. According to Willcutt (2012), ADHD affects 5.9% to 11.4% of schoolage children in America where the prevalence's varies with age, with 11.4% between the ages of 6–12, and decreasing to 8% between the ages of 13–18.

On the other hand, Ferguson et al. (2013) stated that the prevalence of DCD in South Africa is unknown, and that many children might experience problems with motor coordination especially those in low socio-economic environments. Pienaar (2004) in a study of 688 children (338 boys and 350 girls; 10 to 12 years of age) from a low socio-economic status (SES) in the North-West province of South Africa reported a high DCD prevalence of 61.2%. The researcher concluded that the norms of the Movement Assessment Battery for Children should be adjusted for the South African population (Pienaar 2004). One reason for the low motor performance of these children might be their lack of practice, which is referred to in the literature as the practice-deficit hypothesis. In a study conducted by De Milander, Coetzee and Venter (2014) in 559 children (321 girls and 238 boys, ages 6 to 8 years, most from a high SES background) in Bloemfontein, South Africa, 15% of the children had moderate to severe motor difficulties. Similarly, in a study done by Du Plessis et al. (2020) in 242 learners aged 6 to 8 years in the same province but in a low socio-economic environment, 9.9% of children were identified with possible DCD.

Research suggests that boys have a higher prevalence of ADHD and DCD than girls. In the United States of America (USA), the boy:girl ratio for ADHD of 2:1 has been reported (DSM-5-TR™ 2022), while Willcutt (2012) reported a slightly higher ratio of 3.6:1 for children between the ages of 6–12 years, similar to the ratio of 4:1 reported by Roth et al. (2017). For South Africa, Meyer and Sagvolden (2006) reported a 3:1 boy:girl ratio of ADHD. Similar results were obtained by Du Toit and Pienaar (2014) who estimated the boy:girl ratio as 3:1, but Willcutt (2012) indicated that older children between the ages of 13–18 years had a 5.6–1 ratio. The prevalence of DCD is also higher in boys than in girls; boy:girl ratios for DCD range from 3 to 4:1 (Rivard et al. 2007). In South Africa, Wessels, Pienaar and Peens (2008) found the ratios to be 2 to 3:1, but according to De Milander et al. (2014), it was 1.6:1; in fact, Du Plessis et al. (2020) found no difference in the prevalence of DCD between boys and girls.

Regarding the various ADHD-subtypes, the systematic literature review of Willcutt (2012) identified 86 studies on children and adolescents (N = 163 688 participants) and 11 studies on adults (N = 14 112), confirming that boys are more at risk of ADHD than girls: Children between the ages of 6–12 diagnosed with ADHD-C have a boy-girl ratio of 3.6:1, while for the ADHD-H subtype the ratio is 2.3:1 and for the ADHD-I subtype it is 2.2:1. Furthermore, Willcutt (2012) found that the highest prevalence is the ADHD-I subtype (5.1%) followed by ADHD-C subtype (from 3.3%) and the ADHD-H subtypes (2.9%) during the age of 6–12 years. APA (2013) stated that girls are more likely to be diagnosed with the inattentive type than boys.

Children with ADHD and DCD tend not to excel in a variety of academics tasks such as spelling, reading, arithmetic and writing tasks (Cheatum & Hammond 2000; Prunty et al. 2016) as well as in sports (Asonitou et al. 2012; Edwards et al., 2011; Kaiser et al. 2015; Winson & Fourie 2020). According to Kaiser et al. (2015), social interaction of children with ADHD with their peers is affected because of impulsivity or hyperactivity, and Fliers et al. (2010a) as well as Winson and Fourie (2020) state that the children with DCD experience complications in their social life. Children with ADHD are easily distracted (Kern et al. 2015; Roth et al. 2017), which may lead to inappropriate behaviour, children tend to be talkative and may be disruptive (Kern et al. 2015). Similarly, Le Roux (2018, cited in Winson & Fourie 2020) explains that children with DCD finds it hard to know when or how to start a conversation when they can interrupt the current conversation and struggle to keep up with the conversation taking place.

Children with ADHD and DCD are frequently excluded by peers (Riley et al. 2006), which reduces their physical activity (Jarus et al. 2011, Ferguson et al. 2013) and strength (Rivillis et al. 2011), and this increases the risk of being overweight or obese (Rivilis et al. 2011) and poor cardiovascular endurance (Martins et al., 2021; Rivilis et al. 2011). Ultimately this can result in a low self-image (Cheatum & Hammond 2000; Kaiser et al. 2015; Neto et al. 2015; Riley et al. 2006; Winson & Fourie 2020).

Arango (2015) found that the coordination levels of children with ADHD medicated with methylphenidate (Ritalin or

Concerta) and children with ADHD and DCD had lower motor performance compared to peers without medication or peers described as 'typical/normal development' (TD). Therefore, it is of interest to conduct research on the motor skills of children with ADHD, in particular those who are not on medication or not even sure they have ADHD, to understand the relationship between ADHD and motor deficits.

The purpose of the present study was to determine the prevalence of ADHD and possible DCD and to assess the association between ADHD symptoms with possible DCD in Grade 1 boys and girls in the Bloemfontein area, Free State province, South Africa.

Research methods and design

Study design

This study made use of quantitative data. The study involved one testing procedure by means of the Movement Assessment Battery for Children-2 (MABC-2) Performance Test in order to identify possible DCD among Grade 1 children. Twelve Movement Specialists-in-training, had to undergo rigorous training to use the measuring instrument and tested the participants at their school during the Physical Education periods in order to not interfere with their academic time. Each Movement Specialists-in-training was responsible for one of the eight subtests, age band 1 and 2 in order to have reliability across the study. The cut-off scores used in this study were based on Henderson et al. (2007) guidelines, which can be stated as follows: children having no motor difficulties (>15th percentile), moderate difficulties (5th–15th percentile) and severe motor difficulties (≤ 5th percentile). Furthermore, the teachers of each participant were asked to complete the Strength and Weaknesses of attention-deficit disorder (ADD)/ADHD Symptoms Normal Behaviour rating scale (SWAN) rating questionnaire, which were established by Swanson et al. (2001) for teachers and parents to judge if the Grade 1 learners may have symptoms of ADHD (Swanson et al. 2001). However, no formal diagnosis was made by a clinician.

Participants: Children

This was a convenience sample, conducted at two mainstream primary schools. The two participating schools were located within 30 km radius of the University of the Free State in Bloemfontein and were from a high socio-economic environment.

The DSM-5-TR™ (2022) was used to exclude children who had associated symptoms according to the criteria for DCD as stated in the DSM-5-TR™. Children with motor difficulties should not meet criterion C (disturbance is not because of a general medical condition, e.g., cerebral palsy, hemiplegia or muscular dystrophy and does not meet criteria for a pervasive developmental disorder) or criterion D (if mental retardation is present, the motor difficulties are in excess of those usually associated with it). None of the children met these criteria, and, therefore, all of the children were included for further data analysis.

Participants: Teachers

The SWAN was used to determine ADHD symptoms (either the inattentive, hyperactive or combined subtypes of ADHD). The principal investigator explained the procedure to the head of the department (HOD) at each school, and each HOD had to explain the completion of the SWAN rating scale to the Grade 1 teachers. For the teachers to be familiar with each child in the classroom, she and/or he had to observe them for 6 months. According to APA (2013), symptoms of ADHD should be present for at least 6 months before a child can be identified with ADHD. Each class had between 25 and 32 children. The teachers had 1 month to evaluate the children in their personal time; they were notified in advance that they will not receive any compensation for participation in the study and they could withdraw from the study at any time.

Measuring instruments

Movement Assessment Battery for Children-2 (MABC-2 Performance Test)

The MABC-2 was used in this study, and the procedure is the same as discussed elsewhere (De Milander, Coetzee & Venter 2016). The MABC-2 performance test requires learners to conduct a sequence of motor tasks in a specified manner (Henderson et al. 2007). In addition to age-related norms, the test also provides qualitative information on how children should approach and perform the tasks. The MABC-2 test is used to evaluate the motor ability levels of the learner and to identify DCD in learners. The performance test contains 24 items organised into three sets of eight tasks. Each set is designed for use with learners of a different age band. The current study used age band 1 and age band 2. The eight tasks are grouped under three headings, namely manual dexterity (MD), balance (B) and aiming and catching (AC). Age-adjusted standard scores and percentiles are provided, in addition to a total test score for each of these three components of the performance test. In order to interpret the total test score, one can make use of a 'traffic light' system. The green zone indicates performance in a normal range, thus indicating a score above 67 (> 15th percentile), whereas the amber zone indicates that a child is at risk, between 57 and 67, and needs to be monitored (5th to 15th percentile). The red zone is a suggestion of definite motor impairment, up to and including 56 (≤ 5th percentile). Consequently, high standard scores on the MABC-2 performance test represent good performance. The MABC-2 (performance test) was used instead of the checklist, as it is only used for screening purposes of bigger groups by means of a teacher or parent. The MABC-2 test is a valid and reliable tool to use with a reliability coefficient for the total test scores of 0.80 (Henderson et al. 2007).

Strength and weaknesses of attention-deficit disorder or attention-deficit hyperactive disorder symptoms normal behaviour rating scale

The SWAN rating scale, developed by Swanson et al. (2012), was used during this study and the procedure is described by De Milander et al. (2020) in a similar study. The SWAN comprises 18 questions or statements on which the learner is rated by the teacher. The questionnaire needs to be finalised after a period of 6 months of formal schooling in order to ensure that the teachers are familiar with each learner in his or her classroom (Swanson et al. 2012). This recommendation was applied in the current study. When completing the scale, a value of 1 is allocated if the answer to the statement is 'not at all' or 'just a little' and 0 if the answer is 'quite a bit' or 'very much'. The total of numbers allocated to the statements is then summated, and if the sum is ≥ 6 for questions 1–9, the learner is likely to have symptoms of the inattentive subtype attention deficit disorder or attention deficit hyperactive disorder (ADD/ ADHD). If the sum is ≥ 6 for statements 10–18, the learner is likely to have symptoms of the hyperactive or impulsive subtype ADD/ADHD. If the sums of both groups of statements (1–9 and 10–18) are ≥ 6, the learner is likely to have symptoms of the combined subtype ADD/ADHD. If neither adds up to ≥ 6, the learner is unlikely to have symptoms of ADD/ADHD or the symptoms are controlled with medication (Swanson et al. 2012). The psychometric properties of the SWAN were reconfirmed by recent studies (Lakes et al. 2012).

Data analysis

The principal researcher used a Microsoft Excel spreadsheet to capture data from the SWAN and the MABC-2 Performance tests electronically. Categorical data were summarised descriptively using frequencies and percentages. Fisher's exact test was performed to test the association between the variables gender, degree of motor difficulty and ADHD subtype. The data were analysed using SAS statistical software (SAS 2017).

Ethical considerations

Permission from the Department of Education of the Free State province was obtained to conduct the research at the various schools. Furthermore, permissions were obtained from each principal in order to conduct the research on the school grounds during the Physical Education periods, so to prevent the loss of any academic learning time. Approval for the study was obtained from the Ethics Committee of the Faculty of Health Sciences, University of the Free State (ECUFS 111/2015). Informed consent was provided by either the parents or legal guardians of all the participants. Finally, each child participating in the study signed an assent form. The participants' privacy was respected, and his or her participation was voluntary. They could withdraw from the study at any time without being concerned that they might be penalised in any way.

Results

A total of 195 learners, 98 boys and 97 girls, took part in the study. The mean age of learners was 7.2 years (standard deviation [s.d.] 0.34; range 6.4–8.5 years). Movement Assessment Battery for Children-2 scores were available for all 195 children. Strength and Weaknesses of ADD/ADHD Symptoms Normal Behaviour rating scale scores were obtained for 182 learners, namely 90 boys and 92 girls; 12 learners did not have SWAN scores because they were absent from the school during the testing procedure.

Table 1 provides the cross-tabulation of participants by gender and MABC-2 category. Green indicates no motor difficulties, amber indicates moderate motor difficulties and red indicates severe motor difficulties There is no significant association (p = 0.1537) between gender and DCD.

The cross-tabulations of gender and ADHD subtypes are shown in Table 2.

According to the results shown in Table 2, the prevalence of ADHD ranged from 17% for ADHD-I to 6% for ADHD-C. Furthermore, there are no significant associations between gender and ADHD-I (p = 0.5579); ADHD-H (p = 0.4938) or ADHD-C (p = 0.7654) according to Fisher's exact test.

TABLE 1: Cross-tabulation of participants by gender and Movement Assessment Battery for Children - categories (N = 195).

Gender	*n*	MABC-2 category						*p*†
		Red		Amber		Green		
		n	%	*n*	%	*n*	%	
Female	97	3	3.1	2	2.1	92	94.8	0.1537
Male	98	2	2.0	8	8.2	88	88.8	-
Total	**195**	**5**	**2.6**	**10**	**5.1**	**180**	**92.3**	**-**

MABC – 2, Movement Assessment Battery for Children – 2.
†, Fisher's exact test.

TABLE 2: Cross-tabulation of participants by gender and attention-deficit hyperactive disorder subtype (N = 182).

Gender	Variables				*p*†
	No		Yes		
	n	%	*n*	%	
ADHD-I					
Female	78	84.8	14	15.2	0.5579
Male	73	81.1	17	18.9	-
Total	151	83.0	31	17.0	-
ADHD-H					
Female	83	90.2	9	9.8	0.4938
Male	78	86.7	12	13.3	-
Total	161	88.5	21	11.5	-
ADHD-C					
Female	87	94.6	5	5.4	-
Male	84	93.3	6	6.7	0.7654
Total	171	94.0	11	6.0	-

ADHD, Attention-deficit hyperactive disorder; ADHD-I, inattentive; ADHD-H; hyperactive; ADHD-C; Combined.
†, Fisher's exact test

TABLE 3: Cross-tabulation of participants by attention-deficit hyperactive disorder subtype and Movement Assessment Battery for Children-2 category (N = 182).

ADD/ADHD category	MABC-2 category						*p*†
	Red		Amber		Green		
	n	%	*n*	%	*n*	%	
ADHD-I							0.2956
No	4	2.7	6	4.0	141	93.3	-
Yes	0	0.0	3	9.7	28	90.3	-
ADHD-H							0.7570
No	4	2.5	9	5.6	148	91.9	-
Yes	0	0.0	0	0.0	21	100.0	-
ADHD-C							1.0000
No	4	2.3	9	5.3	158	92.4	-
Yes	0	0.0	0	0.0	11	100.0	-

ADHD-I, inattentive; ADHD-H; hyperactive; ADHD-C; Combined; MABC, Movement Assessment Battery for Children; ADHD, Attention-deficit hyperactive disorder.
†, Fisher's exact test.

Table 3 is a cross-tabulation of the learners by ADHD subtype and the degree of motor difficulties. It is interesting to note that the four learners with severe motor difficulties (red zone) had no ADHD, while of the nine learners with moderate motor difficulties (amber), only three had ADHD-I, but none had ADHD-H or ADHD-C. In fact, there were no significant associations between the ADHD subtypes and degree of motor difficulty.

Discussion

The purpose of this study was to determine the prevalence of ADHD and possible DCD and to assess the association between ADHD symptoms with possible DCD in Grade 1 boys and girls.

Attention deficit disorder or attention deficit hyperactive disorder

The results regarding ADHD/ADD indicate that most of the learners did not fulfil the criteria for the various subtypes. Additionally, there were no significant associations between gender and the prevalence of the various ADHD subtypes in the current study. This contrasts with most of the literature indicating that ADHD prevalence differs between boys and girls. For example, Kaiser et al. (2015) conducted a systematic review and found that from the 45 articles for review, 15 articles only included boys, indicating that boys are diagnosed more with ADHD compared to their female counterparts. According to Kaiser et al. (2015), the boy:girl ratio of ADHD is about 2.3:1 although some studies have reported higher or lower values. In South Africa, Meyer and Sagvolden (2006) reported a 3:1 boy:girl ratio of ADHD, as did Du Toit and Pienaar (2014). This sample is from a school in a high socio-economic background, which would suggest that the school's children are well nourished and exposed to mental stimulation, which generally assists with improved cognitive functioning. Note, however, that our study used a population-based convenience sample, not a clinical sample. In addition, we only made use of the SWAN questionnaire, which were completed by teachers, who are not clinicians while the articles that have been reviewed made use of the DSM-IV-TR criteria.

Many arguments support the hypothesis that a shortage of attention is the primary mechanism for the motor skills difficulty. One of the most frequent comorbid disorders cited by these authors for ADHD is DCD.

Developmental Coordination Disorder

The current study indicated that 10.2% of boys compared to 5.2% of girls had possible motor difficulties (amber and red zone); however, the difference between genders was not significant (0.1537). Thus, 7.7% of the total group was identified with possible DCD. This prevalence is about 50% higher than the prevalence of 5% cited by the APA (2022). As stated earlier, Ferguson et al. (2013) stated that the percentage of DCD among the children in South Africa is unknown. However, De Milander et al. (2014) found that the prevalence of DCD was 15% in a high Socio-Economic Environment (SEE), while Du Plessis et al. (2020) found a prevalence of 9.9% in a low SEE.

Corresponding with ADHD, the articles that have been reviewed used the DSM-5-TR™ (2022) criteria to determine DCD and the current study excluded criteria B, which states that Criteria A significantly and persistently interferes with academic or school productivity. The performance test was conducted by trained movement specialists and therefore the term possible DCD is used. In addition, this was also a population-based sample. According to Harvey et al. (2007), children with ADHD scored significantly lower regarding balance as well as activities involving speed compared to the typically developing (TP) children; however, this was not evident in the current study.

Attention deficit hyperactive disorder symptoms with possible developmental coordination disorder

In contrast with the relevant literature, the current study found no significant association between the various ADHD/ADD subtypes and DCD. According to previous studies, 30% – 70% of children with ADHD have motor control problems (Brossard-Racine et al. 2012; Fliers et al. 2010b; Hyunjin et al. 2014; Pitcher Piek, & Hay, 2003).

According to Hyunjin et al. (2014), children with ADHD displayed lower performance on a variety of motor subtests; the subtests that were also used in the current study were manual dexterity and balance since they are two sub-tests of the MABC-2.

De Castro Magalhães et al. (2015) claim that DCD goes unrecognised in developing countries such as South Africa. Norm-referenced measurements that are reliable and valid (Blank et al. 2019) have been developed in Western Europe or North America (Smits-Engelsman et al. 2022). De Castro Magalhães et al. (2015) raise the question of whether these measurements would be valid in other countries. There is a lack of motor proficiency tests that are validated for learners in African countries (Smits-Engelsman et al. 2022). The study sample consists of children in an urban environment, which might contribute to the relatively poor motor skills shown by some children since they might not be exposed to enough space for physical activity.

Limitations

The current study did not recruit children from rural regions and only used children from the Bloemfontein metropolitan area. Moreover, this study was a population-based sample, and therefore criterion B of the diagnostic criteria for DCD was not used and states that children's academic performance should also be considered (APA 2022). Henceforward, the study should be replicated using various provinces and regions in South Africa to provide more generalisable and robust results.

Conclusion

The prevalence of DCD in the current study is higher compared to other parts of the world. This finding suggests that teachers and occupational therapists should be aware of the condition and try to identify children affected by it. In contrast, the current study found no significant association between the DCD and ADHD.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

M.W., J-P.B., S-L.F., H.R.J & L.v.d.B were the researchers who obtained all the data for the study and compiled it, and also wrote the original report for their undergraduate study. M.de M asked R.S to redo the statistics for the current version of the article. M.de M wrote the article and R.S assisted with the editing for possible publication. The final version of the article was approved by all the authors.

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Data availability

The data that support the findings of this study are available from the corresponding author, M.de M., upon reasonable request.

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