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Identifying developmental coordination disorder: MOQ-T validity as a fast screening instrument based on teachers' ratings and its relationship with praxic and visuospatial working memory deficits.

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Abstract

The present study was devoted to test the validity of the Italian adaptation of the Motor Observation Questionnaire for Teachers (MOQ-T, Schoemaker, Flapper, Reinders-Messelink, & De Kloet, 2008) as a fast screening instrument, based on teachers' ratings, for detecting developmental coordination disorders symptoms and to study its relationship with praxic and visuospatial working memory deficits. In a first study on a large sample of children, we assessed the reliability and structure of the Italian adaptation of the MOQ-T. Results showed a good reliability of the questionnaire and a hierarchical structure with two first-order factors (reflecting motor and handwriting skills), which are influenced by a second-order factor (general motor function) at the top. In a second study, we looked at the external validity of the MOQ-T and found that children with symptoms of Developmental Coordination Disorder (children with high scores on the MOQ-T) also had difficulty reproducing gestures, either imitating others or in response to verbal prompts. Our results also showed that children with high MOQ-T scores had visuospatial WM impairments. The theoretical and clinical implications of these findings are discussed.

Keywords: developmental coordination disorder, DCD; visuospatial WM; handwriting; neurodevelopmental disorders; specific learning disorder, SLD; gesture reproduction.

Highlights

- The Italian version of the MOQ-T is a valid instrument for detecting DCD symptoms.
- Children with symptoms of DCD are severely impaired in gesture reproduction
- Children with symptoms of DCD have a moderately impaired visuospatial working memory.

Identifying developmental coordination disorder: MOQ-T validity as a fast screening instrument based on teachers' ratings and its relationship with praxic and visuospatial working memory deficits.

Developmental coordination disorder (DCD) is a chronic neurological disorder that can affect planning of movements and coordination. In the category of neurodevelopmental disorders, it is classified as a motor disorder, and characterized by a delayed acquisition of coordinated motor skills, beginning in the early stages of development, that persistently interferes with activities of daily living and cannot be adequately explained by intellectual or visual impairments (DSM-5, American Psychiatric Association, 2013). DCD has an estimated prevalence of 1.8%, with a male-to-female ratio of 1.9:1 (Lingam, Hunt, Golding, Jongmans, & Emond, 2009). The causes of DCD are still not entirely clear, possibly including perinatal (e.g. low birth weight; (see Edwards et al., 2011 for a review), genetic and physiological factors (see Blank, Smits-Engelsman, Polatajko, & Wilson, 2012).

Children with DCD may have a variety of dysfunctions. In particular, they may have problems with gross motor skills, such as imitating body positions, following motor commands or reproducing gestures in response to verbal prompts (e.g., Sinani, Sugden, & Hill, 2011), or with fine motor skills, such as grasping, dressing and handwriting (e.g., Biancotto, Skabar, Bulgheroni, Carrozzi, & Zoia, 2011), as well as psychosocial problems and difficulties in activities of daily living (Barnhart, Davenport, Epps, & Nordquist, 2003; Magalhães, Cardoso, & Missiuna, 2011).

Many of the difficulties that children with DCD encounter relate to visuospatial processing deficits, and problems with visual memory have been associated with DCD. For example, children with DCD have trouble drawing sequentially-presented geometrical patterns (Dwyer & McKenzie, 1994), and there is abundant evidence to confirm that the most often observed deficits in children with DCD involve visuospatial processing (Wilson & McKenzie, 1998). Children with DCD have working memory (WM) deficits too, particularly as far as visuospatial material is concerned (Alloway & Temple, 2007; Alloway, Rajendran, & Archibald, 2009). Overall, poor spatial abilities may give rise to other problems, such as illegible handwriting or poor drawing skills, that are often associated with DCD.

Questionnaires are often useful for the early diagnosis of DCD. Several questionnaires for parents and teachers are available for screening for DCD symptoms. They serve as a first step in the diagnostic process, and their use is recommended as a tool for collecting information on DCD symptoms (Blank et al., 2012), partly because assessing motor skills with objective measures such as the Movement ABC-2 (Henderson, Sudgen, & Barnett, 2007) may not be feasible in screening protocols due to the time and costs involved (Blank et al., 2012). Among the various questionnaires available, the Motor Observation Questionnaire for Teachers (MOQ-T) seems valuable as a screening tool for identifying children at risk of DCD (Jongmans, Smits-Engelsman, & Schoemaker, 2003), revealing good psychometric properties, sensitivity and specificity (Schoemaker et al., 2008). The Questionnaire is based on teachers' ratings and therefore seems particularly useful when population screenings are required and they must be carried out within the school system. Furthermore, research has showed that the Developmental Disorder Coordination Questionnaire (DCD-Q; Wilson, Kaplan, Crawford, Campbell, & Dewey, 2000), which has been successfully used for the identification of motor coordination disorders on the basis of parents' ratings, and the MOQ-T are highly correlated (r = -.64) (Schoemaker, et al., 2008). These findings suggest that the ratings obtained by the MOQ-T may be substantially confirmed by teachers ratings. Further research on the properties of the MOQ-T is still needed, however, especially as concerns its validity and its adaptation to different languages and countries.

The aim of the present study was to test the validity of the Italian adaptation of the MOQ-T as a fast screening instrument for detecting developmental coordination disorders symptoms and to study its relationship with praxic and visuospatial working memory deficits. In the first part of the study, the Italian version of the MOQ-T was administered to a large sample of children to assess its reliability and its factorial structure. In the second part, we administered a series of tests assessing ideomotor and praxic abilities, and visuospatial WM to a sample of children with or without symptoms of DCD based on the MOQ-T results to see whether or not children with scores in the clinical range on the MOQ-T also showed deficits in motor and visuospatial functions associated with DCD.

1 Study 1. Psychometric properties and factorial structure of the MOQ-T

The aim of the first study was to assess the psychometric properties of the Italian version of the MOQ-T. We performed an exploratory factor analysis (EFA), then used the results to perform a series of confirmatory factor analyses (CFA). We also investigated the reliability of the MOQ-T.

1.1 Method

1.1.1 Participants

A sample of 363 children was assessed by their teachers in the first study. Children and teachers were from Northern Italian schools. From 1 to 3 teachers completed the questionnaires for each child. There were 102 children in second grade (M_{age}=92.82 [3.49], females=40), 80 in third grade (M_{age}=105.09 [3.76], females=38), 81 in fourth grade (M_{age}=116.58 [4.81], females=43), and 100 in fifth grade (M_{age}=128.79 [3.44], females=51)[1].

1.2 Material & Procedure

1.2.1 The Motor Observation Questionnaire for Teachers (MOQ-T)

The MOQ-T is a questionnaire developed to help teachers identify children between 5 and 11 years old with DCD (Schoemaker, 2003). It contains 18 items regarding fine and gross motor functioning. It has revealed good psychometric properties, specificity and sensitivity for detecting symptoms of DCD (Schoemaker et al., 2008). The original was translated (and a back-translation was assessed by the author of the questionnaire) to develop the Italian version of the MOQ-T.

1.3 Results and Discussion

The factorial structure of the MOQ-T was assessed in two steps. In the first step, we performed an exploratory factor analysis (EFA) using a principal axis factor method (PAF) with a promax (oblique) rotation. After examining the Kaiser-Meyer Olkin measure of sampling adequacy, the sample was judged to be factorable (KMO =.936), and the Bartlett's test for sphericity was significant ($p < .001$), indicating that a factor analysis was appropriate. Two factors had eigenvalues greater than unity, and the presence of two factors was also confirmed by the scree-test (Cattell, 1966). The two factors (motor functioning and handwriting) correlated closely (.72), with 52.72% of the variance explained by the first and 5.4% by the second, for a total 58.26%. The two-factor structure of the scale was confirmed and the factor loadings were high and close to the original scale (Table 1; see also Schoemaker et al., 2008).

Table 1 about here

In the second step, the factor structure of the MOQ-T was assessed using a confirmatory factor analysis approach (CFA).[2] We tested several models (Figure 1): in the first, due to the strong correlation between the two factors identified with the EFA, we fitted a model with a single factor that provided a not entirely satisfactory fit with the data (Table 2); in the second model, with two factors, the fit of the model was satisfactory, all parameters of the model were significant (t-values > 1.96), and the model generated a lower Akaike information criterion (AIC) than the first model, meaning that the second model was more parsimonious. Importantly, the correlation between the two factors at latent level was quite high (i.e., .85). Due to the close correlation between the two factors, in a third model we performed a hierarchical CFA that was equivalent to model 2 in terms of fit, but differed in that the association between the two factors was replaced by a second-order factor (general motor factor; gMF). This last model indicated that the association between the first-order factors was determined by the gMF, consistently with other evidence in the literature of a hierarchical structure of motor abilities at primary school level (Schulz, Henderson, Sugden, &

Barnett, 2011). Since model 3 provided a good fit with the data and is theoretically plausible, we opted to retain it as the best model of the MOQ-T.

Finally, we calculated Cronbach's alpha as a measure of reliability, which proved to be very high (α =.95), confirming that the Italian adaptation of the MOQ-T has extremely good psychometric properties and the items are very closely interconnected.

Figure 1 about here

Table 2 about here

To sum up, our first study demonstrated that: (i) the factorial structure of the Italian version of the MOQ-T comprises two first-order factors (reflecting motor and handwriting skills), which are influenced by a second-order factor (general motor factor); and (ii) the MOQ-T has good psychometric properties. These results provided further support for previous reports on the good psychometric properties of the MOQ-T, and encouraged us to further examine the implications of the use of this questionnaire. Hence our second study to evaluate the discriminatory power of the MOQ-T.

2 Study 2. Discriminatory power of the MOQ-T

In the second study, we examined whether children with low scores on the MOQ-T revealed symptoms of DCD. In two groups of children, selected according to whether their MOQ-T scores were in the clinical range (experimental group) or in the normal range (control group), we ran a series of tests to measure ideomotor, praxic, and visuospatial WM to ascertain whether the two groups differed in performance, and to assess the magnitude of any difference[3].

2.1 Method

2.1.1 Participants.

Based on the results obtained with the MOQ-T in Study 1, we selected two groups of children matched for age, gender and socioeconomic status, but differing in their MOQ-T scores. All the children included in the second study were chosen because they had no other symptoms (e.g., specific learning disabilities or mental retardation). The two groups in Study 2 consisted of 23 participants each and were matched for gender and school grade (with 12 females, 11 males; 6 from the second, 6 from the third, 6 from the fourth, and 5 from the fifth grades). The experimental group consisted of children with MOQ-T scores in the clinical range (above the 85th percentile) and the control group consisted of children with scores in the normal range. The two groups did not differ statistically in terms of age [$F(1.44) = .013$, $p = .910$, $\eta^2_p < .001$] or socio-economic status [χ^2 (1, N=46) = 2.09, $p = .148$], while the difference in their MOQ-T scores was statistically significant [$F(1.44) = 62.76$, $p < .001$, $\eta^2_p = .588$]. Parental consent was obtained before assessing the children.

2.2 Materials & Procedure

2.2.1 Ideomotor and praxic abilities test

Ideomotor and praxic abilities test (BVN; Bisiacchi, Cendron, Gugliotta, Tressoldi, & Vio, 2005). Ideomotor and praxic abilities were assessed using a task that involved six symbolic gestures (e.g., the sign of the cross), six non-symbolic gestures (e.g., touching your nose with your forefinger), and six symbolic and non-symbolic facial gestures (e.g., whistling or sneezing), to be reproduced twice, 18 in response to verbal prompts and 18 by imitating the examiner, for a total of 36 gestures. To the best of our knowledge, these are the only tests on ideomotor and praxic skills with Italian norms for the type of sample considered in the present study. These tests are part of a complete neuropsychological battery for children between 5 and 11 years old that was validated in previous studies (Bisiacchi et al., 2005; Chiappedi, Bernardi, Toffola, & Bejor, 2010).

2.2.2 Forward and Backward Corsi blocks test

The material, used in its standardized Italian adaptation (BVS; Mammarella, Toso, Pazzaglia, & Cornoldi, 2008) of Corsi's original version (Corsi, 1972), comprises nine blocks on a board. Participants were asked to recall a sequence of blocks just indicated by the experimenter in the same (forward) or in reverse (backward) order. There were two trials for each level of difficulty (from 2 to 8). If the child failed both trials at a given level, the test was stopped. For scoring purposes, items on the second level of difficulty scored 2 points, on the third level 3 points, and so on. The final scores corresponded to the sum of the last three correct answers. For instance, a participant who gave correct answers in two trials on the fourth level of difficulty and one on the fifth scored 4+4+5=13.The test has a good reliability and validity (Mammarella et al., 2008).

2.3 Results & Discussion

Descriptive statistics for the two groups and the standardized differences between them (expressed as Cohen's *d*) are given in Table 3.

A one-way multivariate analysis of variance (MANOVA) comparing the experimental and control groups' ideomotor/praxic skills in response to verbal prompts (symbolic, non-symbolic, and facial gestures) revealed a significant effect, with a high multivariate effect size [$F(3, 42) = 27.95$, $p < .001$; *Wilk's* $\lambda = .334$, $\eta^2_p = .666$]. A series of follow-up ANOVAs on each variable and the total test score showed that all differences were significant, with large effect sizes (Table 3): in symbolic gestures [$F(1, 44) = 16.99$, $p < .001$, $\eta^2_p = .280$], non-symbolic gestures [$F(1, 44) = 71.10$, $p < .001$, $\eta^2_p = .620$], in facial gestures [$F(1, 44) = 11.57$, $p < .001$, $\eta^2_p = .208$], and in the total test score [$F(1, 44) = 49.13$, $p < .001$, $\eta^2_p = .528$].

As for the children's ideomotor/praxic skills in terms of their ability to imitate the symbolic, non-symbolic, and facial gestures, MANOVA revealed a significant effect, with a high multivariate effect size [$F(3, 42) = 14.89$, $p < .001$; *Wilk's* $\lambda = .485$, $\eta^2_p = .515$]. A series of follow-up ANOVA on each variable and on the total score showed that, here again, all differences were significant with large effect sizes (Table 3): in symbolic gestures [$F(1, 44) = 16.23$, $p < .001$, $\eta^2_p = .269$], non-symbolic gestures [$F(1, 44) = 12.76$, $p = .001$, $\eta^2_p = .225$], facial gestures [$F(1, 44) = 5.88$, $p = .019$, $\eta^2_p = .118$], and total test score [$F(1, 44) = 35.92$, $p < .001$, $\eta^2_p = .449$].

Finally, we performed a MANOVA to test differences in visuospatial WM between the experimental and control groups (using the Forward and Backward Corsi Blocks test), which revealed a significant effect with a medium effect size [$F(2, 43)=3.93$, $p=.027$; *Wilk's* $\lambda=.845$, $\eta^2_p=.155$]. We also ran two separate follow-up ANOVA and found a significant difference in both the Forward Corsi [F(1, 44)=4.57, p=.038 , η^2_p=.094], and the Backward Corsi [F(1, 44)=7.18, p=.010, η^2_p=.140] tests, with medium effect sizes (Table 3).

Table 3 about here

To sum up, our second study showed that: (i) children with symptoms of DCD on the MOQ-T were also found impaired in their ability to reproduce gestures by imitating an experimenter or in response to verbal prompts, with large differences in both cases, but particularly in the latter (verbal prompting); and (ii) children with DCD symptoms also showed deficits in visuospatial WM, but the magnitude of the difference vis-à-vis controls was moderate.

General discussion

The present study was designed to test the validity of the Italian adaptation of the MOQ-T as a fast screening instrument for detecting developmental coordination disorders symptoms (on the basis of teachers' ratings) and to study its relationship with praxic and visuospatial working memory deficits. Our results confirmed that the MOT-Q is a very useful tool for detecting children with symptoms of DCD. We provide evidence of its good psychometric properties and empirically support to confirm its hierarchical structure with two second order factors, which were already identified in the original study (Schoemaker et al., 2008). We also provide evidence of the discriminatory power of the MOQ-T by showing that children with high scores in the MOQ-T also had deficient ideomotor and praxic skills and a moderately impaired visuospatial WM.

As far as the factorial structure of the MOQ-T is concerned, our findings are consistent with evidence of a substantial correlation between motor function and handwriting skills in primary school children. This correlation could be explained by a second-order factor representing general motor abilities. The existence of such a second-order general factor in the model supports the impression that children of this age tend to have a similar performance in the two domains (i.e. motor and handwriting), suggesting a marked continuity in the developmental processes governing their motor abilities. These results are consistent with the findings of a study on the factor structure of the movement ABC-2, which is the most widely used test for assessing individuals for DCD (Barnett, 2008), and which also has a hierarchical structure of motor abilities, with a second-order factor representing general motor skills (Schulz et al., 2011).

As for the discriminatory power of the MOQ-T, we found that children with clinical MOQ-T scores revealed symptoms of DCD in several other tests too. In particular, there were large differences between these children and controls in tasks assessing the reproduction of symbolic, non-symbolic and facial gestures, both in response to verbal prompting and when asked to imitate the examiner. These findings are consistent with a large body of evidence indicating that children with DCD are weak in gesture reproduction (e.g., Hill, 2008). In terms of effect size, we found that 67% and 52% of the variance in gesture reproduction in response to verbal prompts or by imitating others were explained by group differences, which is in line with evidence of children with DCD struggling especially with the reproduction of gestures in response to verbal instructions (Zoia, Pelamatti, Cuttini, Casotto, & Scabar, 2002). We also found that children with DCD symptoms had significant visuospatial WM deficits, although the magnitude of this difference was not large, as emerged from the effect size reported in other studies (e.g., Alloway et al., 2009).

Our study has both theoretical and clinical implications. From a theoretical point of view, the present results confirm that children with symptoms of DCD also have a number of problems with gesture reproduction and visuospatial WM. Their considerable difficulty in reproducing gestures by imitating others or in response to verbal prompts was to be expected because the questionnaire also examines these aspects. But we also found evidence of deficits in visuospatial WM, an aspect not directly tested in the questionnaire. As for the clinical implications of our findings, screening questionnaires like the MOQ-T can be very important as a first step in the process for diagnosing DCD. It is worth noting, however, that the MOQ-T was not developed for use as a population-based screening tool, and it is not sufficiently sensitive for this purpose; the MOQ-T has a good sensitivity when applied to children already identified as being at risk of DCD.

DCD is a condition that warrants special attention because of its negative impact on schooling and activities of daily living (Magalhães et al., 2011). There is abundant evidence to show that children with DCD participate less in activities generally (Magalhães et al., 2011); they often suffer from depression, anxiety and psychosocial distress (Missiuna et al., 2014; Pearsall-Jones, Piek, Rigoli, Martin, & Levy, 2011). The early diagnosis of DCD is fundamental in order to prevent the problems often associated with this condition (e.g., anxiety and depression) from developing. The MOQ-T can be used effectively as a first step in the diagnostic process, after which children suspected of having DCD should be assessed with an objective motor test, such as the movement ABC to confirm their diagnosis, and a physician should investigate whether the other diagnostic criteria are met.

Although it contains some insightful findings, the present study has some limitations. First, although questionnaires like the MOQ-T are useful tools, their predictive power depends largely on the teacher’s experience and abilities and on children’s behavior observed at school. Teachers have the opportunity to observe children and their motor skills in a real-life setting, but not all teachers are trained to detect DCD symptoms (Larkin & Rose, 2005). We believe that teachers should be given support and training before they administer the MOQ-T. It must be noticed, however, that the facts that the MOQ-T scores positively correlate both with parents’ ratings (Schoemaker, et al., 2008) and, in present study, with objective praxic and spatial memory measures offer support to the generalizability of MOQ-T data. Second, learning and attentional problems very often occur together in children with DCD (Dewey, Kaplan, Crawford, & Wilson, 2002; Kaplan, Wilson, Dewey, & Crawford, 1998), but the MOQ-T does not consider these issues, which need to be assessed by other means. Third, the children considered in the present study had been referred by teachers because they were suspected of having symptoms of DCD, but they had not been further assessed and no clinical diagnosis had been established, so the results of Study 2 need to be replicated with children who have received a proper diagnosis.

In conclusion, despite some limitations, the present study produced some interesting results and confirms that the MOQ-T is a very useful screening tool. We demonstrated that a simple questionnaire can be very powerful in detecting motor coordination disorders and may provide clinicians with important evidence of DCD symptoms, although a full examination (possibly including interviews, observation and the use of a standardized individual assessments of motor functioning) is necessary for a definitive diagnosis.

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Footnotes

[1] Children with special needs are included in normal classes in Italian schools, and a small proportion (about 3.3%) of the children in our sample were certified as having various special needs. However, results are consistent and do not change markedly when these children are excluded from the sample.

[2] Since we were dealing with ordinal data, we opted for the robust OLS method (as recommended in the LISREL manual for ordinal data), and the Satorra-Bentler scaled correction because it provides an adjusted, more robust measure of fit for non-normal data (Hu, Bentler, & Kano, 1992). Model fit was assessed using various indices following the criteria suggested by Hu and Bentler (1999). In particular, a model was judged to have a good fit if it had: a non-significant Satorra-Bentler chi-square ($\chi_{S\text{-}B}^2$); a root mean square error of approximation (RMSEA) nearing .06; a standardized root mean square residual (SRMR) ≤ .08; a non-normed fit index (NNFI) and a comparative fit index (CFI) ≥ .96. The Akaike information criterion (AIC) was used to compare the fit of non-nested models. It is worth noting that non-significant values are desirable for the chi-square, but with large sample sizes even slight deviations can result in a significant value, so we considered as acceptable models with a significant chi-square but a good fit in all the other indexes.

[3] Several effect sizes were calculated (Cohen, 1988). Cohen's *d* is a measure of effect size (ES), and effect sizes of 0.2-0.3 are considered "small", those around 0.5 "medium" and those from 0.8 to infinity "large". Finally, partial eta squared values from .01 to.06 are considered "small", those between .06 and .14 "medium" and those higher than .14 "large".

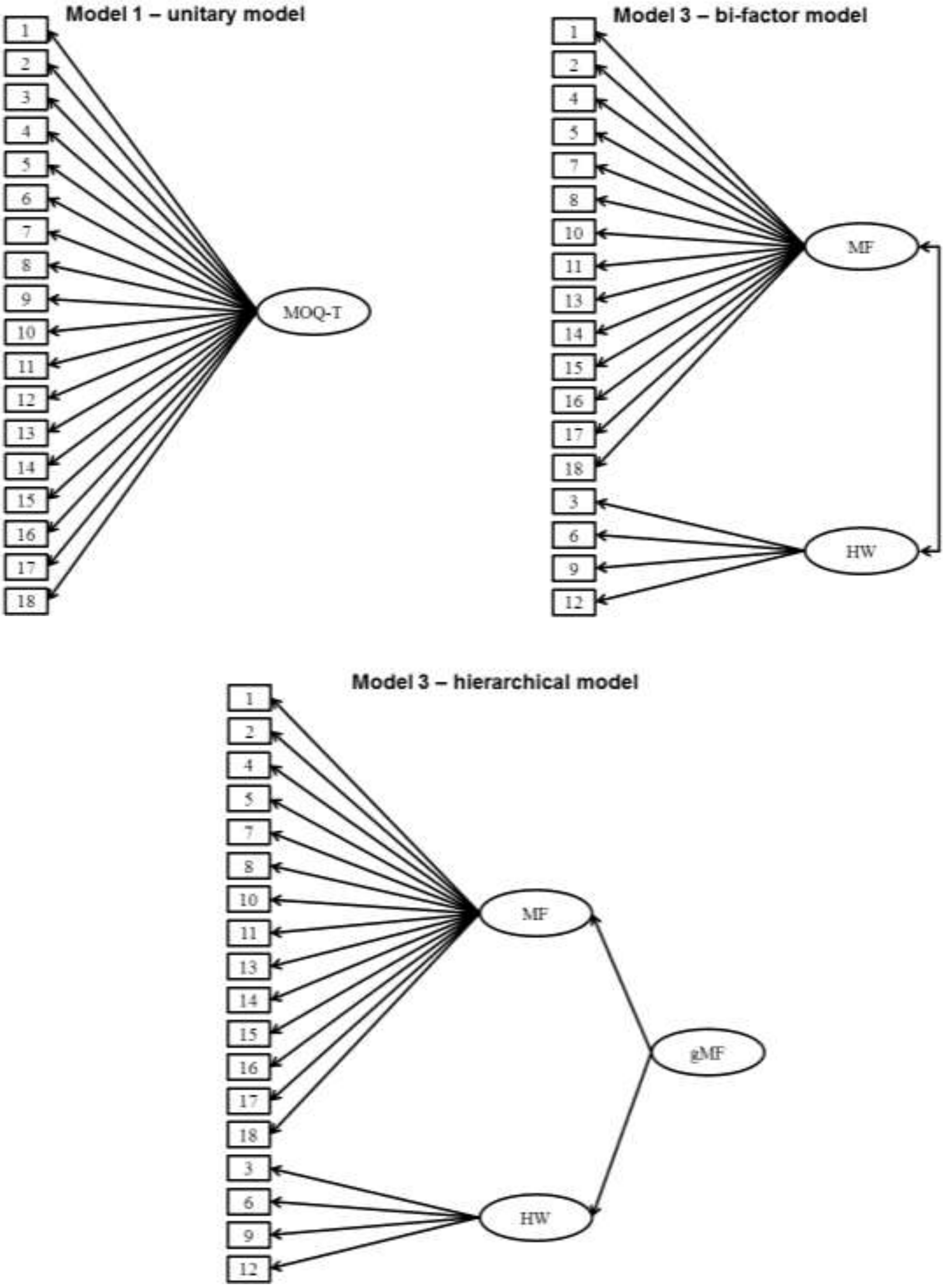

Figure 1. Different CFA models for the MOQ-T. MF, motor functioning; HW, handwriting; gMF, general motor factor.

Table 1

Factor loading in the factor analysis (PAF) with an oblique rotation (Promax) on the MOQ-T

Item	Factor	
	1	2
1	.62	
2	.86	
3		.89
4	.64	
5	.60	
6		.79
7	.43	
8	.68	
9		.62
10	.83	
11	.69	
12		.94
13	.71	
14	.78	
15	.71	
16	.57	
17	.82	
18	.51	

Note. Loadings lower than .35 were not reported. Factor 1, general motor factor; Factor 2, handwriting factor.

Table 2

Fit indexes for various CFA models of the MOQ-T

Model	$\chi^2_{S\text{-}B}$(df)	RMSEA	SRMR	CFI	NNFI	AIC
1	436.83(135)*	.08	.06	.99	.99	508.83
2	269.01(134)*	.05	.05	.99	.99	343.01
3	269.01(134)*	.05	.05	.99	.99	343.01

Note. $\chi^2_{S\text{-}B}$, Satorra-Bentler scaled chi-square; RMSEA, root mean square error of approximation; SRMR, standardized root mean square residuals; CFI, comparative fit index; NNFI, non-normed fit index; AIC, Akaike Information Criterion.

* $p < .001$

Table 3

Descriptive statistics and Cohen's d for the control and experimental groups

Tasks	Experimental		Control		Cohen's *d*
	M	SD	M	SD	
Praxic skills – verbal prompt					
Symbolic	9.00	1.65	10.83	1.34	-1.22
Non-symbolic	8.91	1.20	11.30	0.63	-2.49
Facial	9.22	1.76	10.83	1.44	-1.00
Total	27.13	2.88	32.96	2.75	-2.07
Praxic skills - Imitation					
Symbolic	10.13	1.36	11.52	0.95	-1.19
Non-Symbolic	11.09	0.67	11.70	0.47	-1.05
Facial	10.39	1.53	11.35	1.11	-0.72
Total	31.61	1.88	34.57	1.44	-1.77
Visuospatial WM					
Forward Corsi	11.96	3.32	13.57	1.41	-0.63
Backward Corsi	11.78	2.89	14.13	3.05	-0.79

Note. Verbal, in response to verbal prompts; Imitation, when asked to imitate the examiner