Internal Consistency of a Foot and Eye Dominance Scale in Male Subjects

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ABSTRACT

Objective: To investigate the reliability (internal consistency) of a Combined Foot and Eye Dominance Scale in men - schizophrenia patients and healthy subjects.

Material and Methods: We used a Combined Foot and Eye Dominance Scale to assess a sample of 86 men - schizophrenia patients (mean age 44.51 years (SD = 10.73, range 23-67) and healthy subjects (Mean age 34.70 years (SD = 16.82, range 18-79). The scale consisted of two subscales: Foot Dominance Subscale and Eye Dominance Subscale. Scale reliability statistics, non-parametric Mann-Whitney test and Spearman's rank correlation coefficient were used.

Results: Considerable differences were found in the contribution of the single items to the Combined Scale. Some items show greater means (0, 14 - 0, 80), suggesting greater phenogenetic component and greater contribution to the total scale mean. The mean correlation between the items is positive (0, 30), indicating good internal consistency of the scale.

Conclusions: There is strong consistence and coherence between the two component subscales as well as between the individual dominance tests of the scale in the male population. The Combined Scale strongly and objectively reflects leftedness and provides an easier and more accessible way for researching laterality in men.

Keywords

Schizophrenia, Dysmorphogenesis, Laterality, Foot and Eye Dominance Scale, Internal consistency.

Data availability statement

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

Authorship statement

All authors have made substantial contributions to the conception and design of the study, acquisition of data, analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, final approval of the version to be submitted.

Introduction

Hand, foot, eye and ear dominance, as well as linguistic lateralization, can be regarded as an expression of the functional asymmetry of the brain [1].

Despite these many aspects of functional lateralization, investigators have mostly assessed laterality by hand preference. Many researchers have found that handedness is influenced by different factors - genetic, ontogenetic, as well as cultural factors [2-4]. As many factors interplay on hand preference, the outcome results of handedness tests are compromised.

An example of the cultural pressure against left hand-writing are Victorian schools [5] and the communist regime countries (such as Bulgaria before the collapse of the regime in 1990) where children were forced to write with right hand, which resulted in individuals with misleading right-handed preference. Besides that, human societies are predominantly right-sided and the world and the appliances are adapted for right-handed people (with the greatest impact during the Industrial Revolution in the 19th Century).

There are also sex differences in left-handedness. According to Harris et al., women were less lateralized than men [6]. Various recent studies stated that left-handers range from 5% to 25.9% of the general population and are more common in men than in women [7,8]. According to Olfield [9], left-handedness in men compared to women is 10% vs. 6%; it is 13.5% vs. 9.9% according to Porac and Coren [10]; for Bulgarians 7.27% against 5.08%, according to Dimitrov [11].

In our study, we assessed hand, foot and eye dominance and observed a significantly higher left foot dominance as well as a very strong left eye dominance in schizophrenia patients versus controls. This contrasted with the absence of a statistically significant difference in left-handedness among schizophrenia patients versus controls as well as any sex differences. That was illogical given the fact that we used large number of questions, including different aspects of hand actions. We assessed handedness by using 23 not overlapping questions from the most frequently applied four questionnaires for handedness - Edinburgh Handedness Inventory (EHI), Annett Hand Preference Questionaire (AHPQ), Chapman and Chapman Scale, Hand Preference Demonstration Test (HPDT) and another 7 questions, selected to help in the assessment of spontaneity. This total number of 30 questions, assessing the proximal (shoulders, arm and forearm) and distal (wrist and fingers) muscles in terms of quality of performance and precision, as well as spontaneity, along with the fact that we used performance tasks, not preference questionnaires, made us conclude that assessing handedness is not an adequate and reliable way of measuring lateralization.

We suggest that more refined and objective, independent of cultural interference, measures of laterality are needed. In our opinion, such other methods include assessing foot and eye dominance due to lower or absent cultural influence on them. That is why we integrated foot tests and eye tests into a Combined Foot and Eye Dominance Scale.

The reliability (internal consistency) of the Chapman & Chapman scale as combined with the other 4 tests for foot dominance as well as a set of 3 tests for eye dominance has not been studied, at least according to the literature available to us. We investigated the internal consistency of the proposed Combined Foot and Eye Dominance Scale in patients with schizophrenia, control subjects and by sex. However, in the present publication we present our results only concerning the male population - healthy male subjects and schizophrenia male subjects. This study is part of a larger investigational project on the intriguing relations between six groups of markers of neuronal dysontogenesis - left-handedness, left-footedness, left-eyedness, minor physical anomalies, digit ratio and cognitive (attention and memory) deficit.

Material and Methods
Subjects

The sample included 56 consecutively admitted schizophrenia male inpatients with mean age 44.51 years (SD = 10.73, range 23-67). The study was conducted at the Clinic of Psychiatry at the University Hospital in Sofia and the State Psychiatric Hospital in Radnevo.

The patients satisfied the Diagnostic and Statistical Manual of Mental Disorders-V (DSM-V) criteria for a diagnosis of schizophrenia (American Psychiatric Association, 2013) on the basis of case records review, DSM-V based semi-structured interview and information obtained from relatives for stronger validation of the diagnosis. In order to enhance the homogeneity of the schizophrenia group, potential subjects were excluded if they had a history of drug or alcohol abuse, identifiable neurological disorder (seizure disorder, head injury, multiple sclerosis, etc.), any signs of intellectual disability or somatic disorder with neurological components. Visual acuity (reported by the subjects) more than +/-2 Diopters or more than +/-1 Diopter differences between the two eyes was also an exclusion criterion, as these have been proven to confound eye performance.

The control group comprised of 30 men with mean age 34.70 years (SD = 16.82, range 18-79). Normality was defined as the absence of a psychiatric disorder. Control subjects satisfied exclusion criteria similar to those applied to patients. In addition, exclusion criterion for controls included having a first-degree relative with a history of a psychotic disorder, major affective disorder or suicide.

During an interim statistical analysis, we found that handedness is to a significant extent influenced by age. We attribute this to the right hand writing, culturally enforced during the Communist Regime (abolished after its collapse). In order to compensate for this confound, we afterwards tried to recruit younger subjects, both normal and schizophrenia, scholarized after 1990.

To avoid eventual confound due to ethnic and racial differences of lateralization both patients and normal controls were of Bulgarian origin; individuals were excluded if their parental or grandparental ethnic group was other than Bulgarian.

All procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2013. The study was approved by the local Ethics Committee and all subjects provided written informed consent prior to participation.

Instruments
Foot and Eye Dominance Scale
Foot Dominance Subscale: Among the foot dominance questionnaire sets so far proposed and available from the literature, the most popular is that of Chapman & Chapman [12], including 11 foot performed activities: kick as high as possible, kick a ball, arrange cubes, go through cubes with a ball, rolling a golf ball around a circle, stamp out a cigarette, balance rod, write your initials on the sand, smooth the sand, hopping on one foot, tapping out a rhythm.

Two modifications were made to the questionnaire:
- the task of "Tapping out a rhythm of Yankee Doodle", due to the fact that this melody is unknown to Bulgarians, has been reformulated to „Tapping out the rhythm of a favorite song ";
- the task "Go through cubes with a ball" was excluded due to poor informativeness. The participants (mainly schizophrenia patients) could not complete the task by choosing only one foot to lead the ball and used both feet. This was predominantly associated with the answer "both equally", which, however, did not reflect the actual dominant foot in this task.

Four additional foot dominance tests, measuring more complex tasks, were applied:
1. Step up on a chair (to assess spontaneity);
2. Picking up object with toe (to assess precision);
3. Push shovel into the ground (for strength assessment);
4. Stand on one foot and on which foot is the weight of the body (for balancing movement).

In this way our Foot Dominance Scale included a total of 14 tests. Performance with the right foot was assessed as 0; both foots equally as 1; and left foot with 2. Thus the test scores were treated as ordinal variables (0, 1, 2). The score range for the individual variables was from 0 to 2, and for the total Dominance Foot Scale the range was from 0 to 28.

Eye Dominance Subscale
Eye dominance (ocular sighting dominance) was measured by a set of three tests - looking through a monocle, hole-in-card test and Porta test.
1. In *looking through a monocle test* the participant is asked to take with both hands a monocle and to look through it.

2. In the *hole-in-card test* the participant is asked to hold the card with both hands at arm's length and look with both eyes through the hole at an object. While continuing to focus on the object and keeping the object centred in the hole with both eyes open, the participant has to slowly bring the card towards the face until it touches his nose. The card is positioned over one of the subject's eyes.

3. The *Porta test (modified Miles test)* is performed by asking the subject to extend one arm and with both eyes open to align a thumb with a distant object, then to close his left eye and afterwards the right eye consequentially. The object is still aligned with the thumb when seeing with the dominant eye. A potential limitation of the test is the impact of the arm used by the subject according to his hand dominance.

Each test was performed twice and if there was, any inconsistency in the preference the subject was asked to perform the test again.

Each answer was rated: 0 - preference of right eye, 1 - no preference and 2 - left preference. A score range for the individual variables was from 0 to 2, and for the total eye set - from 0 to 6.
For the combined Foot and Eye Dominance Scale set the range was from 0 to 34.
The same examiner (K.A.) performed all assessments.

Statistical Analysis
Summary scores were calculated for the *Foot Dominance Subscale* (14 foot dominance tests), for the *Eye Dominance Subscale* (3 eye dominance tests) and the *total Combined Foot and Eye Dominance Scale* (17 foot and eye tests).

The data were analysed with SPSS 25.0 using descriptive statistics and scale reliability statistics, including item-scale statistics, summary statistics for the items, Cronbach's alpha.

As our data is not continuous and lacks normal distribution, the non-parametric Spearman's rank correlation coefficient for correlation analysis was used.

Statistical significance was defined as $p < .05$; two-tailed.

Results
The item-scale statistics shows the lowest proportion of left-footedness in male population – under 15% - Write your initials on the sand (10.5%), Kick a ball (12.8%), Rolling a golf ball around a circle (12.9%), Arrange cubes (13.1%). The items with the lowest frequency of leftedness have low mean values (Write your initials on the sand -.21, Rolling a golf ball around a circle -.27, Kick a ball =.29, Stamp out a cigarette -.31). Exclusion of any of these items from the scale exerts little change on the total Foot and Eye Dominance Scale mean. These items also show relatively high correlations with the Foot Dominance Subscale and a relatively low correlation with the Eye Dominance Subscale. This suggests a relative lack of close association between these and the remaining items of the Foot and Eye Dominance Scale, indicating that they do not provide a significant laterality information for the male population. On the contrary, some items - Hopping on one foot (29.4%), Step up on a chair (37.6%), Push shovel into the ground

Table 1: Items of the Foot and Eye Dominance Scale and their relationships to the whole scale (item-scale statistics) in male subjects.

		N=86 n (%)	Item mean	Scale Mean Item Deleted	Item-Total Correlation	Alpha if Item Deleted
Kick as high as possible	Both	3 (3.5%)	.41	7.27	.52	.854
	Left	16 (18.6%)				
Kick a ball	Both	3 (3.5%)	.29	7.44	.67	.849
	Left	11 (12.8%)				
Arrange cubes	Both	8 (9.5%)	.36	7.38	.58	.852
	Left	11 (13.1%)				
Rolling a golf ball around a circle	Both	1 (1.2%)	.27	7.45	.80	.844
	Left	11 (12.9%)				
Stamp out a cigarette	Both	0 (0.0%)	.31	7.44	.72	.847
	Left	13 (15.5%)				
Balancing a rod on the thigh	Both	1 (1.2%)	.39	7.29	.57	.852
	Left	16 (19.0%)				
Write your initials on the sand	Both	0 (0.0%)	.21	7.49	.79	.845
	Left	9 (10.5%)				
Smooth the sand	Both	1 (1.2%)	.36	7.38	.76	.844
	Left	15 (17.6%)				
Hopping on one foot	Both	6 (7.1%)	.66	7.10	.42	.859
	Left	25 (29.4%)				
Tapping out a rhythm	Both	3 (3.6%)	.35	7.41	.49	.856
	Left	13 (15.5%)				
Step up on a chair	Both	0 (0.0%)	.75	6.97	.38	.862
	Left	32 (37.6%)				
Pick up object with toe	Both	4 (4.8%)	.39	7.32	.63	.849
	Left	14 (16.9%)				
Push shovel into the ground	Both	1 (1.2%)	.80	6.90	.26	.868
	Left	34 (39.5%)				
Standing on one foot	Both	17 (20.2%)	.54	7.27	.33	.862
	Left	14 (16.7%)				
Looking through monocle	Both	2 (2.4%)	.60	7.15	.21	.869
	Left	24 (28.9%)				
Hole-in-the-card test	Both	1 (1.2%)	.64	7.11	.20	.870
	Left	26 (31.3%)				
Porta test*	Both	1 (1.3%)	.71	7.01	.34	.863
	Left	27 (34.6%)				
Foot and Eye Dominance Scale Mean-7.71 (SD-7.65)						

*Porta test - 78 subjects

(39.5%) - show the highest frequency of left-footedness. In male subjects the frequency of left-eyedness from all three tests of the Eye Dominance Subscale is high - Looking through a monocle (28.9%), Hole-in-the-card test (31.3%), Porta test* (34.6%).

The analysis of Spearman's rho correlation matrix of the seventeen variables from the Foot and Eye Dominance Scale *in men shows the following:*
126 of the 136 correlations between the individual items are positive and only 10 correlate negatively. About 45% (61) of the correlations between the individual items are strongly statistically significant p<.01 and another about 11% (15) of the correlations are statistically significant at p<.05.

The correlation between the subtotals of the Foot Dominance Subscale and the Eye Dominance Subscale is not statistically significant, but positive.

The correlations between the subtotals of the Foot Dominance Subscale and the Eye Dominance Subscale with the total Foot and Eye Dominance Scale are highly significant (p<.01).
It is worth noting that all 17 items of the Foot and Eye Dominance Scale have strong statistically significant correlations with the total Foot and Eye Dominance Scale score (p<.01).

There are 6 correlations between items of the Foot Dominance Subscale and the Eye Dominance Subscale which are highly statistically significant (p<.01) and another 4 correlations that are statistically significant at p<.05 and a number of small insignificant but positive correlations, which shows consistence and coherence between the two component subscales of the Combined Foot and Eye Dominance Scale.

All the above demonstrates a strong consistence between the two component subscales of the Combined Foot and Eye Dominance Scale.

Table 2: Spearman's Rho Correlations Matrix of the 17 Variables from the Foot and Eye Dominance Scale in Men - Schizophrenia Patients and Healthy Controls.

	Kick high	Kick a ball	Arrange cubes	Rolling a ball	Stamp cigarette	Balance rod	Write on sand	Smooth the sand	Hopping one foot	Tapping a rhythm	Step up a chair	Picking with toe	Push shovel	Stand on one foot	Sum 14-foot tests	Looking-monocle	Hole-in-the-card	Porta test	Eye Subscale
Kick a ball	.41**																		
Arrange cubes	.37**	.40**																	
Rolling a golf ball around a circle	.53**	.76**	.56**																
Stamp out a cigarette	.42**	.54**	.28**	.68**															
Balancing a rod on the thigh	.49**	.56**	.28**	.51**	.31**														
Write your initials on the sand	.29**	.59**	.39**	.73**	.60**	.50**													
Smooth the sand	.52**	.53**	.41**	.66**	.65**	.39**	.72**												
Hopping on one foot	-.04	.25*	.17	.20	.30**	.15	.33**	.28*											
Tapping out a rhythm	.16	.30**	.23*	.27**	.35**	.21	.38**	.34**	.46**										
Step up on a chair	.35**	.20	.18	.24*	.27*	.27*	.29**	.32**	.04	.08									
Picking up object with toe	.51**	.61**	.44**	.69**	.49**	.59**	.55**	.52**	.08	.25*	.24*								
Push shovel into the ground	.25*	-.03	.16	.09	.20	.14	.19	.17	.17	.29**	.15	.05							
Standing on one foot	.14	.29**	.28**	.37**	.31**	.02	.21	.28**	.13	.12	.26*	.19	-.01						
Foot Dominance Subscale	.61**	.48**	.54**	.57**	.54**	.60**	.52**	.63**	.48**	.48**	.56**	.50**	.46**	.42**					
Looking through monocle	.05	.08	.02	.17	.20	-.07	.28*	.32**	.16	.12	-.03	.08	-.05	-.01	.07				
Hole-in-the-card test	.08	.07	.01	.24*	.28*	-.08	.18	.16	.15	.05	-.11	.13	-.01	.10	.09	.63**			
Porta test	.02	.19	.25*	.36**	.35**	.01	.32**	.32**	.35**	.20	.10	.11	.02	.09	.23	.32**	.34**		
Eye Dominance Subscale	.07	.16	.13	.35**	.36**	-.06	.32**	.36**	.25*	.16	.03	.15	-.06	.08	.15	.78**	.80**	.74**	
Total Foot and Eye Dominance	.57**	.45**	.49**	.59**	.57**	.53**	.54**	.62**	.47**	.47**	.55**	.49**	.40**	.39**	.90**	.37**	.38**	.47**	.52**

*Correlation is significant at the .05 level (2-tailed).
**Correlation is significant at the .01 level (2-tailed).

Individually, the correlations of the two components of the Foot Dominance Subscale – the Modified Chapman & Chapman Scale (.95) and the Complex Tasks Scale (.77) - with the Combined Foot and Eye Dominance Scale are strongly statistically significant at p<.01. The Modified Chapman & Chapman Scale correlates (.26) with the Eye Dominance Subscale, statistically significantly at p<.05.

Overall, the analysis of the correlation matrix shows that the Combined Foot and Eye Dominance Scale has a considerable consistency between the foot and eye dominance tests of the scale.

Table 3: Summary Statistics for the Items of the Foot and Eye Dominance Scale in Men.

Statistics for scale	Mean	Min	Max	Range	Max/Min
Item Means	.45	.22	.81	.59	3.69
Item Variances	.65	.40	.96	.57	2.43
Inter-Item Correlations	.30	-.07	.79	.86	-11.25

The mean correlation between the Foot and Eye Dominance Scale items is positive (.30), which indicates good internal consistency of the scale. The summary statistics shows considerable differences in the contribution of the individual items. The mean values of some items are 3.69 times greater than those of other items (from .22 to .81), which suggests a greater contribution of these items to the total scale score.

Cronbach's alpha of the Foot and Eye Dominance Scale in men - schizophrenia patients and healthy controls

Cronbach's alpha coefficient determines the internal consistency of a scale and depends on the correlations and number of items of the scale. As a rule, Cronbach's alpha increases considerably with the increase of the number of the scale variables, even if the mean correlation value between the items does not increase. The predominantly positive and statistically significant correlations between the 17 variables of the Foot and Eye Dominance Scale in schizophrenia patients determine its high Cronbach's alpha = .863 (Standardized Cronbach's alpha = .880). This indicates a high internal consistency of the scale in mentally healthy and schizophrenia male populations.

Prospective use of the scale analysis of the Foot and Eye Dominance Scale in male patients with schizophrenia

For any scale the exclusion of some variables with low inter-correlations may improve the internal consistency of the scale and Cronbach's alpha coefficient may even slightly increase. We excluded the four items with the lowest mean scores (Write your initials on the sand, rolling a golf ball around a circle, Kick a ball, Stamp out a cigarette). The reduced scale composed of the remaining 13 items with the highest mean scores; inter-item correlations and correlations with the total score remained high, Standardized Cronbach's alpha - (.782). This indicates that some items of the Foot and Eye Dominance Scale with less contribution and poor impact to the whole scale could be excluded for the ultimate goal of a less cumbersome, expedient and parsimonious scale.

Discussion

Our data shows that some items - Write your initials on the sand, rolling a golf ball around a circle, Kick a ball, Stamp out a cigarette - have the lowest frequency of leftedness and low mean values, meaning that they provide little information on laterality. All of them are part of the Foot Dominance Subscale and show relatively low correlations with the Eye Dominance Subscale, which suggests a relative lack of close association between these and the remaining items of the Foot and Eye Dominance Scale.

All 17 items of the Foot and Eye Dominance Scale have strong statistically significant correlations with the total Foot and Eye Dominance Scale score (p<.01). Almost all of the items have positive inter-correlations with only 10 negative correlations out of 136 and about 65% of them are statistically significant. The correlations between the subtotals of the Foot Dominance Subscale and the Eye Dominance Subscale with the total Foot and Eye Dominance Scale are highly significant (p<.01). All the above shows a strong consistence and coherence between the two component subscales of the Combined Foot and Eye Dominance Scale as well as between the individual dominance tests of the Foot and Eye Dominance Scale in the male population.

The high Cronbach's alpha = ,863 indicates high internal consistency of the scale in men.

Four items (Write your initials on the sand, Rolling a golf ball around a circle, Kick a ball, Stamp out a cigarette) have the lowest mean score. By excluding them, 13 items remain in the scale, improving the reliability and the convenience of using the scale as a tool for examining left dominance in schizophrenia and healthy men.

Our data in men shows that the Combined Foot and Eye Dominance Scale, including a Foot Dominance Subscale and an Eye Dominance Subscale is the most adequate scale for measuring lateralization, despite the most used means for this having been hand dominance. Such a combined scale may be further optimized, without decreasing its reliability, if four items are deleted, allowing comparability of different studies on male population, irrespective of culture and nation. The reduction to 13 items in the Combined Foot and Eye Dominance Scale provides an easier and more accessible way for researching laterality in men - schizophrenia patients and healthy controls - which is consistent with our previous research, showing the same results in women - schizophrenia patients and healthy women.

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