

COMBINED FOOT AND EYE DOMINANCE SCALE
IN FEMALE PATIENTS WITH SCHIZOPHRENIA
AND FEMALE HEALTHY SUBJECTS – COMPACT
AND EASILY APPLICABLE INSTRUMENT
FOR ASSESSMENT OF LATERALITY

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Received on May 23, 2023

Presented by D. Damianov, Member of BAS, on June 27, 2023

Abstract

The aim of the study was to provide an objective and more useful tool for assessing laterality by investigating the reliability (internal consistency) of a combined Foot and Eye Dominance Scale in female subjects – patients with schizophrenia and healthy subjects.

Ninety-four women – patients with schizophrenia and healthy subjects – were assessed with a Combined Foot and Eye Dominance Scale, consisting of two subscales: Foot Dominance Subscale and Eye Dominance Subscale. Scale reliability statistics (item-scale statistics, summary statistics for the items, Cronbach's alpha), non-parametric Mann–Whitney test and Spearman's rank correlation coefficient were used.

We found considerable differences in the contribution of some of the items to the Combined Foot and Eye Dominance Scale. These items show greater means than other items, which suggest greater contribution of these items to the total scale mean. The scale shows good internal consistency with a positive mean correlation between the items.

The Combined Foot and Eye Dominance Scale reflects leftedness more strongly and objectively, irrespectively of cultural and national differences and it could be a more compact and easily applicable tool for the assessment of lateralization.

Key words: schizophrenia, laterality assessment, Foot and Eye Dominance Scale, internal consistency

Introduction. Lateralization is the functional dominance of one of the dual organs of the body: eyes, arms, legs and even ears, during their spontaneous or purposeful actions.

The most frequently used assessment for functional lateralization is hand dominance. Handedness is influenced by many factors like geographic region, genetic and cultural factors as well as sex [1]. The male brain is thought to be more lateralized than the female [2–5].

Some authors suggested that handedness may be influenced by a combination of cultural and developmental factors [6, 7]. First, left hand writing is strongly influenced culturally e.g., it was under cultural pressure during the communist regime (before 1990). Second, the material world of appliances, devices, instruments, etc., is overall adapted to right-handed individuals and social conformity imposes the use of the right hand.

We assessed hand, foot and eye dominance in our study. We used a total number of 30 questions, assessing the proximal (shoulder, arm and forearm) and distal (wrist, palm and fingers) part of upper limb. They consist of 23 not overlapping questions from the most frequently used four questionnaires for handedness – Edinburgh Handedness Inventory (EHI), Annett Hand Preference Questionnaire (AHPQ), Chapman and Chapman Scale, Hand Preference Demonstration Test (HPDT), and another 7 questions selected to help in the assessment of spontaneity and precision. We used performance assessment not self-reported questionnaires in order to minimize the number of invalid answers. Despite the large number of questions, including different aspects of hand actions and the fact that we used performance tasks, we did not find statistically significant difference in left-handedness among patients with schizophrenia versus controls as well as any sex differences.

When assessing foot and eye dominance, however, we found significantly higher left foot dominance as well as very strong left eye dominance in patients with schizophrenia versus controls.

We consider the explanation of these results related to the fact that during the communist regime (before 1990) in Bulgaria left hand writing was under cultural pressure. Handedness itself is additionally influenced by other cultural factors as already mentioned. All the above made us conclude that foot and eye dominance may be a much better assessment tool for lateralization than hand dominance.

That is why we integrated the Foot Dominance Scale and the Eye Dominance Scale into a Combined Foot and Eye Dominance Scale, consisting of two subscales: Foot Dominance Subscale and Eye Dominance Subscale. The Foot Dominance Subscale includes a modified Chapman and Chapman Foot Dominance scale and a new Complex Tasks scale with four foot tests reflecting more complex tasks for measuring spontaneity, precision, strength and balance. The Eye Dominance scale includes three eye tests.

As far as we know the reliability (internal consistency) of foot and eye dominance scales has not been studied until now. We investigated the internal consistency of the recommended Combined Foot and Eye Dominance Scale in patients with schizophrenia, control subjects and in relation to sex. We present our results concerning only the female groups in our present publication. This study is part of a larger investigational project on the interesting 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 [8].

Subjects and methods. Subjects. The sample included 42 consecutively admitted female inpatients with schizophrenia of mean age 42.20 years (SD = 11.38, range 21–63). 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) [9] criteria for a diagnosis of schizophrenia on the basis of case records review, DSM-V based semi-structured interview, and information obtained from relatives for a 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. Another exclusion criterion included visual acuity (reported by the subjects) more than $+/-2$ diopters and/or more than $+/-1$ diopter difference between the two eyes, as these have been proven to confound eye performance.

The control group comprised of 52 women with a mean age of 34.45 years (SD = 15.67, range 23–79). Normality was defined as the absence of a psychiatric disorder. Controls satisfied exclusion criteria similar to those applied to the patients. In addition, exclusion criterion for controls was having a first-degree relative with a history of a psychotic disorder, major affective disorder or suicide.

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.

The study was approved by the local Ethics Committee – Medical University of Sofia Scientific Ethics Committee. All subjects provided written informed consent to participate, subject anonymity being preserved.

Foot and Eye Dominance Scale. Foot Dominance Subscale. Among the so far proposed foot dominance questionnaire sets found in the literature, the most popular is that of CHAPMAN and CHAPMAN [10] (refer to [8]).

Four additional foot dominance tests, measuring more complex tasks, were applied: Step up on a chair (to assess spontaneity); Pick up an object with toe (to assess precision); Push shovel into the ground (for strength assessment); Standing

on one foot and where (on which foot) is the weight of the body (for balancing movement).

Thus our Foot Dominance Scale included a total of 14 tests. The performance with the right foot was assessed as 0; both feet equally as 1; and with the left foot with 2. The test scores were accordingly 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. We applied them as performance assessments, not preference questionnaires. 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 – for preference of right eye, 1 – for no preference, and 2 – for left eye preference. A score range for the individual variables was from 0 to 2, and for the total eye set – from 0 to 6.

The range for the Combined Foot and Eye Dominance Scale was from 0 to 34.

All assessments were performed by the same examiner (K.A.).

Statistical analysis. The data were analyzed with SPSS 25.0 using descriptive statistics, Spearman's rank correlation coefficient for correlation analysis 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 Mann–Whitney test for means difference between two independent groups and the non-parametric Spearman's rank correlation coefficient for correlation analysis were used.

Statistical significance was defined as $p < 0.05$; two-tailed.

Results. Item-scale statistics of the Foot and Eye Dominance Scale in women patients with schizophrenia and healthy controls. Push shovel into the ground (27.7%), Step up on a chair (28.7%), Hopping on one foot (28.7%), and Standing on one foot (35.1%) show the highest frequency of left footedness from the Foot Dominance Subscale (Table 1), while the lowest frequency of left footedness – under 14% is shown by Write your initials on the sand (7.4%), Stamp out a cigarette (7.4%), Kick a ball (12.8%), Smooth the sand (13.8%). The frequency of left-eyedness in female subjects is high among all the three tests from the Eye Dominance Subscale – Porta test (29.2%), Hole-in-the-card test (31.9%), Looking through a monocle (31.9%).

Table 1 shows that the items with the lowest frequency of leftedness have low mean values (Write your initials on the sand – .15, Stamp out a cigarette – .15, Kick a ball – .27, Smooth the sand – .29). Exclusion of any of these items from the scale exerts little change on the total Foot and Eye Dominance Scale mean. In addition, these items show relatively high correlations with the other items, thus suggesting a relatively close association between these and the

T a b l e 1

Items of the Foot and Eye Dominance Scale and their relationships to the whole scale (item-scale statistics) in female subjects – schizophrenic patients and healthy controls

		N = 94 n (%)	Item mean	Scale Mean Item Deleted	Item – Total Correlation	Alpha if Item Deleted
Kick as high as possible	Both	1(1.1%)	.37	6.72	.54	.869
	Left	17(18.1%)				
Kick a ball	Both	1(1.1%)	.27	6.81	.64	.866
	Left	12(12.8%)				
Arrange cubes	Both	4(4.3%)	.38	6.70	.46	.872
	Left	16(17.0%)				
Rolling a golf ball around a circle	Both	0(0.0%)	.30	6.80	.61	.866
	Left	14(14.9%)				
Stamp out a cigarette	Both	0(0.0%)	.15	6.93	.63	.868
	Left	7(7.4%)				
Balancing a rod	Both	2(2.1%)	.45	6.64	.79	.858
	Left	20(21.3%)				
Write your initials on the sand	Both	0(0.0%)	.15	6.93	.61	.869
	Left	7(7.4%)				
Smooth the sand	Both	1(1.1%)	.29	6.79	.53	.870
	Left	13(13.8%)				
Hopping on one foot	Both	1(1.1%)	.59	6.47	.35	.877
	Left	27(28.7%)				
Tapping out a rhythm	Both	0(0.0%)	.36	6.73	.58	.867
	Left	17(18.1%)				
Step up on a chair	Both	1(1.1%)	.59	6.52	.47	.872
	Left	27(28.7%)				
Pick up an object with toe	Both	2(2.1%)	.32	6.78	.68	.864
	Left	14(14.9%)				
Push shovel into the ground	Both	0(0.0%)	.55	6.55	.46	.872
	Left	26(27.7%)				
Standing on one foot	Both	11(11.7%)	.82	6.27	.25	.882
	Left	33(35.1%)				
Looking through monocle	Both	0(0.0%)	.64	6.48	.56	.868
	Left	30(31.9%)				
Hole-in-the-card test	Both	0(0.0%)	.64	6.48	.47	.872
	Left	30(31.9%)				
Porta test*	Both	0(0.0%)	.58	6.48	.37	.876
	Left	26(29.2%)				
Foot and Eye Dominance Scale Mean – 7.07 (SD – 7.75)						

*Porta test – 89 subjects

remaining items of the Foot Dominance Scale. This indicates that they do not provide significant laterality information and have low phenotypical variation in the female schizophrenia group.

Spearman's rho correlations matrix of the Foot and Eye Dominance Scale items in women patients with schizophrenia and healthy controls.

Spearman's rho correlation matrix analysis (Table 2) of the 17 variables and the sums of the Foot and Eye Dominance Scale in female patients with schizophrenia and healthy controls shows the following results.

Almost all of the correlations between the individual items are positive – 135 of the 136; only one has a very small negative value.

About 61% (83) of the correlations between the single items are strongly statistically significant $p < .01$ and another about 15% (21) of the correlations are statistically significant at $p < .05$.

The strongest correlations in descending order are as follows: Write initials – Stamp out a cigarette, Pick up an object – Balancing a rod, Kick a ball – Rolling a golf ball, Pick up an object – Tapping a rhythm, Pick up with toe – Kick high, Kick a ball – Stamp out a cigarette, Kick a ball – Write on the sand. The following items include those with the lowest frequency of left footedness: Write your initials on the sand (7.4%), Stamp out a cigarette (7.4%), Kick a ball (12.8%), Smooth the sand (13.8%), indicating that these items are connected to each other and provide less information for the left-footed subjects.

The correlations between the Subtotals of the Foot Dominance Subscale and the Eye Dominance Subscale and the total Combined Foot and Eye Dominance Scale are strongly significant ($p < .01$).

Importantly, all 17 items of the Combined Foot and Eye Dominance Scale have strong statistically significant correlations with the total of the Combined Foot and Eye Dominance Scale ($p < .01$).

Almost all of the correlations between the single items of the Foot Dominance Subscale and the Eye Dominance Subscale are positive, as only 1 of the 42 correlations displays very small negative value. A total of 26 correlations are statistically significant – 16 correlations are highly statistically significant at $p < .01$, and 10 correlations are statistically significant at $p < .05$. The above shows strong consistency between the two component subscales of the Combined Foot and Eye Dominance Scale.

Individually, the correlations of the two components of the Foot Dominance Subscale – the Modified Chapman and Chapman Scale (.94) and the Complex Tasks Scale (.81) with the Combined Foot and Eye Dominance Scale are strongly statistically significant at $p < .01$.

The correlation between the subtotals of the Foot Dominance Subscale and Eye Dominance Subscale as well as between them and the total Foot and Eye Dominance Scale is strongly statistically significant at $p < .01$.

Table 2
Continued

Push shovel into the ground	.48**	.30**	.39**	.28**	.21*	.18	.39**	.28**	.50**										
Standing on one foot	.08	.18	.11	.25*	.15	.31**	.21*	.24*	.24*	.07									
Foot Dominance Subscale	.53**	.52**	.54**	.56**	.48**	.52**	.59**	.62**	.59**	.60**	.55**								
Looking through monocle	.31**	.33**	.21*	.36**	.17	.21*	.27**	.16	.42**	.29**	.19	.41**							
Hole-in-the-card test	.25*	.19	.10	.23*	.17	.26*	.21*	.16	.37**	.34**	.16	.36**	.80**						
Porta test	.22*	.25*	.12	.33**	.09	-.04	.17	.10	.27*	.07	.09	.21	.51**	.46**					
Eye Dominance Subscale	.25*	.29**	.15	.31**	.14	.17	.23*	.10	.38**	.26*	.17	.35**	.86**	.85**	.79**				
Total Foot and Eye Dominance	.48**	.53**	.46**	.54**	.42**	.51**	.54**	.55**	.55**	.53**	.42**	.89**	.64**	.60**	.48**	.68**			

*Correlation is significant at the 0.05 level (2-tailed). **Correlation is significant at the 0.01 level (2-tailed).

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

Summary statistics of the Foot and Eye Dominance Scale in women patients with schizophrenia and healthy controls. The summary statistics (Table 3) show considerable differences in the contribution of the individual items. The mean values of some items are 5.92 times greater than those of other items (from 0.14 to 0.80), which suggests greater contribution of these items to the total scale score. The mean correlation between the Foot and Eye Dominance Scale items is positive (.32), indicating good internal consistency of the scale.

T a b l e 3

Summary statistics for the items of Foot and Eye Dominance Scale in schizophrenic female patients

Statistics for scale	Mean	Min	Max	Range	Max/Min
Item means	.42	.14	.80	.66	5.92
Item variances	.62	.25	.85	.59	3.32
Inter-item correlations	.32	-.04	.82	.86	-20.36

Cronbach's alpha of the Foot and Eye Dominance Scale in women patients with schizophrenia and healthy controls. Cronbach's alpha coefficient determines the internal consistency of a scale and depends on the inter-correlations and the number of items of the scale. As a rule, Cronbach's alpha increases considerably with the increasing 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 female patients with schizophrenia determine its high Cronbach's alpha = .877 (Standardized Cronbach's alpha = .889). This indicates high internal consistency of the scale in the schizophrenia and healthy women groups.

Prospective use of the scale analysis of the Foot and Eye Dominance Scale in women patients with schizophrenia and healthy controls. The exclusion of some variables with low frequency may improve the internal consistency of the scale and Cronbach's alpha coefficient may even slightly increase. We excluded the 4 items with the lowest mean scores (Write your initials on the sand, Stamp out a cigarette, Kick a ball, Smooth the sand) and Cronbach's alpha - (.831) remained high. In this way the removal of some items of the Foot and Eye Dominance Scale which correlate poorly with the other items does not significantly reduce Cronbach's alpha. The reduced scale composed of the remaining 13 items is less cumbersome, expedient and parsimonious.

Discussion. Some items of the combined Foot and Eye Dominance Scale in schizophrenia and healthy female subjects (Write your initials on the sand, Stamp

out a cigarette, Kick a ball, Smooth the sand) provide little information on laterality. They also suggest a relative lack of close association with the remaining items of the Foot and Eye Dominance Scale, because of the relatively low correlations with them. It is worth noting that all of these items present foot dominance, not eye dominance, which may be suggesting that eye dominance is a better indicator of lateralization than foot dominance. The results imply that footedness should be identified with a combination of manipulation and stability tasks, and familiar tasks are more likely to elicit a lateralized response. The concept of mobilization and stabilization plays a crucial role in determining foot dominance.

The correlation analysis shows consistency and coherence between the Foot Dominance Subscale and the Eye Dominance Subscale themselves and between them and the total Foot and Eye Dominance Scale. Additionally, the correlation matrix shows that the Foot and Eye Dominance Scale has high consistency and coherence between the individual foot and eye dominance tests of the scale. It is logical that the strongest inter-correlations are between the foot tests. It is worth noting that one of them is from the additional four tests (pick up an object).

The high Cronbach's alpha = .877 indicates high internal consistency of the scale in female subjects. By excluding 4 items (Write your initials on the sand, Stamp out a cigarette, Kick a ball, Smooth the sand) with the lowest mean score, 13 items still remain in the scale. This does not affect the reliability of the scale as an objective assessment instrument for cerebral lateralization in schizophrenia and healthy female subjects. Exclusion of some items with low mean scores makes the scale a more compact and easily applicable instrument for the assessment of laterality. It is likely to improve the convenience of the scale as a tool for examining left dominance in female patients with schizophrenia.

The scale analysis of our data in women shows that eye and foot dominance are a much subtler indicator of altered hemispheric lateralization. The Combined Foot and Eye Dominance Scale, including a Foot Dominance Subscale and an Eye Dominance Subscale is the most adequate scale for the assessment of lateralization, even though the most frequently used measure for this purpose is hand dominance. The so combined scale may be further optimized, without affecting its reliability, if four items are deleted.

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