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SEX CHROMOSOME ABNORMALITIES AND COGNITIVE PERFORMANCE: III. FIELD DEPENDENCE, FRAME DEPENDENCE, AND FAILING DEVELOPMENT OF PERCEPTUAL STABILITY IN GIRLS WITH TURNER'S SYNDROME*[1,2]

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SUMMARY

The Rod-and-Frame Test (RFT) was administered to Turner girls (N = 45), their normal sisters (N = 19), and to nonsiblings with primary amenorrhoea and growth retardation as seen in Turner girls (N = 15). The test was scored by the traditional method which gives a measure of field dependence, as well as by a new method that gives a measure of frame dependence and response inconsistency. The traditional method showed Turner girls to be extremely field dependent. The new method showed that the so-called field dependence in Turner girls was due to response inconsistency, rather than to significant frame dependence. It is concluded that response inconsistency is a characteristic of RFT performance in Turner girls, probably reflecting failing development of "perceptual stability."

A. INTRODUCTION

In 1938 Turner (9) described a group of women with short stature, webbed neck, *cubitus valgus*, and undeveloped secondary sex characteristics. The triad of short stature, webbed neck, and *cubitus valgus* became known as Turner's syndrome, and young women with these characteristics

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[2] Requests for reprints should be sent to Helmuth Nyborg at the address shown at the end of this article.

became known as Turner girls. Only short stature seems, however, always connected with Turner's syndrome (3).

Turner girls have abnormalities in their sex chromosomes. Karyotype 45,X is found in approximately half of the Turner girls; other chromosome aberrations, such as lack of certain parts of a sex chromosome or lack of a sex chromosome in only some cells, appear in the other half (1, 2, 6, 8). Nielsen, Nyborg, and Dahl (3) have estimated the prevalence of Turner girls in a normal population to .004 percent.

The full-scale intelligence in Turner girls is slightly below normal, due mainly to poor performance *IQ*. "Perceptual organization" and "freedom from distractibility" are also lower than normal in Turner girls (*cf.* 3). Shaffer (7) concluded that Turner girls have a "cognitional deficit."

In 1969 we began developmental studies on selected cognitive functions in Turner girls to learn more about the nature of their so-called "cognitional deficit." The Rod-and-Frame Test (RFT) was used in our studies because it is a nonverbal test correlated with performance *IQ* subtests (11). It soon became apparent to us that the traditional method of scoring the RFT described by Witkin and Asch (10) had some serious shortcomings; it failed to provide measures of an individual's characteristic performance in the test. Consequently, we developed a new method of scoring the test.

In the present study, the results of the RFT in Turner girls and in control groups were analyzed by the traditional method and by the new method. The outcomes of the two methods are discussed with special emphasis on obtaining a better understanding of the "cognitional deficit" in girls with Turner's syndrome.

B. Method

1. *Subjects*

Forty-five girls with Turner's syndrome were studied. Twenty-one of them had a karyotype of 45,X while the others had other chromosome abnormalities as described by Nielsen, Nyborg, and Dahl (3). Their age ranged from 7-1 to 38 years with mean age of 20-9 years. Twenty-three of the girls lived in Copenhagen while the others lived in smaller towns and rural districts in Denmark.

Twenty-one of the Turner girls had a sister that was less than five years older or younger than she. Nineteen of these sisters consented to be tested and were studied (sister control group). The mean age in the sister control group was 22-9 with a range of 14-5 to 39 years. Also included in the study was a control group of 15 girls with growth retardation and primary

amenorrhoea as in Turner girls but without chromosome abnormalities (nonsibling control group). The mean age in the nonsibling control group was 19-7 and ranged between 9-3 and 32 years.

2. *Instrument and Procedure*

The RFT apparatus used was a transportable model from DARRO. It consisted of a table-top sized box. The *S* put her head into one end of the box so that her view was restricted to the inside of the box. A square frame with a moveable rod inside it was visible at the other end of the box. The frame was tilted 28 degrees to the right or to the left of gravitational vertical. The *S*'s task was to adjust the rod to apparent vertical within the stationary tilted frame.

3. *Analyses*

The traditional method of scoring the RFT gave an unsigned, unweighed deviation score (USD) for each *S*. The USD mean score was calculated by dividing the arithmetic sum of measured deviations of the rod, in degrees, from gravitational vertical by the number of trials as described by Witkin and Asch (10). This parameter gave a measure of how much the *S*'s judgment of the vertical depended on the tilt of the frame. This parameter is called field dependence. It is to be noted, however, that field dependence scores calculated by the traditional method neither give information about the direction of the deviations nor estimate the response consistency of the *S*s.

The new method of scoring the RFT was carried out for each *S* with use of the procedure described in detail by Nyborg (4) and Nyborg and Isaksen (5). The direction of deviation of the rod from gravitational vertical was recorded to calculate a "signed deviation" score. An account was kept of whether the rod was adjusted to the same side to which the frame tilted or to the other side. The "pure" effect of tilt of the frame on the final position of the rod (frame dependence parameter, ϕ) was calculated from the data on signed deviation of rod setting, in degrees, from gravitational vertical. The tendency of an *S* to adjust the rod consistently to one side of gravitational vertical (constant deviation, μ) was noted. The tendency of an *S* to see the rod as vertical even though it was still inclined towards its original tilted position (the "rod-starting-position effect," ρ) was recorded. Thus, the new method of scoring the RFT enabled the source of each *S*'s deviation to be traced and also gave an estimate of each *S*'s response consistency (σ), which was a measure of the "stability" with which the *S* responded to comparable conditions of initial rod and frame tilt.

In order to assess the significance level of the ϕ values, each S's calculated ϕ value was related to her estimated response consistency (σ) by the formula presented by Nyborg (4). If the ϕ value was found to be significantly different from zero ($p < .05$), then she was classified as "frame dependent." The value obtained by this procedure was called the "weighed ϕ score"; it provided an index of the degree of significant frame dependence with respect to the S's response consistency.

C. Results

Table 1 shows the results of the RFT based on the traditional method of scoring the test. The scores of Turner girls with karyotype 45,X (11.82 ± 8.58) and Turner girls with other chromosome abnormalities (11.16 ± 7.62) were very similar and were therefore combined for statistical analysis. The USD score of Turner girls was significantly higher than that of their sisters. The USD score of the nonsiblings was not significantly different from that of the Turner girls or of their sisters. The *SD* of scores in Turner girls and in the nonsiblings was approximately twice as high as the *SD* in the sister group.

The groups were subdivided on the basis of their USD scores. Scores greater than 8° are considered to indicate extreme field dependence, while scores lower than 2° indicate field independence. Forty-nine percent of the Turner girls showed extreme field dependence, while only 11 percent of their sisters and 27 percent of the nonsibling control group had USD scores greater than 8°. On the other hand, less than 10 percent of the Turner girls showed field independence, while more than 25 percent of their sisters and of the nonsiblings had USD scores below 2°. A chi square test showed that

TABLE 1
MEANS AND *SD*s OF SCORES IN THE ROD-AND-FRAME TEST IN TURNER GIRLS, THEIR SISTERS, AND NONSIBLINGS: UNWEIGHED DEVIATION SCORES FOR FIELD DEPENDENCE (USD), FRAME DEPENDENCE (ϕ), AND RESPONSE CONSISTENCY (σ)

Group	USD[a]		ϕ		σ	
	Mean	*SD*	Mean	*SD*	Mean	*SD*
Turner girls	11.47	7.90	9.84	8.04	3.67	4.07
Sisters	4.59**	4.70	3.97**	5.09	1.97*	1.03
Nonsiblings	7.67	8.14	6.73	8.61	1.71*	1.13

[a] USD data are reprinted with permission from J. Nielsen, H. Nyborg, and G. Dahl, Turner's syndrome: a psychiatric-psychological study of 45 women with Turner's syndrome, compared with their sisters and women with normal karyotype, growth retardation and primary amenorrhoea (3).

* Borderline significantly different from Turner girls ($.1 > p > .05$).

** Significantly different from Turner girls ($p < .05$).

the groups differed significantly in their relative distribution ($\chi^2 = 39.33$, $p < .001$).

Table 1 shows the unweighed scores for frame dependence (ϕ) and for response consistency (σ) in the RFT calculated by the new method of scoring the test. The ϕ scores of Turner girls with karyotype 45,X (10.23 ± 8.99) did not differ significantly from the ϕ scores of Turner girls with other karyotypes (9.50 ± 7.29), so the data were combined for statistical analysis. The mean unweighed ϕ score of Turner girls was significantly higher than that of their sisters. The mean unweighed ϕ score of the nonsiblings was not significantly different from that of the Turner girls or of their sisters. It is to be noted that frame dependence scores obtained by the new method of scoring the RFT were smaller than the USD scores for frame dependence obtained by the traditional method because in the new method constant deviation (μ) and rod-starting-position effect (ρ) are subtracted from the ϕ values (4).

Borderline statistical significant differences were found for mean σ scores between Turner girls and either their sisters or nonsiblings, while the mean σ scores for the sisters and the nonsiblings were nearly identical.

The distribution of weighed ϕ scores greater than zero at the 5 percent level, indicating significant frame dependence, was as follows: Turner girls, 82 percent; their sisters, 68 percent; nonsibling control group, 73 percent. The differences in the relative distribution of significant frame dependence between groups were not significant ($\chi^2 = 5.27$, $p > .05$).

D. Discussion

An important aspect in studies on Turner girls is establishment of appropriate control groups so that the effect of the abnormal karyotype in Turner girls on their perception and performance can be determined. It must be noted that Turner girls typically have primary amenorrhoea and growth retardation in addition to an abnormal karyotype (3). Control groups should be established to permit the effect of the abnormal karyotype in Turner girls to be distinguished from the effects of retarded growth and abnormal sexual development. This was done in the present study by the use of two control groups. One was composed of sisters to the Turner girls. They had normal karyotypes and showed no abnormalities in growth or sex characteristics. Since Turner's syndrome is, to the best of our knowledge, randomly distributed in a given population, the sisters of Turner girls represent a random sample of normal *S*s. The other control group was made up of unrelated girls with normal karyotypes but with primary

amenorrhoea and growth retardation as seen in Turner girls. This group served as controls for the effects of abnormal sexual development and retarded growth on perception and performance in the RFT. All groups were of comparable age, so that possible effects of age on the outcome of the RFT were ruled out in the present study.

The main purpose of the present study was to obtain a better understanding of the "cognitional deficit" in Turner girls. This was accomplished by comparing the results of the traditional method and the new method of scoring the RFT. The outcomes of the analyses of the RFT data for Turner girls, their sisters, and nonsiblings by the traditional method of scoring the test and by the new method were quite different. According to the traditional method, Turner girls appeared to be extremely field dependent compared to control groups. The new method of scoring the RFT showed, however, that Turner girls were not significantly more frame dependent than the controls. Evidently, field dependence in girls with Turner's syndrome measured by the traditional method does not represent *significant* effects of frame tilt on their behavior in the RFT. On the contrary, the new method of scoring the RFT indicated that Turner girls show high response inconsistency that leads to their high field dependence scores. Thus, a characteristic feature of the "cognitional deficit" shown by Turner girls in the RFT was response inconsistency rather than significant frame dependence or field dependence.

Our findings show that the traditional method of scoring the RFT is inadequate mainly because it fails to pin-point the source of the deviations in the test and mistakenly treats all deviations as though they were due to frame dependence. The new method of scoring the RFT differentiates between errors due to "pure" frame dependence, constant deviation, rod-starting-position effect, and response consistency, and thereby provides a more accurate account of the factors responsible for an *S*'s performance in the test. It is obvious that RFT performance can only be fully understood on the basis of multidimensional considerations.

The high response inconsistency shown in the RFT by Turner girls and their lack of significant frame dependence suggest that the focus of studies on the "cognitional deficit" in Turner girls should not be on field dependence but rather on failing development of perceptual stability. It must be noted, however, that not all the Turner girls in the present study showed high response inconsistency. In fact, some Turner girls performed in a very consistent manner in the RFT. However, most traits typical of Turner's syndrome show considerable intersubject variability (3). It is interesting to

speculate, therefore, that the failing development of perceptual stability reflected in high degree of response inconsistency, as well as other traits in Turner girls, might be an expression of their abnormal karyotype.

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