Some observations and measurements of the Pulfrich phenomenon

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The Pulfrich pendulum was evaluated as a potential screening device for the detection of anomalies of binocular vision. For this purpose, a booth was set up at the Kentucky State Fair (1964) and the general public invited to observe the pendulum and record their responses with the equipment provided. The obtained results indicate that a dichotomy can be achieved between those who have binocular vision and those who do not. However, gradations of binocular vision from poor to good cannot be achieved with the pendulum as presently understood. Contrary to explanatory theory the characteristic shape of the seen pendulum path was asymmetrical following the rule that the path was displaced away from the observer on the side of the filtered eye.

In the course of work with the Pulfrich pendulum as a test of binocular vision, it was noted that an individual might see the Pulfrich phenomenon when a filter was held before one eye and not see the phenomenon when the filter was held before the other eye. With the individual in whom this mode of response was first detected, it was further noted that the Pulfrich phenomenon could be seen with both eyes if he wore his glasses, but that the magnitude of the phenomenon was relatively reduced for that combination of eye and filter with which the phenomenon was previously not seen.

A check of the individual's monocular and binocular visual acuity indicated a tendency to suppress the eye with the poorer inherent acuity, i.e., the eye which required the greater refractive correction. Apparently the tendency to suppress was stimulated in the Pulfrich situation when the filter was held before the poorer eye. Without refractive correction, suppression was complete and the seen path of the pendulum was flat, consistent with monocular viewing. With refractive correction, binocular visual function and vision in the poorer eye was maintained, but apparently at an intermediate level between suppression and full effectiveness. These observations suggested the possibility that the relative magnitude of the phenomenon as seen by the two eyes could be used as a measure of balance of binocular visual function (Cibis, 1951).

A preliminary effort to assess balance in binocular visual function with the Pulfrich pendulum was made at the Kentucky State Fair in 1964.

Apparatus

A pendulum was assembled using a three section, blue denim screen to provide support and backdrop. The screen was arranged as a "U" about 2 ft deep

with the open end facing the observer (O) (Fig. 1). A window display motor was mounted to and supported by a 5 ft bar between the top of the open ends of the screen. The swing of the pendulum was 34 in. from side to side, 45 in. above the floor with a half period of .81 sec. The length of the pendulum from the pivot to the center of the bob was 27 in. The pendulum bob was white. Ambient illumination provided 24.8 apparent ft-c on the pendulum bob, and 11.2 apparent ft-c on the overall display. The O viewed the pendulum while seated from a distance of 10 ft. (The dotted features of Fig. 1 were added in the course of subsequent research.)

The O's position consisted of a table on which was an Orthorater and an O's pendulum. The O's pendulum, some 28-32 in. long which mounted a ball point pen and hung from a spring-loaded ball-joint, was formulated as a simple and direct method for securing responses from the general public. Testing was accomplished by fitting the O with an empty glasses frame on which was mounted a pair of clip-on sun-

Fig. 1. Pulfrich pendulum.

glasses with one lens removed or by clipping the modified sunglasses on the O's own spectacles. Persons fitted with spectacles wore their spectacles for the test. The transmittance of the sunglass was 20% and essentially neutral.

Procedure

Verbal descriptions of the seen path of the pendulum viewed with one eye filtered were first elicited by non-directive questioning. The reversal of the seen rotation of the pendulum with interchange of the filter was used to check veracity. The direction of rotation, clock or counterclock with left or right eye filtered served as a final check that the phenomenon was being factually reported. Drawings of the seen path were then made by the O with the O's pendulum. A reference line representing the true path of the pendulum was made by the experimenter (E) in the process of demonstrating the use of the O's pendulum. The drawings in turn became the basis for specific questions with respect to the orientation, shape, and displacement of the seen path. Data taking was culminated with the solicitation of judgments from the O of the seen depth of pendulum path displacement, toward and away from the O, relative to the full width of swing. The drawings of the seen path were used to interpret the following instructions to the O. "If the swing of the pendulum from extreme left to extreme right is 10, how much is the depth from front to back?" The number given, from 1 to 10, was recorded as the seen depth of pendulum path displacement.

Two drawings, one for the view with the right eye filtered and one for the view with the left eye filtered, and a sheet showing the O's responses to the far test of the Orthorater visual screen along with age, sex, handedness, glasses, and history of eye difficulties became the data of this study.

Results

Complete sets of usable data were obtained from 176 persons ranging in age from an arbitrary lower limit of 10 years to 76 years of age (Table 1). Three children under 10 were tested, but their data were rejected since there was some question as to the adequacy of their understanding of the instructions. Five cases were identified in which monocular responses were given to the pendulum. Three of these gave monocular responses without regard to the eye filtered while two, like our initial example, gave monocular responses only when the right eye was filtered.

Of the 176 pairs of drawings obtained, 67 or 38% were confirmed by questioning to be simple ellipses symmetrical about the true path of the pendulum. The balance of Os, 104 or 59%, reported some asymmetry of the seen path either for one or both eyes. The shape and variety of the tracings obtained were much like those reported by Trincker (1953).

Table 1. Frequency Count of Descriptive Category Occurrence

Persons	Descriptive Category	Percent
5	Monocular response, one or both eyes	3%
67	Simple ellipse, both eyes	38%
54	Simple twist, one or both eyes (a)	31%
17	Twist combined with eggshaping, one or both eyes	9%
5	Twist combined with flat path for one direction of pendulum motion, one or both eyes	3%
18	Eggshaping, one or both eyes (b)	10%
7	Path displaced either toward or away from the observer, one or both eyes (c)	4%
3	Path flat for one direction of pendulum motion, one or both eyes (d)	2%
176		100%

The "anomalous" drawings (Weale, 1954b) can be categorized as follows: (a) A twisting of the seen path in its entirety, one end displaced toward while the other is displaced away from the O. (b) An egg shaping of the seen path such that one is larger than the other, the path being asymmetrical left or right. (c) A displacement of the entire path toward or away from the O. (d) An incompletely developed path in which one direction of pendulum motion is seen as flat.

A count of the subcategories indicated that twist when present alone or in combination was uniformly right end toward and left end away for viewing with the filter before the left eye, and right end away and left end toward for viewing with the filter before the right eye. (This rule also describes the twist observed by Trincker even though his pendulum was black against a gray background.) A complete reversal did not occur in any instance though three persons reported the same twist for both eyes. This could have been an error in reporting or a failure of the procedure to detect an inherent imbalance of vision when the pendulum was viewed without filter, a condition reported in a few instances and noted in the literature by Grimsdale (1925; Sachs, 1946). The complete pattern for both eyes as delineated above was reported by 34 persons, the right eye pattern only by an additional 25 persons, and the left eye pattern only by an additional 14 persons totaling 73 persons in all or 41% of the Os.

A subcategory count of eggshaping presents a dichotomous picture. When this category of path was reported as the sole form present, the small end was seen on the right when viewing with the filter before the left eye and on the left when viewing with the filter before the right eye. Three persons reported the complete pattern, eight others saw the pattern only with the left eye filtered and five others saw the pattern only with the right eye filtered totaling 16 persons or 9% of the Os. A reversal of the pattern for both eyes was seen by one person and a reversal of the pattern for the left eye only was seen by one

other person totaling two contradictory cases. When this form of path was reported in combination with twist, the number of cases were essentially equally divided. One person saw the predominant pattern in its entirety, and two persons saw the contradictory pattern. Partial patterns were seen by seven persons in each instance for a total of eight confirmatory cases and nine contradictory cases. Conceivably the confusion arises from the complex nature of the path and a tendency on the part of the O to characterize the entire path from one part. Displacement or flattening which was reported in pure form in 10 instances might actually be the primary effect which, when associated with twist and direction of pendulum motion, generated the more complicated form.

An assessment of the quantitative judgments was made through the device of a scatter plot. Imbalances of acuity and of seen depth displacement were first determined by subtraction. The Orthorater score for the right eye was subtracted from that for the left eye, and the depth displacement judgment for viewing with the filter before the right eye was subtracted from the depth displacement judgment for viewing with the filter before the left eye. These differences were used as coordinates in the making of a scattergram in which the depth displacement differences were treated as the independent variable and acuity differences were treated as the dependent variable. Those Os who reported a zero difference in depth judgments were excluded which left 127 cases for the scattergram. The additional dimension of handedness was discriminated by choice of symbol in the plotting of the scattergram. Eleven cases of left handedness were recorded.

X^2 contingency analyses of the scattergram for the dimensions, handedness versus filter balance, and acuity balance versus filter balance, showed a very slight tendency in support of handedness and no support for acuity balance as contingently related to the balance of judged depth as a function of the eye filtered. A rank order correlation, filter balance against acuity balance, of .11 for the 82 cases showing unbalanced acuities was consistent in sign with the hypothesis formulated from the case reviewed in the introduction. The hypothesis seemed to be supported by selected individuals within the data who approximated the case reviewed, but the number of such instances was not sufficient to be statistically evident in the presence of the experimental error inherent to subjective judgments by inexperienced Os, and the preponderance of visually normal Os in the group tested.

Discussion

Continuing research with the Pulfrich phenomenon has, in no way, negated the data reported here. However, additional unique cases have raised the consideration that the initially observed case was not as simple as presumed. Specifically, two cases have been observed with verified 20/200 foveal vision in one eye (Weale, 1954a; Arden & Weale, 1954), one genetic, and the other the result of a retinal burn, in both of which the full Pulfrich was attained with the filter over either eye. The retinal burn case, when initially observed, evidenced suppression of the burned eye. However, in the course of working with the individual and the phenomenon, the individual was induced to give up the suppression response and a full Pulfrich was reported and measured.

The measurement situation has been progressively modified in an effort to stabilize the phenomenon in the interest of repeatable measures to characterize individual differences. To this end fixed objects beneath the pendulum and a ruler with slides have been added (Harker, 1967). In addition, the short vertical wire immediately behind the pendulum shown dotted in Fig. 1 is felt to be most significant. Prior to the addition of this feature, repeated measures on the same individual were quite variable.

There is little question that there are unique individual differences in the perception of the Pulfrich phenomenon. The interpretation of their significance, however, must wait upon an adequate delineation of the mechanism responsible for the phenomenon and the development of appropriate and simple measures for their identification.

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