

Fig. 1. Phase transformation in ZrO_2 of spectrographic purity.

been previously sintered in an oxygen-deficient atmosphere. When samples are sintered at about 1900°C , and the temperature is lowered into the monoclinic range, and then the temperature is raised, the transformation range for monoclinic to tetragonal is about 1650°C to 1900°C , which is in good agreement with the results of Curtis *et al.* The data reported by Curtis were probably for oxygen-deficient HfO_2 . X-ray patterns taken at from 1600°C to 1900°C agree well with data shown by Curtis, except that lines indexed as (102) and (103) are not observed. These lines (2.35\AA , 1.67\AA) correspond to the two strongest lines of tantalum at high temperatures and probably resulted from contamination from the heater in the high-temperature camera. Such a contamination was induced in the present work by heating HfO_2 on tantalum for 2 hours at 1850°C .

Whether tetragonal HfO_2 is isomorphous with tetragonal ZrO_2 is not yet known. Recently data were presented (4) showing that tetragonal ZrO_2 powder patterns are correctly indexed on the basis of a primitive tetragonal lattice rather than a slightly distorted CaF_2 lattice as reported by Ruff and Ebert (5). This new work depends

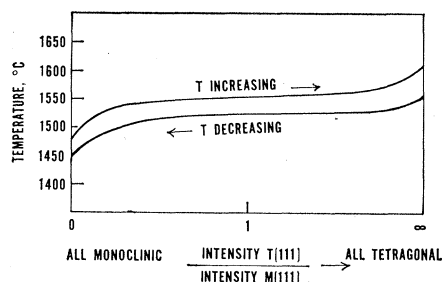


Fig. 2. Phase transformation in HfO_2 of spectrographic purity.

on the appearance of very weak lines which will not index for the distorted CaF_2 lattice. In this present work on HfO_2 , no extra lines were observed other than those expected from a distorted CaF_2 structure. No extra lines (other than those thought to be Ta impurity) were observed by Curtis *et al.* Therefore, it must be assumed that the structures of the tetragonal phases of ZrO_2 and HfO_2 are not the same, although it may be that the reflections missing in the HfO_2 pattern are so weak that they are not detected in the diffractometer.

When one looks at the curves in Figs. 1 and 2, an obvious question is whether the size of the hysteresis loops is due in large part to a kinetic phenomenon. Results of x-ray diffraction indicate that the size of the hysteresis loops is not merely a nonequilibrium situation. Heating and cooling rates have little effect on the size of the hysteresis curves and only a few minutes are necessary to obtain a constant ratio of (111) lines for both phases at a given temperature. Electrical-resistance curves for fused

ZrO_2 show a similar hysteresis with increasing and decreasing temperature (6). However, very recent data (7) on electrical conductivity of ZrO_2 indicate a sharp transition at 1200° to 1205°C with increasing temperature. With decreasing temperature the transition appears more sluggish, occurring between 1050°C and 1000°C . No electrical data at the transition temperature have been found for HfO_2 (8).

WILLIAM L. BAUN

Aeronautical Systems Division,
Wright-Patterson Air Force Base, Ohio

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8. I thank F. Vahldiek for the ZrO_2 and HfO_2 samples of spectrographic purity and for helpful discussions on this subject.

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Statistically Defined Displays and Pattern Detection of Cerebral Palsied Children

Abstract. *Visual displays consisting of arrays of dots are proposed as a possible method for quantifying the parameters of the hidden-figures tests. Detection of form in such displays is difficult for cerebral palsied children as a group. Oculomotor control may be one of the determining factors in successful performance of the perceptual task.*

Hidden-figure tests are visual tasks requiring identification of geometric figures and line drawings embedded in masking backgrounds. The ability to detect such camouflaged figures has been reported to vary with age, intelligence, sex, and damage to the central nervous system (1). The relatively poor performance of brain-injured subjects—which Teuber considers a nonspecific, nonlocalizable consequence of brain-injury—has been attributed to distractibility, inability to organize individual stimuli into wholes, and “pathology” in the figure-background orientation of the visual field (2).

Analysis of the nature of the perceptual deficit is limited by the *ad hoc* nature of the traditional displays. They have not been ordered in difficulty on the basis of defined structural characteristics. They are complex displays in which a given form is to be isolated from interfering, “noisy” fields; inter-

ference is organized into competing forms.

A means for identifying the parameters of the visual problem in hidden figures seems to be provided by the work of Green *et al.*, who studied perception of form in visual displays in which noise was defined in statistical terms (3). In a square matrix, alternate bars of differing density were produced by assigning to the bars different probabilities for the appearance of a black dot. As the differences in the probabilities assigned to adjacent bars decline, the alternating bars become progressively more difficult to discern. Green *et al.* found that for normal adult observers detection of horizontal or vertical arrays was a function of the statistical properties of the displays.

We adapted the Green displays in order to test the perceptual performance of brain-injured children. Our displays consisted of square matrices of

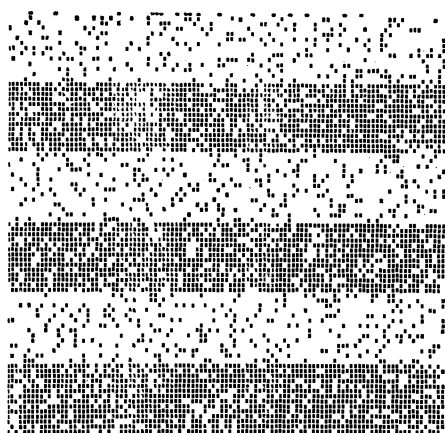


Fig. 1. Display with alternate bars of $p = .80$ and $p = .20$. See (4).

cell spaces arranged into six bars of 14 cells each (Fig. 1). The following pairs of probabilities p_1 and p_2 were employed to produce test patterns: .90 - .10; .80 - .20; .70 - .30; .65 - .35; .60 - .40; .59 - .41; .58 - .42; .57 - .43; .56 - .44; .55 - .45; .54 - .46; .53 - .47 (4). Each pattern was projected in a darkened room, once in horizontal and once in vertical orientation, in a random but constant series. The first three displays were assumed to represent a comparatively simple level of difficulty and were used both as a practice series and as a criterion for inferring that the subject understood the task of detecting the orientation of the bars.

Head movements of the subjects were unrestricted, but the visual angle subtended by the displays was kept at approximately 9° . If a child failed to make a choice of orientation after approximately 10 seconds of binocular viewing he was asked to guess.

The subjects were 70 normal public school children and 99 cerebral palsied children in public and private schools. Distributions by age and by sex were comparable; the age range was between 7 and 19 years for both groups. Ability to communicate a response verbally or nonverbally and successful identifica-

tion of the six practice displays were the only criteria for selection of the palsied school children; normal controls were chosen to match the experimental group in age and sex.

Refractive errors (residual error if corrective spectacles were worn) were measured by the method of static retinoscopy. For some of the palsied children, uncontrollable head movements made this data unobtainable.

The vocabulary scale from Form L of the Stanford-Binet was administered to all verbal children to obtain a measure of intellectual achievement. The problem of equating motor-handicapped children with normal children in intelligence is at best difficult. The experimental visual task seems more primitive than any of the achievements required in any intelligence subtest of which we are aware. While the vocabulary scale is subject to fewer reservations than other measures, its evaluation must also take note of restrictions on learning opportunities imposed by motor handicap.

Table 1 indicates performance of the children in terms of two expressions. Total error refers to the sum of a subject's incorrect responses in the test series, regardless of the level of "difficulty" (probability-differences between bars). Initial error indicates the "easiest" display failed, the highest probability difference at which error occurred. The palsied children have been subdivided into broad diagnostic categories; those with clinically apparent oculomotor difficulties (strabismus, heterophoria, erratic pursuit movements) were treated separately for statistical analysis.

Because of the infeasibility of matching the children on refractive errors and vocabulary score, analyses of covariance were used to assess the extent to which these variables contributed to differences in performance scores. The analysis design was of the single variable form, with several indexes of resid-

ual refractive error and the vocabulary scores individually treated as covariates of the performance scores. The group of palsied children with apparent oculomotor handicap were not included in the palsy group for this analysis (5).

A difference significant at the .001 level was found between the normal children and the cerebral palsied children (without oculomotor handicap). Spastic, athetoid, and miscellaneous categories did not differ significantly from each other.

The mean performance scores of the cerebral palsied children with oculomotor handicap were similar to those of nonhandicapped cerebral palsied children, but variance differences on the initial error score suggested the possibility that errors were grouped in one region of difficulty. Chi-square analysis of these two groups of children for initial error showed the distribution to depart from expected at the .01 level. The oculomotor group tended to err at comparatively "easy" levels of difficulty.

Whether this result is an artifact of the initial error score remains a matter for further inquiry. It raises the possibility, however, that oculomotor control may be a limiting factor in the perceptual performance of the palsied children, including those in whom defect in control is not grossly apparent. There are alternative and related possibilities, for example, that oculomotor defect is an additional, more or less independent indicator of extent of neurological impairment. Our conjecture is that analysis of eye movement may disclose distinctive events related to success and failure in the experimental visual task.

Neither age nor sex differences were found in the performance of the total sample.

Our investigation proceeded from a surmise about the nature of the hidden figure task and the possibility of specifying its parameters. It may be the case that the similarity between the classical and statistical figures does not extend beyond their sensitivity to the presence of brain damage, but the investigation of their relationship and dependence upon oculomotor capacities seems potentially fruitful (6).

CHARLES F. REED

Upstate Medical Center,
Syracuse 10, New York

ALAN POLLACK

Neuropsychiatric Institute,
University of California
Medical Center, Los Angeles

Table 1. Performance scores of normal and cerebral palsied children.

Normal (N=70)		Cerebral palsied							
		Spastic (N=29)		Athetoid (N=14)		Miscellaneous (N=12)		Oculomotor defect (N=34)	
Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
3.06	2.02	6.45	2.77	Total error 6.71 2.84		7.25	2.31	7.68	1.92
12.60	5.53	21.31	9.43	Initial error 23.14 17.61		21.17	7.48	22.95	7.07

References and Notes

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 4. The patterns used in the experiments were printouts from computer-generated instructions. The individual dots are not symmetrical but narrow in one dimension. In order to produce square displays, more spaces had to be included in one direction than the other. Improved displays have now been prepared by photographing the face of the cathode ray output of a computer, the method first used by Green *et al.* but not available when the present experiment was being prepared.
 5. For supplementary tables, giving data for each subject, order Document 7585 from the Chief, Photoduplication Service, Library of Congress, Washington 25, D.C., ADI, Auxiliary Publications Project, remitting \$1.75 for microfilm (35 mm) or \$2.50 for photocopies (6 by 8 inches).
 6. Supported by U.S. Public Health Service grant No. M-4761 (A).
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Brown Fat: Thermogenic Effect during Arousal from Hibernation in the Bat

Abstract. In the bat *Eptesicus fuscus* the temperature of brown fat exceeded that of other tissues by about 3°C during the late stages of arousal from hibernation. Heat production seems to be a major function of brown fat in the hibernating mammal.

Brown fat is widely distributed in many mammals and is particularly abundant in species that hibernate. It has been postulated that brown fat plays a definite but undetermined role in the hibernation process (1). Smith (2) has proposed that it serves as a heat source in cold-adapted rats, and there are some data linking it also to

arousal from hibernation (3, 4). During arousal, the body temperature rises from about 5°C to the homeothermic temperature of the species, so that considerable heat production is necessary in a short time. As part of a biochemical study of brown fat, we have investigated the thermogenic capacity of brown fat in the big brown bat, *Eptesicus fuscus*, during arousal from hibernation under controlled conditions.

Bats were collected locally in September (late summer colony) and in January (hibernating in caves). They were maintained in the laboratory refrigerator at 5° ± 2°C without food, but with free access to water. Temperatures of tissues were measured with a rapid-response microthermistor probe that passed through polyethylene tubes surgically implanted while the bat was under ether anesthesia. The tubes were implanted in interscapular brown fat, dorsal and lateral muscles adjacent to brown fat, ventral pectoral muscle, ventral and dorsal aspects of the caudal region, and the dorsal midline just posterior to the brown fat. Efforts to implant tubes in the thoracic cavity were unsuccessful. After surgery the animals were maintained at room temperature (22° ± 2°C) without food, but with free access to water, for 1 to 4 days and then replaced in the refrigerator. They entered hibernation without apparent difficulty and after 2 to 4 days they were placed in the cold room at 4° ± 2°C for measurement of tissue temperature. A pain stimulus for arousal was provided by a hemostat applied to the abdominal skin. Three tissue temperatures could be recorded per minute. Recordings were continued until the animal became too active to manage. Care was taken to prevent the transfer of heat from the operator to the animal during the measurement.

During the arousal period the temperature of brown fat exceeded that of all other tissues examined (14 determinations on 10 animals). The temperature of brown fat exceeds that of other thoracic areas, including the heart itself, by about 3°C. The caudal temperature shows a distinct lag. To follow the time course of thermogenesis, we made use of the time required for the measured temperature of the brown fat to rise 10°C (T_{10}). On the average, T_{10} was 18 minutes. A warming curve (average of data from six bats) is shown in Fig. 1, in which ventral muscle temperatures are compared with those of dorsal muscle and brown

fat. The differences between brown fat and ventral muscle became significant ($P = 0.01$) as early as $T_{10} = 0.3$.

Preliminary experiments on animals from which the interscapular brown fat had been removed indicated that such animals warm up at a significantly lower rate. In these individuals (two cases) temperatures in the area formerly occupied by the brown fat did not exceed that of the pectoral muscle.

Two animals were allowed to awaken at room temperature with the same pain stimulus as that used in the cold environment. In these cases the temperature of the brown fat did not exceed that of the musculature.

Our results demonstrate that brown fat has a pronounced role in thermogenesis in the big brown bat. It seems probable that the provision of metabolic heat is its main role in hibernation, at least in this species. In the bats studied the ratio of the weight of brown fat (450 mg) to that of the combined heart, shoulder, and thoracic musculature (1300 mg) was approximately 1:3. This indicates that the tissue could provide a significant portion of the heat necessary for arousal in the bat.

It is not known whether a thermogenic role can be demonstrated for brown fat in all hibernators, but such a function has now been shown in two different mammalian orders, Rodentia (2) and Chiroptera. While our experiments dealt only with arousal, it is pos-

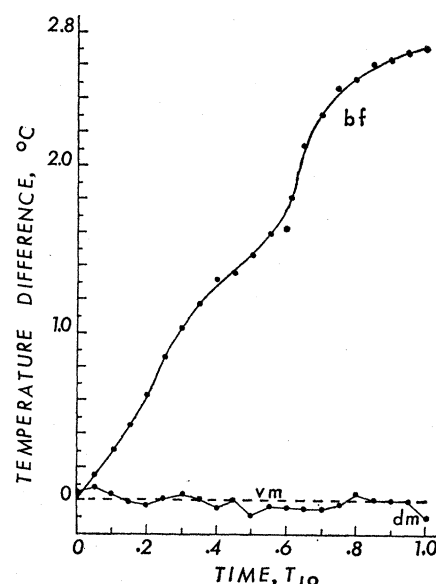


Fig. 1. Temperature differences between brown fat (bf) and dorsal muscle (dm) compared to ventral muscle (vm). See text for a description of T_{10} .