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Heredity, Environment, and Cranial Form:

A Reanalysis of Boas's Immigrant Data

Clarence C. Gravlee
University of Michigan
Ann Arbor, MI 48109-2029

H. Russell Bernard
University of Florida
Gainesville, FL 32611

and

William R. Leonard
Northwestern University
Evanston, IL 60208

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ABSTRACT

Franz Boas's classic study, *Changes in bodily form of descendants of immigrants*, is a landmark in the history of anthropology. More than any single study, it undermined racial typology in physical anthropology and helped turn the tide against early-20th century scientific racism. In 1928, Boas responded to critics of the immigrant study by publishing the raw data set as *Materials for the Study of Inheritance in Man*. Here we present a reanalysis of that long-neglected data set. Using methods that were unavailable to Boas, we test his main conclusion that cranial form changed in response to environmental influences within a single generation of European immigrants to the U.S. In general, we conclude that Boas got it right. However, we demonstrate that modern analytical methods provide stronger support for Boas's conclusion than did the tools at his disposal. We suggest future areas of research for this historically important data set.

[Key words: *Franz Boas, cranial form, immigrant study, heredity, environment*]

From 1908 to 1910, Franz Boas conducted an enormous study of changes in bodily form among descendants of immigrants in New York City. Boas's team completed a series of anthropometric measurements on nearly eighteen thousand European immigrants and their children in order to determine the effect of the new U.S. environment on the physical type of immigrants. This classic study was the first authoritative statement on the nature of human biological plasticity, and it has enduring importance for our understanding of human biological variation. Boas's legacy as "the man who did more than any other to lay the ghost of racism in scientific disciplines" (Gossett 1997:450) is due in large part to this landmark work.

The immigrant study was highly controversial, and in 1928 Boas answered his critics by publishing his raw data set as *Materials for the Study of Inheritance in Man*. Despite the historical significance of Boas's work, these data have been almost entirely overlooked. Now is a good time to rediscover this material. Nearly a century of developments in analytic methods facilitates the search for new answers to the old questions that motivated Boas and that remain important today. In this article, we use Boas's original measurements to reevaluate his central hypotheses regarding the influence of environment on human bodily form.[1]

Given the historical significance of Boas's study, we first outline its development and place it in the context of his career as an anthropologist. This review highlights the study's significance for 20th century physical anthropology and for the critique of biological determinism. From this discussion, we identify three of Boas's central hypotheses regarding the influence of environment on cranial form. The results of the reanalysis show that, on the whole, Boas got it right. However, the application of analytical tools not available to Boas allows us to refine his principal conclusions and to understand better the extent to which changes in environment and lifestyle influence the biology of migrant populations. The new findings highlight the importance of reconsidering Boas's original material and should encourage others to ask new questions of this historically significant data set.

BACKGROUND

Leslie Spier once remarked that Boas was perhaps "the last man who can be said to have embraced the whole field of anthropology" (Spier 1959:146). Some recent commentaries tend to overlook this point, emphasizing Boas's cultural over his biological anthropology (e.g., Darnell 1998; Visweswaran 1998). Yet central to Boas's legacy is his integration of linguistics, ethnology, archaeology, and physical anthropology in the critique of 19th century biological determinism (Baker 1998; Barkan 1992; Smedley 1998; Williams 1996). Boas articulated this four-field attack on scientific racism in his classic *The Mind of Primitive Man* (1911), which highlights early results from the immigrant study alongside evidence from other subfields of anthropology. Indeed, the immigrant study is significant in part because it demonstrates Boas's commitment to developing an integrated science of humankind.

As a physical anthropologist, Boas was concerned primarily with biological *process* and with the formation of human physical types (Stocking 1968; Tanner 1959, 1981). Melville Herskovits observed that this emphasis reflected Boas's "habit of thinking culturally" (1943:50). However, Herbert Lewis (2001) gives us reason to turn this formulation around. Bolstered by his rediscovery of Boas's lecture on "The relation of Darwin to anthropology" (Boas n.d.), Lewis stresses that Boas's work in cultural and in biological anthropology were united by a concern with process and the evolution of individuals, rather than with the classification of abstract types. He suggests that this concern "is specifically a lesson learned from Darwin," and that Boas's writings

> foreshadow what is known today as the 'populational' approach that is basic to the modern 'Darwinian synthesis'…in contrast to an essentialist or typological one. It underlies Boas's way of understanding race and heredity, and it is the foundation of much of his cultural anthropology. [Lewis 2001:382]

This emphasis on process and individual variation set Boas apart from most of his contemporaries and is central to his critique of race. Anthropologists of the day generally assumed that humankind consisted of a few distinct, fixed races or types—"'permanent forms' which have lasted without variation from the beginning of our modern geological period up to the present time" (Boas 1940:35). Following this assumption, most were preoccupied with developing racial typologies based on supposedly suitable measurements of racial phylogeny. The immigrant study was significant because it disputed the validity of such measurements on empirical grounds and thereby helped to undermine racial classification as "the *raison d'être* of physical anthropology of the living" (Kaplan 1954:781).

Boas's immigrant study is best remembered for its challenge to the "central tabernacle of the doctrine" of race, the cephalic index (Tanner 1981:250). This simple measure, the ratio of head breadth to length, was valued most of all for its supposed stability. Anthropometrists agreed that a useful measurement for racial classification would have to fulfill a number of requirements: It would have to be resistant to environmental influences; it would have to be unaffected by cultural practices; and it should be possible to demonstrate heritability. Head form was thought to satisfy all these criteria (Gould 1996; Marks 2002; Montagu 1997).

Yet, early in his career, Boas objected to the significance his colleagues attributed to the cephalic index. In 1899, he argued in the *American Anthropologist* that the cephalic index "may be a very desirable measurement in one case, while in another case it may be of no value whatever. *Measurements should always have a biological significance*. As soon as they lose their significance they lose also their descriptive value" (Boas 1940:169, emphasis added). This sentiment set the stage for Boas's immigrant study, which put the biological significance of the cephalic index to an empirical test.

The immigrant study was conceived in March 1908 when Boas submitted a proposal to the United States Immigration Commission (Boas 1910, 1912a; Stocking 1968). Although the study was a continuation of Boas's prior theoretical interests, he was careful to couch his work in terms that would appeal to the interests of the commission as well. The important question, he wrote, was whether the "marvellous power of amalgamation that our nation has exhibited for so long a time" would continue to have the same effect on the new immigrants from eastern and southern Europe (Stocking 1974:202).

Boas's initial proposal to the Commission called for a study much grander in scale than the one he eventually carried out. He posed a broad set of research questions and figured that it would require measurements on 120,000 participants to obtain reliable answers (Stocking 1974). The actual study was somewhat more modest in scope. From 1908 to 1910, Boas and a team of 13 assistants collected a series of anthropometric measurements on 17,821 immigrants and their children living in New York City. The sample was stratified by immigrant group so that seven groups were represented: East European Hebrews, Bohemians, Sicilians, Neapolitans, Poles, Hungarians, and Scotch. The largest of these groups was the East European Hebrews, with around 6,000 individuals in the study. Bohemians, Sicilians, and Neapolitans were represented in equal number at about 3,000 individuals each, and smaller numbers of the remaining groups rounded out the sample (Tanner 1959). About 5,500 of the study participants were adults age 25 and over, and more than two-thirds were between the ages of four and 25 (Boas 1912a:84). Roughly 40 percent were born in the United States, while the rest were born in Europe (1912a:10-23).

"In planning the investigation," Boas wrote, "it seemed desirable to select such measurements as would be most characteristic in defining the stage of development and the characteristic racial types of each group" (1910:33). To assess the stage of development, Boas and his team aimed to collect measurements of stature, weight, and general physiological development for each person. They were unable to measure people without clothing, so only the stature measurements were obtained for the entire sample. To define the "characteristic racial types of each group," Boas measured maximum head length and width, the width of face between the zygomatic arches, and color of hair, eyes, and skin. Boas excluded skin and eye color from his discussion of the data because of problems in standardizing these measurements. His 1912 report does include a brief chapter on hair color, however (1912a:93-98).

Boas published his results in several forms, each bearing the title *Changes in bodily form of descendants of immigrants*. First, in 1910, Boas submitted his initial report to the United States Immigration Commission. Two years later, he presented his extended analysis to the Commission in a final report that was reprinted by Columbia University Press that same year. Boas also published the results in the *American Anthropologist* in 1912 and in his collection of essays in 1940.[2]

Because the main question of interest was the effect of the U.S. environment on new immigrants, Boas's principal comparison was between U.S.-born and foreign-born children of each group. The differences he discovered revealed "much more than was anticipated" (Boas 1910:7). Throughout his report, Boas emphasized the cephalic index, "which has always been considered as one of the most stable and permanent characteristics of human races" (1910:7). His comparison of U.S.-born and foreign-born children, however, showed that the cephalic index "undergoes far-reaching changes due to the transfer of races of Europe to American soil" (1910:7). Figure 1, reproduced from Boas's preliminary report (1910:9), illustrates Boas's analytical approach to the problem. He used this graph to show that "the two races in Europe" are quite distinct, but that their children born in the United States show an intermediate type of head form, beginning early in childhood and persisting throughout life. Boas drew out the implications in a passage that must have been astonishing at the time:

> The east European Hebrew, who has a very round head, becomes more long-headed; the south Italian, who in Italy has an exceedingly long head, becomes more short-headed; so that both approach a uniform type in this country, so far as the roundness of the head is concerned… This fact is one of the most suggestive ones discovered in our investigation, because it shows that not even those characteristics of a race which have proved to be most permanent in their old home remain the same under our new surroundings; and we are compelled to conclude that when these features of the body change, the whole bodily and mental make-up of the immigrants may change. [1910:7-8]

For Boas, then, the immigrant study demonstrated not only plasticity of human cranial form but also plasticity of human potential. This point was critical to the broader argument against racial determinism he developed in *The Mind of Primitive Man*.

Table 1, taken from Boas's 1912 report, shows that the mean differences between U.S.-born and foreign-born children persisted for each of the four largest immigrant groups in all anthropometric measures. Boas pointed out, however, that not all changes occurred in the same direction (1912a:57). Indeed, he noted that the direction of change is uniform across all groups only for width of face. Boas never proposed any compelling explanation of these differences, but he did point out the decline in stature among Sicilians. Writing to a member of the Immigration Commission, Boas concluded: "We can now say with great certainty to the Sicilians that they should stay away from New York, because the hygienic influences are bad" (Stocking 1974:213). Boas did not pursue this matter any further, however, and the explanation for differences among groups in response to the new environment remains an open question.[3]

[Place Figure 1 about here – half-page]

[Place Table 1 about here – half-page]

Boas's conclusion about the differences between U.S.-born and foreign-born children is more persuasive than is his advice for the Sicilians. He recognized that his finding was "so surprising and unexpected that it requires the most thorough-going criticism before being accepted as definitely established" (Boas 1910:43). He therefore supplemented his initial results with three further analyses.

First, he thought it necessary to test whether the observed differences in head form became more pronounced with increased exposure to the new environment. To investigate this question, Boas first divided the U.S.-born children of each immigrant group into those born within ten years and those born more than ten years after their mothers' arrival in the United States. He then compared these measurements to each other, to those for foreign-born children, and to the general average for the total series. This analysis revealed the greatest changes in head form for children born more than ten years after their mothers' arrival. Boas also observed even more marked changes in weight and stature (1910:44). Taken together, these results were evidence for the "strong and increasing effect of the American environment" (1910:17).

The second supplementary analysis was the comparison between children and their own immigrant parents. Boas realized that the differences between children born within ten years and those born more than ten years after their mothers' arrival could possibly be explained by differences in the type of immigrants from one year to the next. The only way to avoid this objection would be to compare children with their own parents. Boas reasoned that, if the differences between immigrant parents and their children born in the United States were greater than differences between parents and their children born abroad, there would be additional evidence for the influence of environment on physical type. This comparison showed that the difference in cephalic index between parents and their own children was greatest when the children were born in the United States. The effect also seemed to increase with time, since even greater differences between parents and their children were observed when the children were born more than ten years after their mothers' arrival. This finding was consistent with the comparison of U.S.-born and foreign-born children, and it reinforced Boas's claim about the influence of environment.

The third supplementary analysis was an attempt to head off the objection that secular changes in Europe could account for the results. Boas recognized that the comparison between immigrants and their descendants necessarily referred to groups that immigrated at different times. For example, he noted that the parents of 15 year-old U.S.-born children immigrated more than 15 years ago; the parents of 15 year-old foreign-born children immigrated less than 15 years ago. The observed differences between U.S.-born and foreign-born children could therefore be an artifact of comparing different immigrant cohorts (Boas 1940:64). To rule out this explanation, Boas compared children born in Europe in a given year with U.S.-born children of mothers who left Europe in the same year. Boas found that the differences in cephalic index persisted throughout the total series, which seemed "to eliminate entirely this source of error" (1940:69).

Boas summarized these findings in a 1912 article for the *American Anthropologist*, in which he outlined the ten "principal results" of his study (1912b:530-33). All ten can be regarded as testable hypotheses, but we will consider only the three most important here:

H_1: There are significant differences in head form between U.S.-born and foreign-born descendants of immigrants; these differences are not the same direction in all groups; they develop early in childhood and persist throughout life.

H_2: The influence of U.S. environment on changes in head form increases with the duration of time elapsed between arrival of the mother and birth of the child; children born more than ten years after their mothers' arrival show greater differences in head form than those born within ten years.

H_3: There are significant differences in head form between U.S.-born children and their own immigrant parents; these differences are greater than those between foreign-born children and their parents.

These findings deserve priority in the reanalysis of Boas's data because they provide the most compelling evidence for plasticity of head form. This point more than any other caused an outburst of public and professional attention, since it challenged one of the basic tenets of physical anthropology and the contemporary understanding of "race" (Gould 1996:140; Herskovits 1943:47; Stocking 1968:180; Tanner 1981:250). Almost immediately after Boas published his preliminary report to the Immigration Commission in 1910, European and U.S. scholars weighed in with their criticism, and the Commission itself dismissed Boas's conclusions (Baker 1998:107). Alternative explanations for the findings ranged from poor measurement technique to a high illegitimacy rate among immigrants. But none of these objections was so original that it was beyond Boas's own imagination; even in his preliminary report he took considerable pains to preempt them (e.g., Boas 1910:35-37, 52).

The protracted debate over the immigrant study gave Boas the opportunity to clarify and refine his position in a series of publications that lasted nearly until his death in 1942 (Boas 1912a, 1912b, 1936, 1940). But Boas's most impressive response to the controversy was his decision in 1928 to publish 504 pages of raw, handwritten data from the immigrant study, supplemented by additional measurements on Hebrew families (Boas 1928). The idea of publishing such a mountain of data seems remarkable even today when modern telecommunications would make it accessible to almost anyone. The idea of doing it in 1928 is far more striking—even if Boas was known for his tendency to append "page upon page of raw data" to his papers "when publication outlets would permit" (Stocking 1968:171).

This habit had something to do with his stern commitment to scientific method, which also earned him a reputation. As J. M. Tanner notes: "Boas, with his unbounded regard for scientific integrity and the ethics of research, made a practice of publishing all his raw data whenever possible, so that others also could use them to further knowledge" (1981:244). This practice extended, more famously, to Boas's work as a linguist. He and his students published thousands of pages of Native American texts, sometimes with little or no analysis. In fact, of Boas's 5,000 pages of published work, 4,000 pages are unannotated translations of Kwakiutl language texts (Berman 1996:216). Leslie White (1963) complained that these texts were not intelligible because they were without commentary, and George Peter Murdock (1949:xiv, note 5) mocked Boas's "five-foot shelf" of monographs as contributing little to understanding the social structure of the Kwakiutl.

Nevertheless, as Lewis argues, "these are not the works of a mindless fact-collector" (2001:388). The publication of Boas's immigrant data in particular shows that "for Boas there was always a point to the collection of facts; it was usually in order to test propositions" (Lewis 2001:388). Thus, we would extend Lewis's assessment of Boas's unannotated texts to his raw anthropometric data from the immigrant study: "It is true that relatively little has been done with them, but Boas had hopes for their use…"

MATERIALS AND METHODS

Data Entry

Figure 2 shows a single page from the original data set published in *Materials for the Study of Inheritance in Man*. As the figure shows, the data set includes information on immigrant group, age, sex, familial relationships (mother, father, son, or daughter), year of immigration, and birthplace (Europe or the U.S.). In addition, it includes six anthropometric variables: maximum head length, maximum head width, bizygomatic width, stature, eye color, and hair color. To make this data useful for modern researchers, our first task was to convert the handwritten data into machine-readable format. The data set we produced will be made available electronically as a resource to scholars.

[Place Figure 2 about here full-page]

A team of undergraduate students assisted in data entry, and one of us (Gravlee) was responsible for monitoring the quality of the data set. We randomly selected 50 pages of

Materials for the Study of Inheritance in Man to check manually for errors. Those pages contained 12,474 observations, and we found 48 errors, for an error rate of 0.0038. Next, we searched the entire data set for extreme values on each variable and discovered another 347 errors. Finally, following Jantz et al. (1992:442), we plotted head length versus head breadth and face breadth versus head breadth to identify additional outlying values on the cranial measurements. This procedure uncovered 17 errors in data entry. Altogether, then, we identified and corrected 412 data entry errors. Assuming representativeness of the 50-page sample, we would expect only about 483 errors over the 504 pages of Boas's data set, making the number of undetected errors negligible.

Data Quality

An additional concern is the quality of Boas's original data set, an issue that attracted much criticism from Boas's contemporaries. The greatest potential source of error is the lack of any systematic sampling technique (Tanner 1959:102). Despite Boas's "methodological meticulousness" (Herskovits 1943:39), he was not as wary of sampling error as we might be today, and there is very little discussion of sampling in any of his publications on the immigrant study. The relevant question is whether the lack of random sampling procedures renders the data set useless for modern researchers.

Here we might follow the example of a group of researchers who recently rediscovered the anthropometric data Boas collected on North Amerindians in 1892 (Jantz 1995; Jantz et al. 1992; Szathmáry 1995). They ask whether nonrandom sampling might have introduced some systematic bias for the specific traits being studied. In the case of the immigrant study, such bias might have occurred, for instance, if there were patterned differences in socioeconomic status between U.S.-born and foreign-born children. The Boas data set does not include the information necessary to resolve this issue conclusively, but the parent-offspring comparisons make this objection a moot point. There is no obvious consequence of Boas's sampling procedures so damaging that it should prevent us from taking a second look at his material.

A second potential threat to data quality is interobserver measurement error, which was the favorite target of Boas's critics. However, Boas was sensitive to interobserver error in the design of his study, so that "particular pains were taken to make their measurements comparable" (Boas 1910:35). In various reports, Boas discusses in detail procedures to ensure interobserver reliability and responds point-by-point to his critics (Boas 1910:35-37; 1912a:82-92; 1912b:539; 1940). The consensus now seems to be that Boas's data are reliable. Even Morant and Samson (1936), who were critical of Boas's conclusions, conceded that the data regarding interobserver variation suggest that the errors "were not large enough to influence appreciably comparisons made between different parts of the total material" (1936:14).

Again, the recent reanalyses of Boas's Amerindian data are instructive. Richard Jantz (1995; Jantz et al. 1992) and Emoke Szathmáry (1995) point out that Boas was aware that interobserver variation was a problem and took steps to minimize it—nearly 20 years before he undertook the immigrant study. The challenge of ensuring comparability in the Amerindian data was even greater, since 50 observers from the East to the West Coast were involved. Still, Jantz and colleagues (1992) conclude that

Boas's efforts to reduce measurement error were successful enough to regard the data as reliable. If Boas was able to achieve sufficient comparability in 1892 with 50 observers, some of whom he never met, we have reason to believe that he was able to do so in 1909 with 13 of his graduate students.[4]

A final issue of data quality causes some concern. Boas reports measurements for 17,821 individuals (1912a:84), of whom 10,509 were males. *Materials for the Study of Inheritance in Man* does not contain all of these measurements. The new data set includes only 13,836 individuals, less than half of whom are males (Table 2). This discrepancy is all the more surprising, since Boas states that the published material includes not only the data from the original immigrant study but also an additional "series of Hebrew families measured in 1913" (1928:viii). Nevertheless, *Materials* contains some 876 fewer Hebrews, 877 fewer Sicilians, 852 fewer Bohemians, and 634 fewer Central Italians than are described in Boas's reports. There is no apparent explanation for this difference, and there is no way to determine how it might affect the reanalysis. It would be a worthwhile project for future researchers to explain this discrepancy and locate the missing data.

[Place Table 2 about here – half- or full-page]

Statistical Methods

To test the main hypothesis regarding differences between U.S.- and foreign-born children in the mean cephalic index (H_1), we modeled the effect of age, sex, birthplace, and immigrant group on cephalic index, using analysis of covariance (ANCOVA). Following Boas, this analysis included all second-generation immigrants age 25 and under for whom data were available. Of the 8,242 descendants of immigrants under age 25, data are missing for birthplace in 626 cases, and another 14 cases have missing values for cephalic index. Thus, there were 7,602 valid cases for this analysis. For all analyses, we retain Boas's division of the sample into seven immigrant groups in order to ensure comparability with his results.

The initial model included a cross-product interaction term to test Boas's observation that the effect of birthplace varied across immigrant groups. Since the interaction was significant, appropriate follow-up tests examined seven hypotheses—one for each immigrant group—of the general form:

Cephalic index$_{ijk}$ = ì + age + sex$_i$ + usborn$_j$ + immigrant$_k$ + usborn*immigrant$_{jk}$ + error$_{ijk}$

where ì denotes the overall mean; age is continuous; sex$_i$ denotes the ith level of sex (i = 1,2); usborn$_j$ denotes the jth level of birthplace (j = 1,2); immigrant$_k$ denotes the kth level of immigrant group (k = 1,2,3,4,5,6,7); and usborn*immigrant$_{jk}$ denotes the (j,kth) interaction effect of birthplace and immigrant group. This procedure produces a series of univariate ANCOVAs that test the simple main effect of birthplace at each level of immigrant group, adjusted for age and sex.[5]

Next, we used two analytical approaches to test Boas's conclusion that the influence of U.S. environment increases with the time elapsed between mother's immigration and child's birth (H_2). The first mimics Boas's analysis by dividing descendants of immigrants into three groups: foreign-born, U.S.-born less than ten years after mother's immigration, and U.S.-born ten years or more after mother's immigration. This division excluded 1,017 U.S.-born descendants who were missing data on mother's year of immigration, leaving 6,585 cases available for analysis. Mean age- and sex-standardized cephalic indexes of the three groups were compared using analysis of variance (ANOVA), and a cross-product interaction term tested Boas's observation that the temporal effect varies across immigrant groups. Follow-up tests included Bonferroni-adjusted pairwise comparisons.

The ANOVA approach to the hypothesized temporal effect has the advantage of replicating Boas's analysis, but in dichotomizing the time elapsed between mother's immigration and child's birth, this approach throws away a lot of information. Therefore, the second means of testing H_2 was to treat the time elapsed between mother's immigration and child's birth as a ratio-level variable in a least squares regression analysis. Time elapsed was estimated by subtracting the respondent's age and mother's year of immigration from 1910, the last year of Boas's data collection. Then, to satisfy the assumption of normality, the square-root transformation of time elapsed was modeled as a predictor of age- and sex-standardized cephalic index separately for each immigrant group. This model also included maternal height to control for possible confounding effects. Of the 4,632 U.S.-born descendants of immigrants in the entire data set, 1,047 were missing data necessary to calculate time elapsed, and another seven were missing data for cephalic index. This analysis therefore included the remaining 3,578 individuals.

Finally, we used parent-offspring correlations and regression coefficients to test Boas's conclusion that the differences in head form between U.S.-born children and their parents are greater than those between foreign-born children and their parents (H_3). In separate regression analyses for U.S.- and foreign-born children, we compared child's age- and sex-standardized cephalic index with both mother's and father's cephalic index. We repeated these analyses with the midparent cephalic index, or the average of mother's and father's cephalic index, as an independent variable.

RESULTS

Table 3 compares the age- and sex-adjusted mean cephalic indexes for U.S.- and foreign-born descendants of immigrants age 25 and under (H_1). Consistent with Boas's findings, this table shows that the differences in head form between U.S.- and foreign-born descendants are small in magnitude and vary in direction across immigrant groups (compare Table 1 and Table 3; see also Figure 3). The initial ANCOVA model confirmed the interaction between birthplace and immigrant group ($F = 40.73$, df = 6, $p < .001$), making it necessary to compare U.S.- and foreign-born children within each immigrant group in subsequent inferential analyses.

[Place Table 3 about here – quarter- or half-page]

[Place Figure 3 about here – quarter- or half-page]

The results of these follow-up tests are also reported in Table 3. The ANCOVA for age- and sex-adjusted cephalic index by birthplace within each immigrant group shows that, for the four largest groups in Boas's sample, the differences in head form between U.S.- and foreign-born children are highly significant. For Sicilians, Central Italians, Bohemians, and Hebrews, the probability of observing such large differences if they did not exist in each population is less than 1/1000. However, the results for the three smallest groups in Boas's sample provide less convincing evidence in support of Boas's hypothesis. The differences in head form between U.S.- and foreign-born descendants of the Scotch and Hungarian and Slovak samples are of borderline significance, and the Polish sample provides no evidence whatsoever of a generalizable difference.

Table 4 presents the initial test of Boas's conclusion that the influence of the U.S. environment increases with the time elapsed between mother's immigration and child's birth (H_2). This table provides little support for Boas's conclusion. Only for the Bohemian and Hebrew samples is there evidence of a difference in head form between the two groups of U.S.-born descendants of immigrants, those born less than and those born at least ten years after their mothers' immigration. However, both cases exhibit the pattern Boas cited, since descendants born at least ten years after their mothers' arrival show differences from their foreign-born counterparts more extreme than those of the remaining U.S.-born descendants. This pattern is also evident in the Sicilian and Scotch samples, although the differences between the two groups of U.S.-born descendants are of dubious significance in these cases.

[Place Table 4 about here – half-page]

[Place Table 5 about here – half- or full-page]

The formation of two groups at a cut point of ten years is in itself an arbitrary procedure imposed by the computational limits of Boas's day. The least squares regression analysis in Table 5, however, retains the continuous variation in the time interval between mother's arrival and child's birth and provides more information about its explanatory power. The results show that, for the two largest immigrant groups in this analysis, cephalic index changes as a linear function of the time elapsed between arrival and birth, controlling for maternal stature (Hebrews: â = -.141, *p* = .000; Bohemians: â = -.099, *p* = .004). Although this association is highly statistically significant, the magnitude of the relationship is notably small.

There is also limited evidence of such a linear relationship for the Sicilian and Central Italian subsamples. Partial correlations between cephalic index and time elapsed, controlling for maternal stature, are .098 (*p* = .032) and -.068 (*p* = .056), respectively, although the regression model including maternal stature is not statistically significant. Meanwhile, there is no evidence of an association between cephalic index and time elapsed for the Scottish, Polish, or Hungarian and Slovak samples. This finding is consistent with the initial comparison of cephalic index for U.S.- and foreign-born immigrant descendants. Table 5 also shows that the strength of the association between cephalic index and time elapsed is remarkably weak across all groups. In no case does the time elapsed between arrival and birth explain more than two percent of the variation in cephalic index, as measured by the square of the part correlations.[6] Indeed, for most groups it explains less than one percent.

Finally, parent-offspring correlations and regression coefficients for cephalic index are presented separately for U.S.- and foreign-born families in Table 6 (H_3). The differences between the two groups of immigrant descendants are clear. In terms of head form, foreign-born descendants are notably more similar to their parents than U.S.-born descendants are to theirs. The difference in Pearson's correlation between the two groups of descendants is nearly identical for both mother-offspring and father-offspring correlations (.191 and .198, respectively). This pattern is summarized by the midparent-offspring correlations for U.S.- and foreign-born descendants (.431 and .643, respectively). Furthermore, the temporal effect of the change in environment can be seen in the smaller parent-offspring correlations for U.S.-born descendants born more than 10 years after mothers' arrival than for those born within the first 10 years. These figures corroborate Boas's conclusion that a change in environment leads to decreasing similarity between parents and offspring in terms of head form.

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DISCUSSION

In general, the reanalysis of *Materials for the Study of Inheritance in Man* supports the principal hypotheses derived from Boas's immigrant study, but it also provides new information to refine his conclusions about the plasticity of head form. The evidence is clear that there are statistically significant differences in cephalic index between U.S.- and foreign-born descendants of the Sicilian, Central Italian, Bohemian, and Hebrew immigrant samples (H_1). As Boas concluded, the changes in head form are moderate in size and vary in direction across immigrant groups. The use of inferential statistics not available to Boas allows us to reject the null hypothesis of equality of means for U.S.- and foreign-born descendants of the four largest sub-samples, but it requires us to be more conservative in our conclusions for the remaining groups. For the smallest subsamples, there is insufficient evidence to conclude that significant differences in mean cephalic index exist between the two groups of immigrant descendants.

These mixed results point to the impact of sample size on the probability of detecting a difference in head form between U.S.- and foreign-born immigrant descendants, given the modest size of that difference. Boas himself was concerned about this point. In responding to criticism that the total number of observations was inadequate, Boas pointed out that "in most cases the differences between the foreign-born and U.S.-born series are considerably larger than their mean square errors" (1912b:545). In his partial report, however, Boas noted that "only a few of the European types have been tested, and none in adequately large numbers" (1910:33). The results presented here partly substantiate Boas's concern, as the test of H_1 for the Poles, Scotch, and Hungarians and Slovaks would have been unlikely to discover a difference in cephalic index even if one existed in these populations (observed power = .091, .402, .479, respectively). Such low power values reflect the small effect size of the change in environment over a single generation on cephalic index.

The significance of this reanalysis is demonstrated well by the test of Boas's hypothesis that the influence of U.S. environment on changes in head form increases with the duration of time elapsed between mother's immigration and child's birth (H_2). Limited by the data processing technologies of his day, Boas was forced to reduce the duration of time to an ordinal variable with only two categories. As the results presented here demonstrate, this approach does not provide a powerful test of Boas's hypothesis. The accessibility of computing technology today facilitates a superior approach that treats the time elapsed between immigration and birth as a continuous predictor in a least squares regression model, and the results clarify Boas's conclusions in two important ways.

First, the regression model demonstrates a *linear relationship* between time elapsed and cephalic index; Boas inferred but could not establish such a direct effect. Inferential statistics now give us confidence that this result is unlikely to be an artifact of chance. Second, the regression coefficients specify that this relationship is uniformly weak across all groups: The time elapsed between mother's immigration and child's birth explains less than two percent of the variation in cephalic index, although some of these associations are highly statistically significant. These analyses serve as a reminder that, given sufficiently large sample size, we can demonstrate impressive statistical significance even in the absence of meaningful biological significance (Benfer 1968).

The lack of evidence for a strong association is not entirely surprising, given that time elapsed since mother's immigration is only a rough proxy for the effect of many unspecified intervening variables. However, it exposes an important limitation of Boas's analysis. George Stocking notes that "the *most crucial positive evidence* for the influence of the U.S. environment was the fact that changes in physical type varied directly with the time elapsed between the arrival of the mother and the birth of the child" (1968:178, emphasis added). Our analysis shows that this evidence is actually quite weak. In addition, the reanalysis raises questions about potential bias as a result of missing values in tests of H_2. Missing values in the ANOVA and regression analyses require us to exclude roughly 13 and 22 percent of eligible cases, respectively. We found no evidence of a statistically significant difference in cephalic index between dropped and remaining cases, yet the extent of missing values weakens the evidence for a temporal effect of a change in environment on cranial form.

However, our analysis also provides new, more compelling evidence for the plasticity of head form. We use parent-offspring correlations and regression coefficients to test Boas's conclusion that U.S.-born descendants are more dissimilar to their immigrant parents than foreign-born descendants are to theirs (H_3). To substantiate this conclusion, Boas pointed to mean differences in cephalic index between parents and both U.S.- and foreign-born offspring. This approach was sophisticated for its time, but the parent-offspring regression provides a better, more direct measure of the similarity among parents and their U.S.- and foreign-born children. As Boas hypothesized, our results show that children born in the U.S. environment are markedly less similar to their parents in terms of head form than foreign-born children are to theirs ($r=.412$ and $r=.648$, respectively). Moreover, inferential statistics practically eliminate the possibility that this observation is a result of random sampling error ($p<.001$ for all regressions). This finding thus corroborates Boas's overarching conclusion that the cephalic index is sensitive to environmental influences and therefore does not serve as a valid marker of racial phylogeny.

For each of the principal hypotheses, then, the application of new analytical techniques to Boas's data set overcomes some of the limitations in Boas's original analysis and provides new insight into the plasticity of head form. It is worth emphasizing that the limitations in Boas's analysis were imposed by data processing technology, not by his lack of statistical sophistication. Indeed, Boas "brought to his problems a greater degree of statistical knowledge than practically anyone else concerned with human biology in America or Continental Europe" (cf., Camic and Xie 1994; Tanner 1959:78;

Xie 1988). But in the days of pencil, paper, and Hollerith machines, there were severe technological constraints on the type of analysis one could carry out. As Jantz and Spencer remark in their discussion of Boas's Amerindian data, "the volume of data is enormous and difficult to handle even with modern computers" (1997:188). Additionally, statistics is a relatively young discipline, and many of the methods that are now standard were not developed until well after Boas completed the immigrant study.

Nevertheless, Boas understood the analytical problems involved in his work, and he foresaw many of the techniques we have used to extend his analysis. In 1894, Boas published a paper in the *American Anthropologist* in which he described correlations between two anthropometric measurements. Two decades later he tried to estimate the hereditary component of head measurements and stature by comparing sibling and parent-offspring correlations, an attempt he later abandoned with concern over the number of simplifying assumptions (Boas 1940:82-85; Tanner 1959).

Boas was a pioneer in other techniques as well. Herskovits (1943:49) proclaims that "the most important contribution of Boas to anthropometry" might turn out to be a simple formula that expresses in a rudimentary way the idea behind analysis of variance, which R. A. Fisher did not work out until the 1920s (Agresti and Finlay 1997). By 1916, Boas had already published a paper in which he worked out the mathematical proofs to split total population variation into what we would now call between-group and within-group variance. Characteristically, Boas himself was the first to point out the tentative nature of his calculations, but he was sure a further elaboration of the method would enable us to attack the problem of heredity and environmental influence (Herskovits 1943; Tanner 1959).

Yet even the normally cautious Boas was impressed by the “wholly unexpected” finding of changes in the cephalic index of descendants of immigrants. At the time he conceived the immigrant study, the prevailing view was that humans could be divided into a number of distinct, fixed races or types. The champions of this view were physical anthropologists, who placed enormous value on the fixity of traits, particularly head form, to validate their elaborate racial typologies. In this context, Boas’s immigrant study was revolutionary. His demonstration of plasticity in head form “laid to rest, forever, the belief that body characteristics were…only under hereditary control” (Little and Leslie 1993:67). The old notion of race has been slow to die out, but Boas’s study of immigrants and their children was a crucial step toward the development of the modern anthropological concept of race.

Other biological disciplines had long recognized the plasticity of organisms, but Boas’s immigrant study was the first authoritative statement on *human* biological plasticity. Since then, plasticity has become an important concept in physical anthropology. In the 40 years after Boas’s study, at least 25 researchers conducted studies of plasticity and the environment (Kaplan 1954), and the effort continues up to the present day (e.g., Bogin and Loucky 1997). But John Allen has argued that Boas himself was not entirely clear about the meaning of the term:

> With regard to the idea of plasticity, Boas could not tie the loose ends of this problem together without the analysis-of-variance technique, which

> would have provided the mathematical justification he sought, or without a hierarchical conception of gene and morphology. [1989:82]

Today we have both of the things that Allen says impeded Boas's understanding of human plasticity. Analysis of variance is now taught in beginning statistics classes, and we have replaced Boas's understanding of genotype and phenotype as mutually exclusive with a hierarchical conception of the two. Even more sophisticated advances in both statistics and human biology invite further exploration of Boas's data.

Indeed, Boas himself issued the invitation. In the brief introduction to *Materials for the Study of Inheritance in Man*, Boas explained: "It seemed necessary to make the data accessible because a great many questions relating to heredity and environmental influences may be treated by means of this material" (1928:viii). Given Boas's hope that others would tackle these questions, we suspect Tim Ingold is right that Boas "would have been among the first to put his copious materials on the web" (2001:398). Fortunately, we are now in a position to do so.

The availability of Boas's data set in an accessible format makes further exploration feasible, and there remain many new uses for the data. Among the priorities for future research should be the study of familiar resemblances to estimate environmental influences on growth (Bogin 1999; Mueller 1986). Here it is important to emphasize that Boas's data set, "the largest collection of family measurements ever published" (Tanner 1981:250), includes not only the head form data but also measurements of stature, one of the most frequently examined traits in family studies.

The accessibility of Boas's data set also facilitates future research on the nutritional and hygienic status of the immigrants and descendants in Boas's study relative to modern-day populations and to their contemporaries in Europe and North America. Drawing on existing research in historical anthropometrics (Cuff 1995; Fogel 1986; Komlos 1994; Tanner 1986), Boas's data can be examined to learn more about the status of immigrants in their new home, the effects of migration on growth, and the selection involved in the process of migration. Boas himself anticipated such questions, even if he was unable to pursue them (Boas 1910:28; Stocking 1974:202).

CONCLUSION

Even though *Materials for the Study of Inheritance in Man* has been cited in a number of prominent places (Allen 1989; Barkan 1992:82; Jantz and Spencer 1997; Tanner 1959, 1981), it remains relatively obscure. When it is mentioned, it is generally regarded as an interesting historical fact, not as a vital source of research material. The relative obscurity of Boas's data is perhaps not surprising. As Stephen Jay Gould observes in *The Mismeasure of Man*, "Scientists are used to analyzing the data of their peers, but few are sufficiently interested in history to apply the method to their predecessors. Thus, many scholars have written about Broca's impact, but no one has recalculated his sums" (1996:58).[7] Of course, Gould could just as well have made this point about Franz Boas instead of Paul Broca, the nineteenth century master of craniometry and scientific racism. In anthropology, Boas's immigrant study is textbook material, widely cited as a turning point in the discipline's treatment of race. Yet, for 90 years, no one recalculated his sums, even though Boas took the extraordinary step of publishing his original data set as volume six of the *Columbia University Contributions to Anthropology*.

We believe that the historical significance of Boas's immigrant study makes the reanalysis of his data set imperative. In this paper, we have replicated Boas's analysis and tested his principal conclusions regarding the plasticity of head form. We conclude that, on the whole, Boas was right, despite the limited analytical tools at his disposal. However, the strongest evidence that environmental factors influence the cephalic index is not the direct association between cephalic index and the time elapsed between mother's immigration and child's birth, as previously had been thought. Rather, it is the difference in parent-offspring correlations and regression coefficients between U.S.- and foreign-born immigrant descendants and their parents. This result provides new insight into the immigrant study and helps us refine Boas's main conclusions. There remain many questions to ask of Boas's data, and the effort to address them would be consistent with Boas's own commitment to scientific method.

Renewed attention to Boas's relatively neglected work in physical anthropology is also timely and appropriate, given the increasing fragmentation of our discipline along subdisciplinary lines. The immigrant study is significant in part because it highlights Boas's fundamental concern with process and individual variation, which integrates his cultural and biological anthropology and sustains his critique of biological determinism. At a time when the "growing divide between physical and cultural anthropologists" (Mukhopadhyay and Moses 1997:523) impedes research on race and human diversity, we would be wise to adopt Boas's commitment to anthropology as an integrated science of humankind.

Notes

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1. At the time of writing, we were aware of only two partial reanalyses: Morant and Samson's (1936) reanalysis of the East European Hebrews data and Fisher and Gray's (1937) reanalysis of the Sicilian series. Shortly after submitting our manuscript for publication, we learned of a recent M.A. thesis (Sparks 2001) that analyzes 4,668 individuals from Boas's data set. While our manuscript was in press, Sparks and Jantz (2002) published their reanalysis of the immigrant data in which they conclude that Boas was wrong.
2. For the sake of clarity, we will generally cite the 1910 report. Unless otherwise noted, the same material can be found in the 1912 final report to the Immigration Commission, which is more than five times greater in length but contains little more in the way of text.
3. For more on environmental influences on cranial form, see Beals et al. (1984), Henneberg (1988), and Henneberg and Steyn (1993).
4. Even so, the reliability of Boas's data need not be taken for granted. Jantz et al. (1992:442) originally used the plotting method described above to detect measurement errors in Boas's Amerindian data. Using the same technique, we identified only a single implausible value; this case was in fact marked as suspicious in

Boas's original material and is excluded from the reanalysis. Twenty-nine other dubious cases are excluded from the test of Boas's conclusion that the influence of environment on head form increases with time. These cases appear suspicious because they are coded as U.S.-born but produced negative values in the computation of time elapsed between mother's immigration and child's birth. We should note also that the most serious critique of the reliability of Boas's measurements came from Fisher and Gray (1937), who reanalyzed the Sicilian data. As far as we are aware, neither Boas nor anyone else ever responded to their criticism; Allen (1989:83) seems to endorse it. We intend to address Fisher and Gray's analysis in a future publication using the entire data set, not just the Sicilian data.

5. We used the LMATRIX subcommand in SPSS 9.0 for Windows.
6. Strictly speaking, it is the square of the part, rather than partial, correlations that reflects the proportion of variance in cephalic index explained by time elapsed (Blalock 1964). However, in this case, the part correlations are practically identical to the partial correlations—and to the standardized partial regression coefficients. For the sake of brevity, we do not present the correlations separately.
7. Gould is not alone in recognizing the value of reexamining classical data sets. Leon Kamin, for example, noted the improbability of Sir Cyril Burt's published results and launched an inquiry that eventually exposed Sir Cyril's astonishing fraud. Burt's studies of the heritability of IQ in separated twins had long been regarded as the gold standard among IQ researchers, largely on account of Burt's supposedly rigorous

methods. We now know, however, that Burt's influential work was based on a complete and utter fabrication of data and even of colleagues (Rose et al. 1984:101-106).

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Table 1. Boas's presentation of mean differences in anthropometric measures between U.S.-born and foreign-born children

Nationality and sex	Length of head (mm)	Width of head (mm)	Cephalic Index	Width of face (mm)	Stature (cm)	*N*
Bohemians:						
Males	-0.7	-2.3	-1.0	-2.1	+2.0	170
Females	-0.6	-1.5	-0.6	-1.7	+2.2	180
Hebrews:						
Males	+2.2	-1.8	-2.0	-1.1	+1.7	654
Females	+1.9	-2.0	-2.0	-1.3	+1.5	259
Sicilians:						
Males	-2.4	+0.7	+1.3	-1.2	-0.1	188
Females	-3.0	+0.8	+1.8	-2.0	-0.5	144
Neapolitans						
Males	-0.9	+0.9	+0.9	-1.2	+0.6	248
Females	-1.7	+1.0	+1.4	-0.6	-1.8	126

Note: Differences calculated within each yearly age group and weighted by number in each group (Boas 1912a:56)

Table 2. Descriptive statistics for major variables, by immigrant group

	Bohemian	Central Italian	Hebrew	Hungarian and Slovak	Polish	Scotch	Sicilian
				Females			
N	1324	1329	2087	346	272	143	1489
Age (yr)	24.8 (15.3)	23.6 (15.3)	21.7 (14.3)	22.3 (13.5)	22.0 (13.8)	25.6 (14.8)	24.1 (14.6)
Stature (cm)	147.9 (.409)	142.6 (.415)	141.4 (.351)	143.0 (.708)	140.2 (.787)	154.0 (1.188)	145.1 (.378)
Head Length (mm)	176.9 (.171)	177.1 (.181)	175.5 (.148)	175.8 (.323)	179.0 (.365)	184.3 (.470)	181.0 (.164)
Head Width (mm)	150.0 (.152)	144.9 (.152)	146.9 (.120)	148.7 (.272)	146.8 (.295)	144.5 (.415)	142.4 (.127)
Bizygomatic Width (mm)	130.0 (.182)	127.0 (.189)	126.8 (.152)	129.5 (.321)	129.0 (.321)	127.5 (.519)	126.6 (.163)
				Males			
N	964	1000	1892	304	205	140	1118
Age (yr)	23.9 (16.9)	22.6 (17.2)	20.0 (15.1)	21.2 (15.0)	23.9 (15.7)	28.7 (17.8)	24.8 (16.5)
Stature (cm)	149.9 (.515)	141.3 (.497)	141.5 (.391)	143.3 (.773)	146.7 (1.037)	158.1 (1.385)	147.7 (.471)
Head Length (mm)	182.5 (.228)	181.4 (.244)	180.3 (.168)	179.7 (.384)	182.2 (.496)	191.6 (.557)	186.8 (.216)
Head Width (mm)	154.1 (.198)	148.3 (.187)	150.1 (.136)	152.6 (.334)	151.7 (.399)	150.2 (.460)	146.6 (.159)
Bizygomatic Width (mm)	132.5 (.220)	128.5 (.233)	128.8 (.162)	131.8 (.364)	133.5 (.466)	131.9 (.623)	130.0 (.211)

Note: Mean age is given with standard deviation in parentheses. Age-adjusted means with standard errors in parentheses are given for Head Length, Head Width, Bizygomatic Width, and Stature. Subsample sizes are number of valid cases for all variables.

Table 3. Age- and sex-adjusted mean cephalic index of U.S.-and foreign-born descendants of immigrants, by immigrant group

	U.S.-born		Foreign-born			
	N	**Adjusted mean ± SE**	***N***	**Adjusted mean ± SE**	***F***	***p***
Bohemian	1159	84.97 ± .10	163	85.92 ± .26	12.02	.001
Central Italian	886	82.96 ± .11	497	82.06 ± .15	23.37	.000
Hebrew	1486	82.94 ± .09	1159	84.61 ± .10	152.52	.000
Hungarian and Slovak	215	84.78 ± .23	153	85.35 ± .27	3.18	.074
Polish	151	84.32 ± .27	98	84.42 ± .34	0.19	.661
Scotch	115	78.36 ± .31	39	79.45 ± .53	2.91	.088
Sicilian	546	80.31 ± .14	935	78.95 ± .11	56.32	.000

Note: Descendants of immigrants age 25 and under. Means, F-statistics, and associated significance values (p) from ANCOVA of cephalic index by birthplace within each immigrant group, adjusted for age and sex, df = 1.

Table 4. Pairwise comparisons of mean age- and sex-standardized cephalic index by trichotomized birthplace, by immigrant group

	Foreign-born v. U.S.-born <10	Foreign-born v. U.S.-born ≥10	U.S.-born <10 v. U.S.-born ≥10
Bohemian			
I-J	.138	.289*	.151*
SE	.081	.076	.060
Central Italian			
I-J	-.263*	-.154*	.109
SE	.053	.064	.063
Hebrew			
I-J	.321*	.588*	.268*
SE	.041	.049	.054
Hungarian and Slovak			
I-J	.144	.036	-.180
SE	.105	.133	.139
Scotch			
I-J	.145	.289	.143
SE	.210	.182	.201
Polish			
I-J	.033	.140	.172
SE	.121	.179	.179
Sicilian			
I-J	-.297*	-.361*	.064
SE	.052	.086	.092

* Significant at á = .05 level after Bonferroni adjustment for multiple comparisons.

Table 5. Regression of age- and sex-standardized cephalic index on time elapsed and mother's stature, by immigrant group

	Bohemian	Central Italian	Hebrew	Hungarian and Slovak	Polish	Scotch	Sicilian
N	862	786	1065	169	128	82	479
Time Elapsed							
â	-.099	-.068	-.141	-.025	-.132	-.118	.098
SE	.032	.036	.026	.090	.099	.083	.042
p	.004	.056	.000	.752	.138	.309	.032
Mother's Stature							
â	.049	-.031	.007	.003	-.130	.157	-.008
SE	.004	.006	.005	.014	.016	.013	.007
p	.147	.379	.828	.972	.143	.177	.868
Adjusted R^2	.009	.003	.018	-.011	.016	.004	.006

Model *p*	.007	.117	.000	.950	.132	.321	.097

Note: Square-root transformation of time elapsed. â = standardized regression coefficient.

Table 6. Parent-offspring regressions for cephalic index of U.S.- and foreign-born descendants of immigrants

	U.S.-born			
	≥10 years	<10 years	Total	Foreign-born
Mother-Offspring				
b	.365	.360	.365	.590
r	.353	.391	.379	.570
SE	.026	.018	.014	.017
N	1,428	2,145	3,787	2,508
Father-Offspring				
b	.315	.335	.321	.539
r	.326	.346	.336	.534
SE	.032	.026	.018	.020
N	819	1,218	2,517	1,782
Midparent-Offspring				
b	.420	.405	.412	.648
r	.411	.441	.431	.643
SE	.033	.024	.019	.020
N	819	1,218	2,156	1,511

Note: Regressions use age- and sex-standardized cephalic index for descendants of immigrants; cephalic index is standardized separately for maternal, paternal, and midparental values. All correlations are significant at á = .001 level.

Subgroups of U.S.-born do not add to total because cases with missing values for year of mother's immigration are excluded. b = unstandardized regression coefficient; r = Pearson's correlation coefficient.

List of Figures

Figure 1. Boas's comparison of head form of U.S.-born and foreign-born Hebrew and Sicilian males

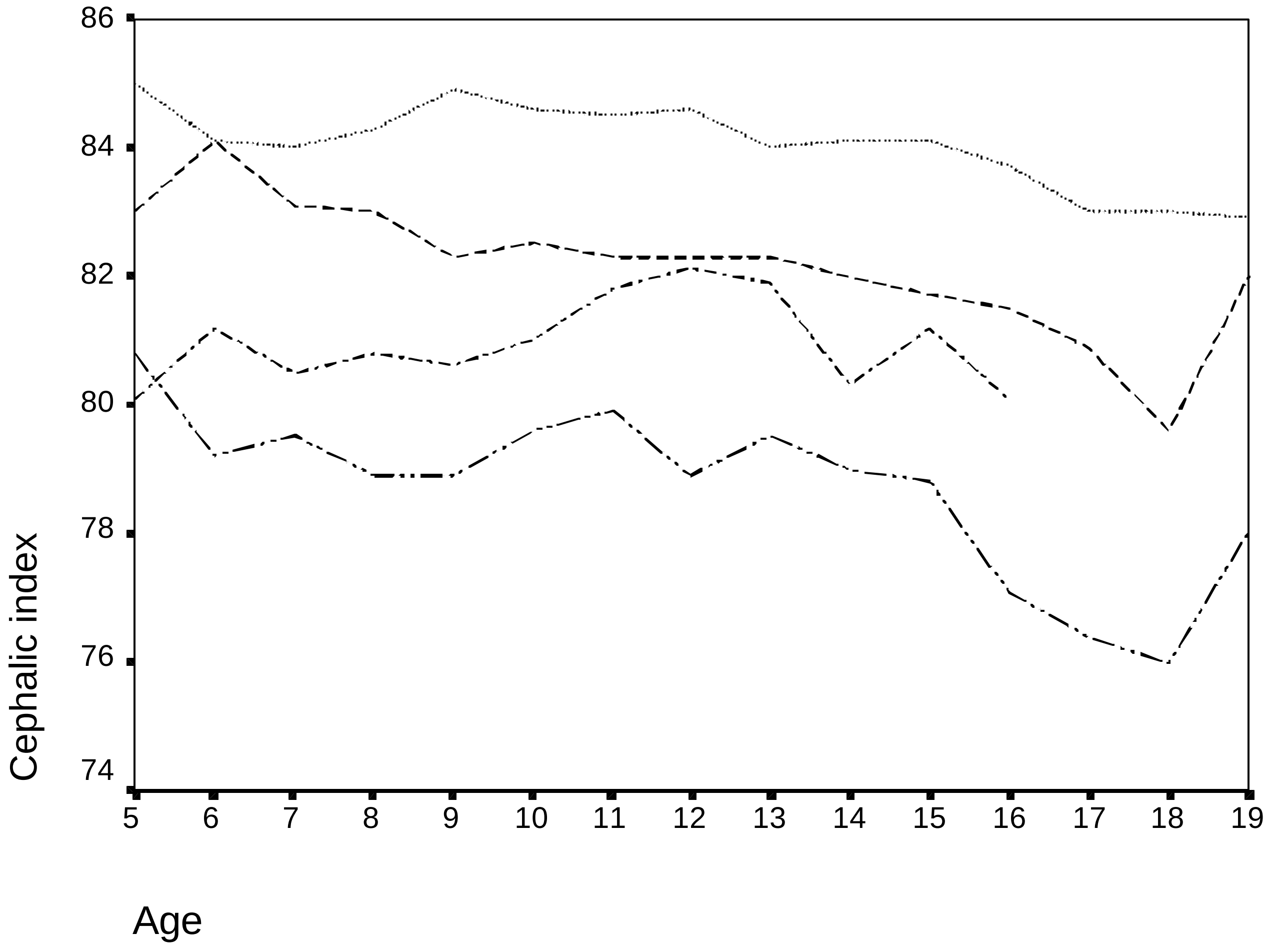

Figure 2. Sample page of Boas's data in *Materials for the Study of Inheritance in Man*

Hebrews

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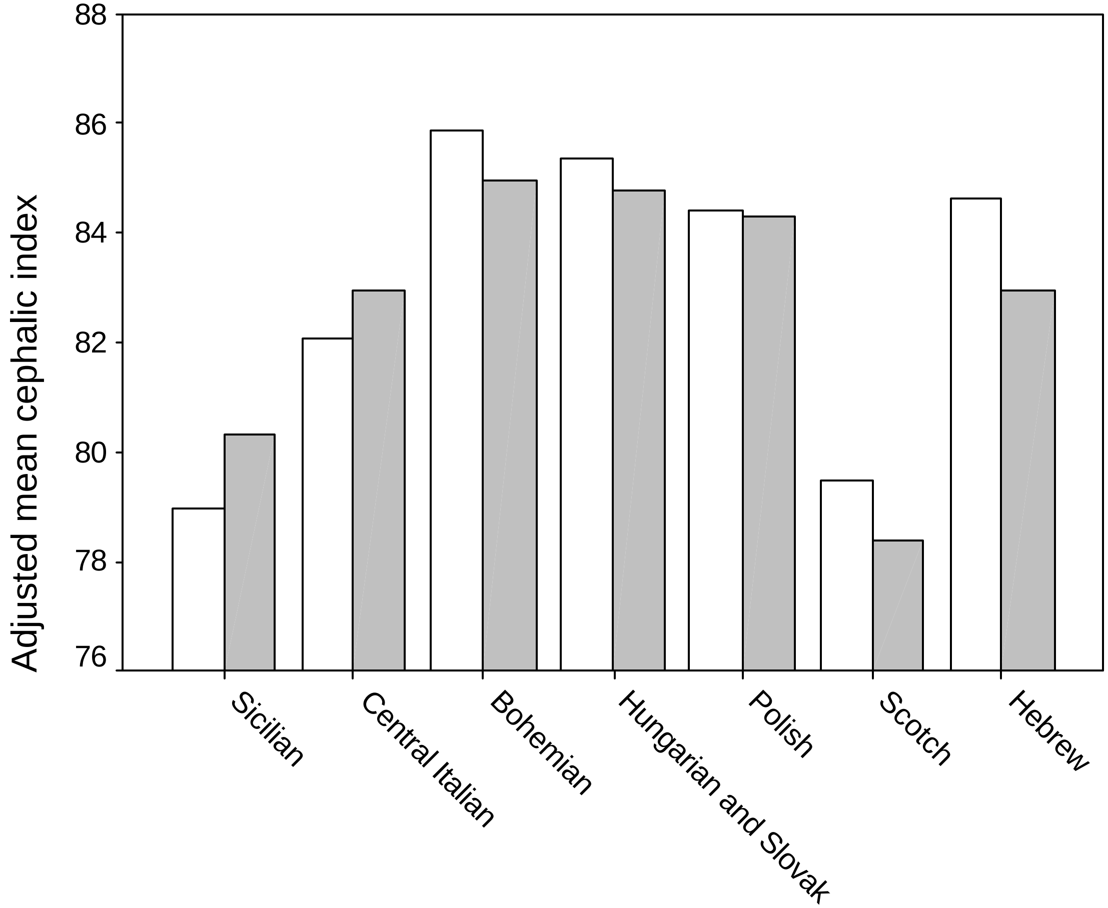
Current No.		Immi-gra-tion	Age	LH	WH	WF	St	Ci	Wfi	Color	
Fam.	Ind.									Eyes	Hair
482	2496	1899 S	16	182	154	131	155	84.6	85.1	l. Br.	10
Bq. L.F. B.	2599	1899 S	15	177	149	130	156	84.2	87.3	Br.	6
	3157	1899 S	13	176	146	127	141.5	83.0	87.0	l. Br.	6
477	446 161	1906 S	11½	173	149	128	138	86.1	85.9	l. Br.	6
S.	178 161	1906 S	11½	180	139	114	121	77.2	82.0	Bl.	15
	123	1906 S	9	168	148	121	116	88.1	81.7	Br.	5
481	406	U.S.S.	15	178	154	132	145	86.5	85.7	Br.	3
S	389	U.S.S.	13	183	152	129	134	83.1	84.9	Br.	6
	211	U.S.S.	11	181	152	126	125	84.0	82.9	l. Br.	5
37	167	1903 S	26	193	171	147	162.2	88.6	86.0	Br.	3
F	169	1907 S	21	195	160	146	172	82.0	91.2	l. Br.	7
	170	1908 S	19	184	160	143	164.5	87.0	89.4	Br.	3
162 22 c.	110	1904 S.	28	199	152	138	160	76.4	90.8	Br.	2
H.L	109	1909 D	32	188	149	134	160	79.3	89.9	Gr.	5
	106	1905 D	29	186	146	129	157	78.5	88.4	Gr.	2
48 b.	209	N.Y.S.	14	178	149	130	157.8	83.7	87.2	Gr.	4
F	210	N.Y.S.	12	170	145	128	116.2	85.3	88.3	Gr.	9
	211	N.Y.D	9	168	132	115	120	78.6	87.1	Br.	7
504	413	1904 S	20	184	158	137	167.5	85.9	86.7	Bl.	3
O.S.	412	1906 S.	19	176	151	129	162	85.8	85.4	Br.	4
	445	1902 D.	40	180	145	131	152	80.6	90.3	Bl.	2
163 5 b.	22	1907 S.		182	158	136	154.5	86.8	86.1	Bl.	9
F.	20	1901 D	36	172	157	136	149	91.3	86.6	Br.	3
	23	1907 D	18	170	152	128	148	89.4	84.2	Br.	5

Figure 3. Age- and sex-adjusted mean cephalic index of U.S.- versus foreign-born children, by immigrant group



Note: Age- and sex-adjusted means computed for descendants of immigrants age 25 and under (N = 7,602).

Figure Legends

Figure 1. Boas's comparison of head form of U.S.-born and foreign-born Hebrew and Sicilian males

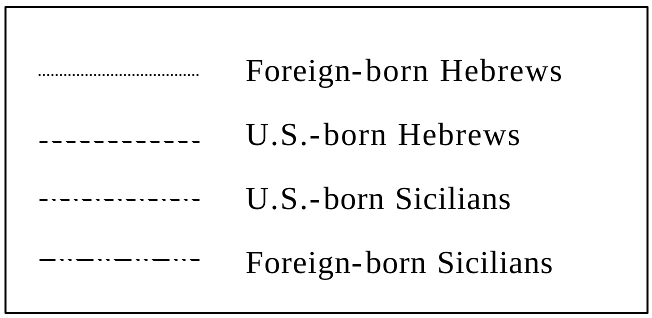


Figure 3. Age- and sex-adjusted mean cephalic index of U.S.- versus foreign-born children, by immigrant group