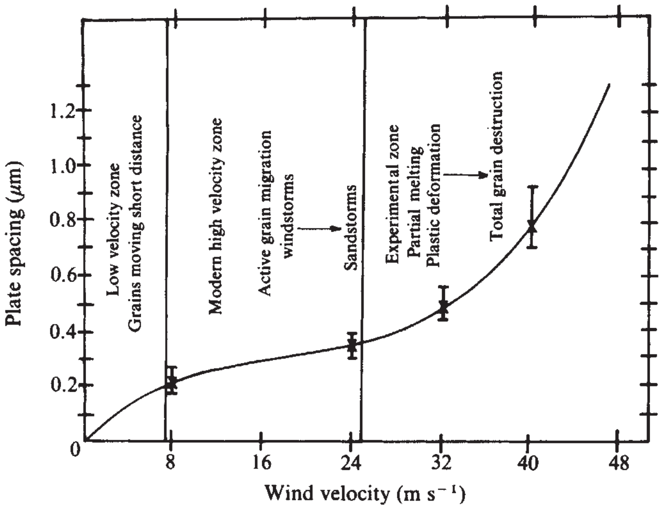

**Fig. 1** Comparison between changes in slope of experimental data and wind velocity for various types of sand grain movements observed in deserts.

of plate spacing were substituted in the regression equation; the calculated wind velocity is 29 m s$^{-1}$, a value slightly higher than the strongest continuous wind velocities observed in the modern Sahara (22 m s$^{-1}$ (ref. 6)). If the technique is valid, these sands could have been transported and deposited in a hot arid Saharan type desert by winds of higher velocities than those in the modern Sahara.

If the time required to remove a thickness equal to the relief of the plates is short enough, the spacing measured will represent the final abrasion episode. If the time is measured in days, weeks, or months, then the spacing must represent some average value related to the velocity of a number of storms.

Crushed Brazilian quartz averaging $\sim$500 μm in diameter was abraded at a velocity of 8 m s$^{-1}$ for three hours in the paddle wheel device. The grains were then removed and studied with the scanning electron microscope; >80% of all surfaces were covered with small abrasion markings. Upturned plates constituted a large portion of the abraded surfaces. Three hours is probably the maximum abrasion time necessary to cover almost completely the surface with abrasion markings; the only remaining non-abraded areas were those that were at least 5 μm below the general surface and thus were protected from immediate abrasion. Although the original starting material was fairly large and quite angular, the experiment suggests that times of the order of minutes or hours in a sandstorm would resurface natural sand grains.

Additionally, 500 g of natural quartz sand (sieved to between 125 and 180 μm) was fed into an aeolian whirling arm device[11] and used to abrade, in an aeolian mode, six quartz flats at 20 m s$^{-1}$. The sand stream struck the targets perpendicular to their surfaces for 23 min with 16 g of sand actually striking each target. Note that each grain of sand struck each flat only once. Finally the targets were weighed to an accuracy of five places before and after bombardment.

The time needed to remove completely a layer of quartz the height of an average plate (0.5 μm) was calculated and was 29 min. This is probably the maximum time needed to remove a significant fraction of the old plates and produce new ones; thus in a very short time a high velocity wind could reset the spacing over a large portion of grain surfaces. The experiment, of course, was conducted with a fixed target; natural aeolian grains are round and rotate, which would tend to create an isotropically eroded surface similar to the experimental targets. The two experiments give order of magnitude results, but even if the final answer were three times as large, plate spacing on aeolian grains probably represents the final windstorm velocity to which the grains were subjected.

**Table 2** Sample locations, plate spacing and calculated wind velocities for Saharan and Permian sands

| Sample location | No. of grains | No. of measurements | Average spacing (μm) | Calculated wind velocities (using equation (1)) |
|---|---|---|---|---|
| Sehba Sand Sea, Libya (Sahara desert) | 5 | 92 | 0.172 ± 0.045 | 6.33 ± 0.04 m s$^{-1}$ |
| Great Western Erg, Algeria (Sahara desert) | 5 | 102 | 0.262 ± 0.039 | 13.53 ± 0.05 m s$^{-1}$ |
| Permian sandstone County Durham, UK | 5 | 100 | 0.354 ± 0.047 | 29.34 ± 0.04 m s$^{-1}$ |

We stress that plate spacing results from the last abrasion event that occurred on a given sand grain; a change in velocity is assumed to eliminate previous plate spacing imprints and to superimpose the most recent velocity spacing on surfaces. The ability to determine ancient wind velocities could aid further understanding of the paleogeography and paleoclimatology of the vast continental aeolian sand deposits preserved in the geologic record. This research was supported by NASA consortium agreement 2-0R035-801 and 2-0R035-901, Office of Planetary Geology. We thank Paul Spudis and Alan Peterfreund for reviewing this manuscript, also Michael Malin and Steve Williams for technical assistance.

Received 21 August; accepted 5 December 1979.

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# Why do Bedouins wear black robes in hot deserts?

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**Survival in hot deserts has always posed a problem for man; Moses had to solve it in order to lead the children of Israel through the wilderness of the Sinai—a formidable hot desert. It seems likely that the present inhabitants of the Sinai, the Bedouins, would have optimised their solutions for desert survival during their long tenure in this desert. Yet, one may have doubts on first encountering Bedouins wearing black robes and herding black goats. We have therefore investigated whether black robes help the Bedouins to minimise solar heat loads in a hot desert. This seemed possible because experiments have shown that white hair on cattle[1,2] and white feathers on pigeons[3] permit greater penetration of short-wave radiation to the skin than black. In fact, more heat flowed inward through white pigeon plumage than through black when both were exposed to simulated solar radiation at wind speeds greater than 3 m s$^{-1}$ (ref. 3). We report here that the amount of heat gained by a Bedouin exposed to the hot desert is the same whether he wears a black or a white robe. The additional heat absorbed by the black robe was lost before it reached the skin.**

0028-0836/80/040373—03$01.00

**Table 1** Radiation exchange and convective heat loss

| | Radiation gain | Radiation loss | Net radiation gain | Convective loss | Net radiation gain–convective loss |
|---|---|---|---|---|---|
| Black robe | 838 ± 10 | 543 ± 2 | 295 ± 8 | 57 ± 7 | 238 ± 12 |
| White robe | 649 ± 3 | 534 ± 3 | 115 ± 2 | 31 ± 5 | 84 ± 6 |
| Tan army uniform | 644 ± 3 | 452 ± 2 | 192 ± 2 | 45 ± 3 | 147 ± 4 |
| Shorts (semi-nude) | 624 ± 10 | 442 ± 6 | 182 ± 5 | −2 ± 4 | 184 ± 7 |

The rate of net heat gain by radiation was more than 2.5 times as great in the black robe as in the white. The greater heat loss by convection from the black robe due to its higher surface temperature was not great enough to compensate for its higher net radiation gain. This leads us to postulate that additional heat was lost by convection through the robes through a bellows effect or a chimney effect. Values in W m$^{-2}$ are the means of nine experiments ± s.e.

To quantify the effects of the colour of a robe on the heat load imposed by a hot desert, we measured and/or calculated the net heat gain by radiation, heat loss by convection, heat loss by evaporation, heat storage and metabolic heat production of a man standing facing the Sun in the desert at mid-day while he wore: (1) a black Bedouin robe; (2) a similar robe that was white; (3) a tan army uniform; and (4) shorts (that is, he was semi-nude). We used one individual as a calibrated heat exchanger, because we were interested in the effects of the coverings rather than in physiological differences among individuals. Robes were purchased from Bedouins and we used two layers of robes in the same manner as they did. Only the outer robe was changed when comparing black and white robes. We selected experimental conditions where both solar radiation and air temperature were high. The measurements were made during the summer at mid-day (1030–1430 h) at the Hatzeva Field School (in the Negev Desert at the bottom of the rift valley between the Dead Sea and the Gulf of Elat). During the measurements air temperatures ranged between 35 °C and 46 °C (average 38 °C) and wind speed between 0 and 4.1 m s$^{-1}$ (average 1.3 m s$^{-1}$).

**Table 2** Avenues of heat gain and loss of a subject facing the Sun in a hot desert at mid-day and in a temperature-controlled room at 48 °C

| | $\dot{H}_{\text{gain}}$ | = | $\dot{H}_{\text{evap}}$ | + | $\dot{H}_{\text{stor}}$ | − | $\dot{H}_{\text{metab}}$ | $T_{\text{amb}}$ |
|---|---|---|---|---|---|---|---|---|
| Desert | | | | | | | | |
| Black robe | 142 ± 4 | = | 199 ± 4 | + | 10 ± 1 | − | 67 ± 2 | 59.5 |
| White robe | 134 ± 11 | = | 191 ± 8 | + | 8 ± 1 | − | 65 ± 2 | 58.6 |
| Tan army uniform | 161 ± 7 | = | 217 ± 7 | + | 10 ± 1 | − | 66 ± 2 | – |
| Shorts (semi-nude) | 208 ± 7 | = | 264 ± 8 | + | 8 ± 1 | − | 64 ± 2 | 62.2 |
| Temperature-controlled room at 48 °C | | | | | | | | |
| Black robe | 66 ± 7 | = | 126 ± 6 | + | 7 ± 2 | − | 67 ± 2 | |
| White robe | 65 ± 9 | = | 123 ± 9 | + | 6 ± 1 | − | 64 ± 3 | |
| Shorts (semi-nude) | 86 ± 9 | = | 144 ± 9 | + | 9 ± 2 | − | 67 ± 2 | |

Rates of net heat gain ($\dot{H}_{\text{gain}}$) from the environment, evaporative heat loss ($\dot{H}_{\text{evap}}$), heat storage ($\dot{H}_{\text{stor}}$) and metabolic heat production ($\dot{H}_{\text{metab}}$) are given in W m$^{-2}$ and are the means of nine experiments ± s.e. To determine the temperature in our environmental room ($T_{\text{amb}}$) that would be necessary to simulate conditions of our hot desert at mid-day, $\dot{H}_{\text{gain}}$ was quantified when the room was set approximately 10 °C above average skin temperature. It was then assumed that $\dot{H}_{\text{gain}}$ would be directly proportional to the temperature gradient between the skin and room in order to calculate the room temperature required to obtain the same $\dot{H}_{\text{gain}}$ as we obtained in the hot desert.

Radiation exchange and heat loss by convection were calculated according to the procedures outlined for cattle[4] and goats[5] with the following minor modifications. (1) Swinbank's empirical formula[6] was used for calculating long-wave radiation from the sky; (2) surface area was calculated from Dubois' formula[7] when the subject wore the army uniform or was semi-nude (this area was multiplied by 0.85 when calculating diffuse radiation exchanges to correct for exchanges between the legs, arms and body); and (3) surface area for the subject wearing the robes was calculated by assuming he approximated a cylinder whose circumference was measured around the chest.

Rates of metabolic heat production ($\dot{H}_{\text{metab}}$), evaporative heat loss ($\dot{H}_{\text{evap}}$), and changes of heat content of the body ($\dot{H}_{\text{stor}}$) were measured, then net heat gain by non-evaporative means ($\dot{H}_{\text{gain}}$) was calculated by applying the first law of thermodynamics where:

$$\dot{H}_{\text{gain}} = \dot{H}_{\text{evap}} + \dot{H}_{\text{stor}} - \dot{H}_{\text{metab}} \qquad (1)$$

All measurements were made during 30-min intervals. The techniques and their accuracies were the same as we have described in detail for similar measurements on the Bedouin's black goats[5].

The absorptivity of the black robes for radiation in the visible part of the spectrum (0.89) was more than 2.5 times as great as that measured for the white robe (0.35) and about 1.5 times as great as for the army uniform (0.72) or the semi-nude subject (0.66). The greater rate of absorption of visible radiation by the black robes was not accompanied by a greater rate of radiation loss (Table 1). Although convective heat loss from the black robe was greater than that from the white because of its higher surface temperature, the net inward flow of heat through the black robe (that is, net radiation gain − convective loss) was calculated to be almost three times as great as through the white (Table 1).

In spite of the greater net heat gain by the black robe, there was essentially no difference in rates of net heat gain ($\dot{H}_{\text{gain}}$) by the subject wearing black or white robes (Table 2). Rates of evaporative heat loss, heat storage, and metabolic heat production were essentially the same in the black and white robes.

How does one reconcile these seemingly conflicting results? The explanation must be greater convective transfer of heat through the air spaces beneath the black robe, either by a bellows action as the robes flow in the wind or in a manner analogous to the functioning of a chimney where the chimney in this case would be the air space between the robes and the skin. The air beneath the robe might rise and pass through the loosely woven fabric as it was warmed, pulling in cooler air from the bottom of the robe. Either explanation would be supported by our measurments of temperatures in the air space between the robes and the skin. The temperature of the air space beneath the inner robe was approximately the same as the temperature of the surrounding air when the outer robe was black or white, despite as much as a 6 °C difference in surface temperature of the different coloured robes (47 °C for the black and 41 °C for the white) (Fig. 1).

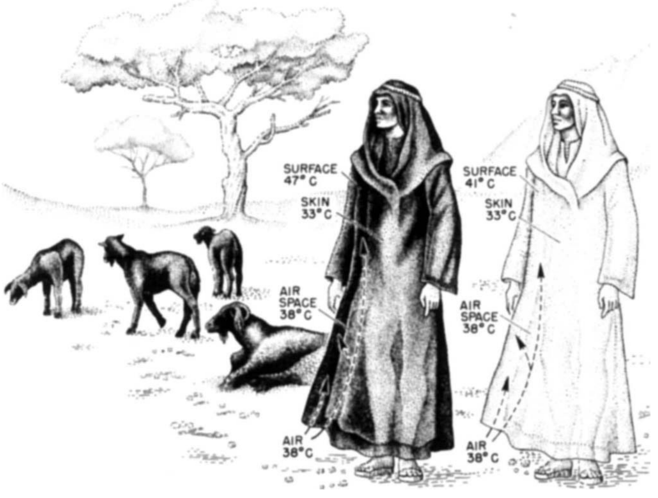

**Fig. 1** Black Bedouin robes gain two to three times as much heat by radiation from the Sun as white robes, but enhanced convection of air beneath the robe carries this heat away before it reaches the skin. The temperature of the air space between the robe and the skin was the same for black and white robes and equalled the temperature of the surrounding air. The greater convection beneath the black robe might make it feel more comfortable. Mean temperatures of the robe surface, skin and air space (see text) are typical of temperatures observed when air temperature was 38 °C at mid-day, the sky was cloudless, and the subject was orientated facing the Sun.

Whether a bellows action, a chimney effect or some other mechanism explains the enhancement of convection beneath the black robes, it seems clear that the difference in radiation exchange at the outer surface of the robes is not affecting the heat exchange of the subject. Other authors have also observed that the colour of clothing has little effect on heat gain of a subject exposed to direct solar radiation[8,9].

This work was supported by grants from the United States–Israel Binational Science Foundation and the US NSF. We thank the director and members of the Hatzeva Field School for facilities and assistance.

Received 30 July; accepted 2 November 1979.

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# Data from kinships of monozygotic twins indicate maternal effects on verbal intelligence

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**Familial resemblance in intellectual skills is well documented, but its interpretation is a source of continuing controversy. The critical problem is that a family's shared genes are confounded with its shared experiences, and controls possible in animal research (selective mating, cross-fostering, and uniform or randomised environments) do not directly apply to human subjects. Conventional twin and family methods reveal substantial genetic variance in intelligence quotient (IQ) test scores, but the same methods also document significant environmental influences. Research designs which can identify the nature of these environmental factors may effect progress in the 'IQ debate' (ref. 1). The families of monozygotic (MZ) twins provide a new research design[2] which permits a unique assessment of maternal influences in quantitative traits. We describe here initial applications of the design to verbal IQ, with results suggesting that maternal effects significantly contribute to familial similarity in verbal intelligence.**

Maternal effects influence cognitive development in early childhood[3]. Observations of mothers of adopted infants, which eliminate the confounding of genetic transmission with maternal attributes, have identified specific maternal behaviour which fosters intellectual development in infancy[4,5]. Characteristics of maternal care and qualities of the home environment during early life predict pre-adolescent IQ[6], and longitudinal studies in London[7] and Kauai[8] document effects of the quality and intensity of early maternal stimulation. These and other data[9–11] suggest that a mother's sensitivity to her infant's needs facilitates early intellectual growth. In part, cognitive developmental differences in childhood may reflect differences in children's interactions with their mothers.

Mothers are not merely models for imitation. They establish the conditions and incentives for children's early achievement. This pervasive, but indirect influence may significantly affect a child's cognitive growth without increasing mother–child resemblance, because the relevant attributes of a mother's child-rearing may be attitudes and expectations which are uncorrelated with her IQ. Thus, the fact[12] that children's IQs exhibit no greater resemblance to their mothers than to their fathers does not preclude significant maternal effects, as such effects can[13] and do[14] occur in the absence of increased mother–child covariance.

A direct test of maternal effects on intelligence is possible within the kinships of adult identical twins. Because their twin parents are monozygotes, the children of identical twins are related to one another as conventional half-siblings; socially, they are cousins reared in different households. Because they derive from twin parents, MZ half-sibships have the same expected age and size, in contrast to conventional half-sibships resulting from death, divorce or illegitimacy. The offspring of female MZ twins form a unique group of maternal half-siblings who allow a direct measure of maternal effects on human traits. When such effects are present, the offspring of female twins will resemble one another more than do the offspring of male twins.

0028-0836/80/040375—03$01.00