in which strong social bonds were not maintained. The importance of a strong positive social relationship between the ape and the trainer is emphasized in most projects, since such bonds obviously exist for humans in the initial acquisition of language.

From all these studies one can conclude that signs and items in the artificial lexicons do, on some occasions, operate as if they represent objects or events in the real world. Yet there is no convincing evidence that apes' utterances are grammatical. Further, the rate of acquisition for the apes is dramatically lower than that of human children; the average length of utterance is short; and the apes seem to repeat much and not add to what has just been communicated to them. It is thus difficult to conclude that the apes' productions bear more than a rudimentary similarity to human language. However, one would probably find it difficult to describe the production of young children as linguistic, if we did not know that these children will grow into language using adults. And the ape language projects do indicate cognitive abilities and possible mental states in the apes.

ANIMAL COMMUNICATION
ANIMAL INTELLIGENCE
SIGNS AND SYMBOLS

D. Robbins

LASHLEY, KARL (1890–1958)

One of the early behaviorists in psychology in the United States, Lashley is best known for his work on localization of brain functions and his discoveries of how imprecise and generalized the functions of the brain can be. He was a student of John B. Watson at Johns Hopkins University, where he got his Ph.D. in 1915. He was on the staff of the universities of Minnesota (1917–1926), Chicago (1929–1935), Harvard (1935–1952), and the Yerkes Laboratory of Primate Biology.

His behavioristic interpretation of consciousness put him in general agreement with the ideas of John Watson. He had no use for the concept of consciousness or the method of introspection. Watson considered the brain a "mystery box," while Lashley was interested in digging—quite literally—into the brain to find out the nature of its functions.

As a result of his own research and that done with Shepard I. Franz, Lashley formulated two principles of brain functioning: mass action and equipotentiality. To illustrate the principle of *mass action*, Lashley taught cats to escape from a puzzle box, then removed various parts of the cortex of the animals' brains. After the cats had recovered from the operation, they were placed back in the box. He found that the cats could no longer perform the acquired task, but with further training they could relearn the task even in cases where both frontal lobes had been removed. On the basis of this experiment and many others, the principle of mass action indicated that learning was not dependent on specific neural connections in the brain but on the brain as a whole. The rate of relearning turned out to be a function of the total mass of brain tissue involved.

The principle of *equipotentiality* stated that each part of the brain was just as important as any other. If some parts of the brain were removed, other parts could carry on their functions. For example, when the visual area of rats' brains was removed, although they lost patterning, the rats could still discriminate differences in light intensity and could follow light.

Lashley's major publication was *Brain mechanisms and intelligence*.

R. W. Lundin

LATERAL DOMINANCE

Lateral dominance is the use of one side of the body more often or more skillfully than the other in unilateral activities. The most obvious example of lateral dominance is more frequent or skillful use of one hand over the other. Lateral dominance is associated with asymmetrical organization of the functions of the two cerebral hemispheres, although the relationship is not exact.

The majority of people are right-handed, although there is considerable variation in the discrepancy between the efficiency, force, and frequency of use of the right hand as opposed to the left. Questionnaires are sometimes used as tests for handedness, but more accurate and descriptive behavioral methods include observation of the individual performing such tasks as writing, throwing, and cutting (R. M. Reitan, *Manual*).

The preference for the use of one foot or one eye over the other, while not as frequently studied as handedness, is as important a part of lateral dominance. While most right-handed people are also right-footed and right-eyed, there are many whose eye/hand/foot lateral dominance is mixed. Such tasks as stepping on something and kicking differentiate right-footed from left-footed individuals, while tasks such as looking through a telescope and sighting a rifle are used to evaluate eye dominance (R. M. Reitan, *Manual*).

While environmental factors probably play a large part in determining lateral dominance, some studies suggest that there may be hereditary influences as well (H. D. Chamberlain, 1928; S. P. Springer & G. Deutsch, 1981; H. Hécaen & J. de Ajuriaguerra, 1964).

Some lateral dominance apparently exists in many nonhuman animals (R. L. Collins, 1968, 1969; J. M. Warren, J. M. Abplanalp, and H. B. Warren, 1967). Cats, monkeys, and mice often show a preference for use of one limb over the other.

BRAIN LATERALITY
NEUROLINGUISTICS
NEUROPSYCHOLOGY
PSYCHOPHYSIOLOGY
SPLIT-BRAIN RESEARCH

T. S. Bennett

LAW OF FILIAL REGRESSION

For many continuous traits such as stature and intelligence, it is generally found that the adult offspring of a given parent deviates to a lesser degree from the mean of the population than does the parent. That is, the offspring "regresses" toward the population mean. Sir Francis Galton termed this observation "the law of filial regression to mediocrity." He conceived of it as a fundamental law of heredity (1889). But he probably overestimated its fundamental significance, and we now know his theoretical explanation of the phenomenon to be incorrect.

Galton had obtained measurements of the heights of a large number of men and of their adult sons. He observed that the frequency distribution of heights closely approximated the normal or Gaussian curve and was virtually identical for father and sons. This observation at first deeply puzzled Galton. Because parents have offspring that deviate above and below the parental measurement on the trait in question, Galton wondered why the offspring of the most extremely deviant (e.g., the tallest and shortest) parents in each generation did not cause the range of variation to increase in each successive generation. He then plotted the scatter diagram of the bivariate frequency distribution of fathers' and sons' heights. This was the birth of the important statistical concepts of regression and correlation.

Using Cartesian coordinates, with fathers' heights plotted on the abscissa and sons' heights on the ordinate, Galton determined, within each one-inch interval of fathers' heights, the median height of their sons. He connected the median points and found that it formed an approximately straight line, which he termed the "regression" line. It clearly showed that the average height of sons of fathers of a given height "regressed" toward the mean of the general population. The rectilinearity of the regression line meant that the degree of regression was a constant fraction (about $\frac{1}{3}$) of the father's deviation from the population mean. Galton later showed that the offspring also regress from the midpoint value (i.e., the average of both parents). He also performed a true genetic experiment on sweet peas, to find that the size of peas, measured by weight, displayed the "law of regression." It should be noted (and Galton himself did not overlook the fact) that there are *two* regression lines in the bivariate scatter diagram, the regression of offspring on parents and the regression of parents on offspring, and both regression lines (when the measurements for parents and offspring are expressed as standardized deviations from the mean) have the same slope, which in this case is termed the standardized regression coefficient. (It is the same numerical value as the Pearson correlation coefficient.)

Galton theoretically explained the phenomenon of regression in terms of his law of ancestral inheritance, by which the genetic contribution of each parent to an offspring is $\frac{1}{4}$, of each grandparent $\frac{1}{16}$, of each great-grandparent $\frac{1}{64}$, and so on; presumably, each further removed ancestral generation comes closer to being a random sample of the general population. Therefore the offspring's total genetic inheritance for the trait in question, being the sum of this infinite series of decreasing fractions, comes closer to the mean of the population than does that of the parents. This explanation for regression, however, has been totally rejected by modern geneticists.

The importance of Galton's law of regression for psychology arises from the fact that Galton argued that general mental ability, which he believed to be largely inherited (1869), manifests filial regression in the same way as stature and other hereditary physical traits. Indeed, empirical evidence from mental tests obtained on parents and children has borne out Galton's argument: the offspring of exceptional parents (in either direction of deviation from the population mean) are less exceptional than their parents, and by a constant fraction of the parents' deviation from the mean. But the interpretation of this well-established phenomenon has been a source of confusion to psychologists from Galton to the present day.

To correctly understand the phenomenon of regression requires, first, that one distinguish clearly between the statistical (descriptive) and the substantive (causal) aspects of the phenomenon. The regression coefficient (i.e., the slope of the regression line) merely *describes* the raw fact of regression quantitatively; it does not *explain* anything. Since the regression coefficient, when based on standardized scores in both variables, is the correlation coefficient r, it is a mere tautology to say that when any two correlated variables, x and y, are less than perfectly correlated (i.e., $r_{xy} < 1$), the standardized regression slope will be less than 1, and the corresponding value of y for any given value of x will deviate less from the population mean of y than x deviates from the mean of x, and vice versa. Statistically, regression and correlation essentially describe or quantify the same phenomenon, which is most simply thought of as imperfect correlation between two variables, including measurements of a trait in parents and children, siblings, twins, or any other kinships. Hence the theoretical explanation of regression is essentially the explanation of why the two variables in question (e.g., fathers' and sons' heights) are not perfectly correlated. For any particular trait, genetic factors may or may not be a part of the explanation. It is a question that can be answered only by empirical investigations expressly designed to test an explicit genetic model.

The possible causes of regression among parents and offspring (or any other kinships) can be classified into three main categories: (1) errors of measurement, (2) genetic factors, and (3) environmental factors.

1. Unreliability or measurement error attenuates correlation and thus contributes to decreasing the slope of the regression line. The effect of attenuation can be corrected, provided we know the reliability of the measurements.

2. The genetic aspect of regression, assuming trait variation involves hereditary factors, results from the fact that each offspring inherits only a random half of each parent's genes. Particular combinations of genes in either or both parents can have nonadditive effects on the phenotypic expression of a trait, and these combinations may not be passed on to the offspring. The more deviant the parent, the more likely the deviation is caused by relatively rare nonadditive combinations of genes, such as dominance and recessiveness (the interaction of alleles at the same chromosomal loci) and epistasis (the interaction of genes at different loci). Rarer combinations of the parental genes are less likely to be passed on to the offspring, who therefore will generally differ from the parents in the direction of less deviance from the population mean. Similarly, the offspring can inherit rare genetic combinations that do not exist in the parents and which make the offspring more deviant than their parents. When all the genes that contribute to variance in a trait have only additive effects and there are no interactive effects of particular combinations of genes, the offspring will, on average, have the same genetic mean as the midparent, that is, there will be no genetic regression of the offspring toward the mean. Hence a well-known method in genetics for estimating the "narrow heritability" of a trait (i.e., the proportion of trait variance attributable to additive gene effects) is the regression of the offspring on the midparent. But this method is strictly valid only if parents and offspring have not shared the same environment; it is necessary that the offspring have been reared in environments selected at random in the population. The phenomenon of regression is a valid argument in support of a hypothesis of genetic inheritance of a given trait, only if the amount of regression is closely consistent with an explicit genetic model that predicts the degree of regression that should be theoretically expected for any given degree of kinship.

3. Because individual differences in the development of a trait may be affected by environmental factors, and because parents and their offspring (or siblings, twins, or other kinships) do not share identical environments, the correlation between relatives may be decreased because of differences between their environments. The more deviant parents, for example, may have had more rare and unusual environments than the environments they provided for their own children, hence the children will be less deviant than their parents. There is nothing in the phenomenon of regression *per se* that proves either genetic or environmental causes or some combination of these. However, the complex methods of quantitative genetics, which are intended to partition the total population variance in a trait into its genetic and environmental components, may yield an estimate of how much observed regression is attributable to genetic factors, to environment, and to measurement error.

ANTHROPOLOGY
HEREDITY AND INTELLIGENCE
HERITABILITY
INSTINCTS
STATISTICS IN PSYCHOLOGY

A. R. JENSEN

LAZARUS, ARNOLD A. (1932–)

Born and educated in Johannesburg, South Africa, Lazarus did his academic studies at the University of the Witwatersrand and obtained a Ph.D. in clinical psychology in 1960, serving part of his internship in London at the Marlborough Day Hospital. While a full-time private practitioner in Johannesburg, he maintained an interest in clinical research. He gained recognition as a clinical innovator through an article on group therapy published in 1961 in the *Journal of Abnormal and Social Psychology.* Invited to spend a year teaching at Stanford University, he first came to the United States in 1963.

In 1958 Lazarus was the first to use the term "behavior therapy" and "behavior therapist" to describe certain objective treatment strategies. He has contributed papers, articles and chapters to the behavior therapy literature, and was elected president of the Association for Advancement of Behavior Therapy in 1968. Then professor of psychology at Temple University Medical School, he later went to Yale University (1970–1972) as direc-