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ABSTRACT

The current state of and opportunities for basic research related to child and adolescent development are described in this report. The document was prepared as a resource for developing the National Institute of Child Health and Human Development's 5-year plan of research for the years 1983-1987. Five broad areas of research are addressed: (1) physical growth and physiological development, (2) developmental behavioral biology, (3) learning and cognitive development, (4) language development and communication, and (5) social and emotional development. Within each broad area a number of specific foci for research efforts are discussed. (RH)

Child Health and Human Development

An Evaluation and Assessment of the State of the Science

Child and Adolescent Development

Foreword

This report is one of ten prepared in 1980 for the Steering Committee for the Five-Year Research Plan of the National Institute of Child Health and Human Development (NICHD). In developing the plan, a Study Group for each of the ten NICHD program areas was asked to evaluate the state of the science, identify areas of promise, and recommend directions for future research. Each Study Group consisted of leading scientists and staff of the NICHD. The Steering Committee conducted an extensive scientific and policy review of the reports, and collected and published them in Child Health and Human Development: An Evaluation and Assessment of the State of the Science (October 1981). The reports reflect specific interests and expertise of the authors and not necessarily NICHD policy. The report on the following pages is reprinted from the collection. The ten program areas are:

I Fertility and Infertility
II Pregnancy, Birth, and the Infant
III Nutrition
IV Sudden Infant Death Syndrome
V Congenital Defects
VI Mental Retardation
VII Child and Adolescent Development
VIII Contraceptive Development
IX Contraceptive Evaluation
X Population Dynamics

Each program area will be reviewed and updated annually as part of the NICHD planning and evaluation process. By this means, areas not emphasized adequately can be addressed, the guidance of other experts can be sought, and changes in the state of the science and changes in health issues can be accommodated.

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Child and Adolescent Development

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I. Physical Growth and Physiological Development

The study of growth and development is the study of changes that occur in an organism as it reaches maturity. Human growth and development represent a continuum. Those concerned with child health and the child's ultimate outcome as an adult look upon the study of growth and development as basic to understanding the foundations of a healthy adulthood.

Current State of the Science

Somatic Growth and Body Composition

Many standards of somatic growth and body composition for infants and children have been developed, such as the National Center for Health Statistics Growth Charts with reference percentiles for boys and girls from birth to 36 months of age. Although current methodological research on growth and development has moved beyond anthropometrics, growth trajectories, and incremental growth curves, these approaches are still in widespread use in clinical diagnosis and in epidemiological studies of nutritional status of populations throughout the world.

In the area of physical growth, current work is focused on basic biophysical and radiologic studies of skeletal development and mineral density of bone, and on sophisticated mathematical models of the effects of torsion and stress on skeletal growth and on the development of normal gait. Investigators are also interested in the effects of various kinds of nutritional intake on physical growth and body composition and in developmental studies of physical

and mental performance in situations of reduced nutritional intake.

A major analysis has begun of approximately 2,500 subjects who were enrolled in seven longitudinal studies of growth, some of which were initiated in the early 1930s. Many of the subjects are available for modern technical analysis of body density, fat cell populations, and serum lipids.

The study of body composition has advanced over the years from the measurement of body weight and skinfold thickness to the measurement of fat-cell size and number, analysis of the lipid content of fat cells, and whole-body plethysmography. The development of an air-displacement technique for determining body composition of newborn infants is now being perfected. Lean body mass can now be estimated by the use of a whole body counter of ^{40}K, a stable isotope of potassium. Bone density can be measured by neutron activation analysis and by photon absorptiometry. These techniques are currently being used to determine changes in body composition of pregnant women at various gestational stages, and to assess the differences in body composition of newborn infants born prematurely.

Obesity

Obesity during infancy and childhood is a serious problem; obese children tend to become obese adults. Thirty-seven percent of infants who exceed the 95th percentile of weight for age during the first 6 months of life will become overweight or obese adults.[1] The odds against an overweight child becoming an average-weight adult are estimated as 4 to 1 at age 12. These odds rise to 28 to 1 among those who fail to reduce during adolescence.[2]

The prevalence of obesity among American children appears to be a function of sex, race, socioeconomic level, and especially, the presence of obesity in their parents, whether biological or adoptive. Using triceps skinfold thickness greater than 18.6 mm for males and greater than 25.1 mm for females as an anthropometric sign of obesity, the Ten State Nutrition Survey showed that at age 12-13, 17 percent of white males and 9 percent of black males are obese and that 12 percent of white females and 11 percent of black females are obese. By age 16-17, the percentages increase to 24, 13, 13, and 13 respectively.

The variance in obesity of white children at ages 5-18 that is associated with income level ranges from 15 percent in upper and upper middle to 34 percent in lower and lower

middle for males, and from 6 percent in upper and upper middle to 28 percent in lower and lower middle for females.[3] In both adoptive and biological families, the risk of childhood obesity is 10, 40, and 80 percent, respectively, when neither parent is obese, one parent is obese, and both parents are obese.[4]

Obesity is a heterogeneous condition of many causes. The appetites of plump adolescents who snack frequently and consume double desserts differ from the gargantuan appetites of children with the Prader Willi syndrome, who require physical internment and padlocked refrigerators to be kept from indiscriminate gorging. Both kinds of appetites lead to obesity, caused by the storage of energy in excess of expenditure as triglycerides in the fat cells of adipose tissue of the body.

Hunger originates in the brain, not in the stomach, but its precise physiological basis is unknown. It is probably determined by a signal in the blood that registers in the hypothalamus. Animal studies and unusual cerebral tumors and other lesions in humans have shown that the ventrolateral nucleus of the hypothalamus is a neural center that promotes the hunger drive. When this center is destroyed, either experimentally or by an accidental lesion, the hunger drive disappears and death by starvation may ensue.

A collection of neurons in the hypothalamus, the ventromedial nucleus, determines satiety. Presumably, chemical signals sent from the peripheral tissues of the body are perceived by neurons within this center, and a sense of satiety develops. If this center is destroyed, the hunger drive remains unopposed, and insatiable eating and obesity result. Research scientists have determined that cholecystokinin, a polypeptide secreted by parts of the gastrointestinal tract, is also found in the hypothalamus, and that it curbs the hunger drive. Recently an octapeptide fragment of cholecystokinin was found to cause satiety as well. Other neuropeptides, some of gastrointestinal origin, such as secretin and gastrin, have been found to have binding sites in brain tissue. Still other neuropeptides such as endorphins may play a role in the hunger drive. For example, the genetically obese mouse has been found to have ten times the amount of cerebral endorphin as a lean littermate. Naloxone injections reduce the rate of food ingestion by these mice, presumably by blocking the sites of endorphin action. Glycerol, the three-carbon backbone of triglycerides, which are the major component of fat tissue, has been shown to reduce significantly the hunger drive when injected into certain animal models.

New avenues have also recently been opened in the psychology of obesity. For example, external cues, such as

attractiveness of food presentation, texture, and palatability, are more important to obese individuals than to those of normal weight. When obese people are given an unappealing liquid diet, they nearly halt their food intake. People of normal weight continue to eat about the same number of calories no matter what the texture or taste of the diet. This observation suggests that obese individuals ignore or override the internal satiety signals that originate in their hypothalamus and continue to eat when surrounded by palatable food presented with visual appeal. In this light, it has been shown that the intake of snack food among obese individuals, but not among lean, varies directly with the amount of ambient illumination in the room. This study shows the importance of external visual cues to obese individuals.

Intrauterine Growth Retardation

Many complex factors may interact to influence intrauterine growth retardation (IUGR). They have not been clearly defined, nor has a clear definition of an IUGR fetus been established. Some causal factors have been identified including hypoplasia and fetal malnutrition.

In the maternal-placental-fetal nutritional complex, it seems that maternal metabolic needs for energy, amino acids, and minerals may take precedence over fetal requirements, with a resultant degree of IUGR. Investigators are examining a variety of possible causal factors other than nutrition that include defects in maternal-fetal endocrinology, placental insufficiency, intrauterine asphyxia, systemic or intrauterine infection, maternal immune intolerance of fetal antigens, alcohol consumption, and smoking that may operate singly or together to produce growth retarded fetuses.

Puberty

Next to birth, puberty represents the most dramatic change experienced during life. The control of the sexual and somatic changes that overtake a child's body for the most part remains unknown, although the origins of this control are now being studied. In some children, the onset of puberty is delayed; others never become sexually mature. Because of a lack of secondary sex characteristics, they may be excluded from their chronological peer group and come to doubt their sexual identity. In the rare instances when puberty is early, children tend to grow taller than their schoolmates in elementary school but fall behind in junior high school and end up a foot or more shorter than their peers. At either extreme, the occurrence can lead to social ostracism and psychological handicaps.

Ninety-eight percent of females in America have breast budding by age 13, and 95 percent experience menarche by age 15. If age 15 is used as a norm, 5 percent of American girls experience a delay in reaching sexual maturity (an estimated 75,000 per year). Among males, puberty is considered to be delayed if their testes have not started to enlarge by age 14. This delay in development occurs in about 3 percent of American males (about 45,000 per year), although genitalia of adult size are attained in 98 percent of the male population within 4 1/2 years of the onset of pubertal development, regardless of the time of onset.[5]

Delay of sexual maturation (hypogonadism) may be caused by physiological failure at three different levels of the hypothalamo-pituitary-gonadal axis. In primary hypogonadism, the lesion lies in the gonads (testes or ovaries). In secondary hypogonadism, the problem lies in the pituitary gland's inability to manufacture or secrete adequate quantities of gonadotropins [follicle stimulating hormone (FSH) and luteinizing hormone (LH)]. In tertiary hypogonadism, the hypothalamus, a neurosecretory portion of the brain that sits above the pituitary gland, fails to manufacture or secrete adequate quantities of luteinizing hormone releasing hormone (LHRH).

Recent advances have shown that although the pituitary is still the master gland, it may also be considered the servant of the hypothalamus and of even higher structures of the central nervous system (CNS). The roles played by the limbic system and by other parts of the CNS in the initiation of puberty are now being explored. Electrophysiological and neuropharmacological studies have been undertaken in the search for the cerebral origins of puberty. This work may help to ascertain the causes of delayed and precocious pubertal onset. Neuroendocrinological studies should shed light on what may prove to be a group of primary deficiencies of hypothalamic releasing factors, such as thyrotropin releasing hormone (TRH) and growth hormone releasing factor (GHRF), which cause cases of cretinism and dwarfism.

Currently, males who fail to develop secondary sexual characteristics are treated with injections of long-acting testosterone, and females with primary amenorrhea are treated with cyclic administration of oral estrogen and progesterone. Although this steroid replacement therapy has been shown to ameliorate primary hypogonadism, it causes gonadal atrophy in the secondary and tertiary forms of pubertal delay. The recent isolation and synthesis of LHRH offers the promise of using this neuro-hormone (or an analogue of LHRH with a longer biological half-life) to initiate puberty in cases of tertiary hypogonadism.

Primary gonadal disease, such as anorchia or gonadal dysgenesis, may be detected early in childhood and diagnosed by elevated gonadotropins in urine and blood, and in the case of gonadal dysgenesis (XO genotype) by chromosome preparations. Gonadal dysgenesis occurs about once per 7,000 live-born female births. Klinefelter syndrome (XXY genotype) occurs about twice per 1,000 live male births and results in permanent lack of sexual maturation.[6]

Short Stature

Research in the field of growth hormone-deficient dwarfism has received increasing attention. Of a cohort of 100,000 short children, about 1,000 will be found to have growth hormone deficiency, and of these, about 50 will prove to have familial isolated growth hormone deficiency. The most numerous subgroup is made up of the 50,000 children who have normal variant short stature (NVSS). New evidence suggests that children with NVSS comprise a heterogeneous group and that about 15 percent of them can be made taller by treatment with exogenous human growth hormone. Although they release normal amounts of immunoreactive growth hormone during provocative tests, the hormone seems to be in an abnormally aggregated form, a mass variant that is biologically less active than normal growth hormone.

Not enough human growth hormone has been available to treat all children who have a deficiency of immunoreactive growth hormone or all those with NVSS who might be responsive to exogenous growth hormone. Human growth hormone must be derived from pituitary glands removed from cadavers. About 4 mg of growth hormone can be received from each gland. Each treated child requires about 600 mg a year, or the amount supplied by 150 cadavers. Each child needs to be treated for at least 2 years to allow an increase in height of about 8-12 inches, or until he or she is nonresponsive. If only 500 new cases enter a treatment program each year, 150,000 cadaver pituitaries would be required to provide enough hormone for 2 years of treatment. To compound the problem, 40 percent of the treated children develop antibodies to the injected polypeptide that reduce its potency. It is thought that these antibodies are formed in response to deaminated and denatured fragments of growth hormone that are generated during the process of extraction and preparation.

The extreme rarity of human growth hormone has led to searches for sources other than human cadavers including animal sources, manufacture by solid-phase synthesis, manufacture by bacterial clones, and isolation of smaller growth-promoting fragments of the larger molecule. Recently, research on recombinant DNA technology has led to the synthesis of human growth hormone by bacterial clones.

In the near future, enough pure human growth hormone may be available, not only to treat all hypopituitary dwarves who are demonstrably deficient in growth hormone, but also for use in clinical trials of the efficacy of growth hormone in the much larger number of growth-hormone responsive children with NVSS. An important benefit of using pure growth hormone manufactured by bacterial clones would be the elimination of the production of antibodies to the injected hormone by the recipient. Research is also beginning on genetic variants of growth hormone and its receptors.

Catchup Growth

"Catchup growth" refers to the acceleration of growth that occurs during recovery from a period of growth retardation. It is frequently observed in children who have undergone illness or starvation. Despite the frequency with which catchup growth is observed, the mechanisms that initiate and maintain the acceleration remain unknown. Observations in children with brain defects and in head-irradiated rats, however, indicate that an intact central nervous system is necessary. Research is now in progress to test the hypothesis that a central mechanism monitors the discrepancy between actual and appropriate size for age. Presumably, the output of such a sensing mechanism initiates signals for growth acceleration.

Hyperactive children treated over long periods with a stimulant drug have experienced a suppressant effect on growth. An abrupt cessation of such medication seems to result in a greater catchup gain in weight and height than would be expected. Serious insults to normal growth and development prenatally do not result in similar gains. Depending on the degree of insult, its timing, and duration, catchup growth may never occur.

The actual cause of such greater-than-usual catchup growth velocity is not known. It is not due to higher-than-normal levels of growth hormone, though it may be in the case of somatomedin. Because such central mechanisms may be involved in normal growth as well as catchup growth, research is needed to improve the basic understanding of the controls of growth rates and the treatment of growth disorders in children.

Brain Development

A topic of current interest is the interaction of hormones with the central nervous system, especially during fetal life and puberty. An important area is the study of how exposure to certain hormones in fetal life influences

the development of appropriate sexual behavior later in life. It is important to determine when and where electrical signals originate in the brain that stimulate the hypothalamus to initiate the secretion of releasing hormones that cause the onset of puberty. Research that correlates summed electrical events in the brain with alterations in secretion of releasing factors and subsequent hormonal changes is now in progress.

Other aspects of central nervous system development now being studied are how the brain develops rhythmic control of such diverse cyclical functions as breathing, thermoregulation, steroid secretion, ovulation, intestinal motility, sleep, hunger, feeding, and satiety.

Research is also being done on how the brain perceives and integrates environmental stimuli, such as ambient light, temperature, and pheromones, and then translates the stimuli into hormonal release and reproductive behavior. Many studies focus on the development of cholinergic, serotonergic, and adrenergic neurotransmitter systems in the brain in order to understand how the brain makes the translation. Such research also entails work on hormonal and neurotransmitter receptor proteins, their functions, mechanisms of action, and metabolism. In order to accomplish specialized research of this kind, work must also continue on radioimmunotechniques for detection and quantification of minute quantities of neurotransmitters, receptor proteins, and brain peptides, such as β-endorphin, the enkephalins, bombesin, somatostatin, and neurotensin. Nutritional biochemists, experimental psychologists, and neuropharmacologists have jointly discovered how specific kinds of nutrients alter levels of cerebral neurotransmitters such as serotonin, acetylcholine, and catecholamines. In fact, some amino acids such as glutamate, aspartate, and glycine themselves may act to excite or inhibit neuronal discharge. These neurochemicals influence levels of neural activity in different parts of the brain and thus determine states of arousal, quiescence, satiety, and motivational behavior.

In addition to neuroendocrinology, investigators are studying the structural development of the brain, including neuronal fine structure and assembly of cerebral myelin membranes. Such work is related to research on the functional neuroanatomy of the developing visual and auditory systems of the brain.

Neurochemical research is progressing on the biosynthesis of glycolipids, gangliosides, myelin proteolipid, neuronal surface antigens, and other chemical components of brain tissue. The influence of nerve growth factor and other hormones, such as thyroxine and steroids, on the growth and development of the brain is also being studied.

Investigations are needed on neurophysiological correlates of certain behaviors of infants and children, such as vision, olfaction, cognitive processes, psychomotor behavior, and social development.

Action of Thyroid Hormones in Brain Development

Although it has been known for some time that cretinism develops because of insufficient thyroid hormone during infancy, the specific mechanisms by which lack of thyroid hormones interfere with brain development and skeletal growth remain largely unknown. Research on mechanisms of action of thyroid hormones in growth and development is currently in progress.

Most of this research is done in amphibian models, because of the dramatic maturational changes induced by thyroid hormones during metamorphosis from tadpole to frog. Every cell of the tadpole carries the genetic information to become a frog, and somehow thyroid hormones release this repressed information at the proper time. In addition to the obvious changes of skeleton and breathing apparatus, the brain of the tadpole undergoes profound structural changes during metamorphosis. Its relative simplicity and its sensitivity to thyroid hormones make the amphibian brain a good model for learning more about the cerebral deficits of cretinism.

Developmental Endocrinology

Current research is concerned with the endocrinology of the fetus in relation to fetal growth, brain development, and gastrointestinal development. It also encompasses study of the functional maturation of the hypothalamus, pituitary, thyroid, adrenal, pancreatic islets, and reproductive glands. Advances in the techniques of radioimmunoassay (RIA), regional immunoassay, receptor assay, polypeptide sequence analysis, and the use of complementary DNA probes have made rapid expansion of the field possible. Growth hormone has been found to be unnecessary for fetal growth, whereas insulin is instrumental in its advancement. The roles played by other hormones during fetal development, such as cholecystokinin, nerve growth factor, epidermal growth factor, somatomedins A and C, as well as by various tissue organizers and inducers, need to be examined in greater detail, and research is progressing in this area, particularly in animal models.

An important area of clinical research is on endocrine disorders of infancy, childhood, and adolescence, such as congenital adrenal hyperplasia, hypothyroidism, hypopitui-

tary dwarfism, diabetes, disorders of parathyroid function, abnormalities of sexual development, and disorders of pubertal onset. Advances in this area involve the recent recognition that these conditions are heterogeneous. Although it has been known, for example, that several different steroid hydroxylase deficiencies can cause congenital adrenal hyperplasia, it has recently been discovered that 21-hydroxylase deficiency can become apparent early in infancy or later in childhood and can be associated with different levels of 17-OH progesterone. The gene for 21-hydroxylase has been localized to human chromosome 6, and the deficient condition has been found to be associated with certain human leukocyte antigens, such as HLA-Bw35. Such information can be useful in detecting congenital adrenal hyperplasia prenatally in mothers who have already given birth to an affected infant.

Sophisticated use of radioimmunoassay and peptide chemistry has revealed the existence of variant insulins and growth hormones. Although these variant polypeptides appear immunologically identical to the normal hormones, they are less potent biologically. The discovery of variant polypeptide hormones explains paradoxical observations like dwarfism in the face of apparently normal levels of growth hormone. Variant polypeptide hormones may also be found that are responsible for other endocrinologic conditions of childhood and should be identified.

Studies are needed on receptor and post-receptor defects as causes of dwarfism, hypothyroidism, hypoparathyroidism, adrenal disorders, sexual ambiguity, and infertility. Similarly, receptor defects, post-receptor defects, and polypeptide variants may be found that are involved in fetal maldevelopment and intrauterine growth retardation.

Insulin-Dependent Diabetes Mellitus

The prevalence of insulin-dependent diabetes mellitus among children 5-18 years of age has been estimated among Michigan school children at 1.6 per 1,000.[7] If this rate is extrapolated to 55 million, about 88,000 children under age 18 have insulin-dependent diabetes. In the United States, about 3,000 infants are born annually to mothers with insulin-dependent diabetes.[8] About 1.4 percent of them will become diabetic before age 40.[9] The etiology of insulin-dependent diabetes is still unknown. It has now been shown to be a heterogeneous condition, not only because of variant insulin, but more commonly because of insulin receptor defects, both immunologic and genetic in origin.

New knowledge has been generated on the epidemiological genetics of diabetes. An HLA-identical brother of a child with insulin-dependent diabetes, for example, has a 16

percent chance of developing the disease, a risk 80 times greater than that of the general population.[10] These kinds of data will be helpful in planning intervention strategies, especially if antiviral vaccines can be developed for use in families at risk.

Molecular Biology

Another aspect of endocrinological research is molecular biology. Research on nuclear binding of gonadal steroids and on estrogen control of genetic transcription is currently in progress. Advances in this area will increase the understanding of how steroid hormones can induce cellular differentiation and control the maturational development of such diverse tissues as gonads and lungs. Research has increased on the interaction of peptide hormones and neurohormones with their specific membrane-bound protein receptors of target organs. New techniques of peptide chemistry allow the synthesis of active hormone analogs, including classes of agonists, super-agonists, and antagonists, that have very different biological half-lives and receptor binding characteristics from the parent molecule.

Recently, a super agonist analogue of LRF, a decapeptide with substitutions at the 6 and 10 positions, has been used successfully to halt the progression of precocious puberty. This synthetic molecule is degraded much more slowly than LRF and binds to the LRF receptors in the pituitary with at least 10 times the affinity of the naturally occurring neurohormone. Presumably, this tightly bound analogue prevents LRF from further stimulating pituitary production of gonadotropins. In fact, levels of gonadotropins fall from high to undetectable levels in the children who have so far been treated with this analogue.

Directions for Future Study

Growth Standards

There are two uses of growth measures: first, to evaluate differences in health and nutrition between populations or groups in a population and to monitor changes over time; and second, to assess an individual child's position, normal or abnormal, in various settings.

Growth standards are necessary in child health epidemiology. Research using new and sophisticated biometric technology is continually needed in this area.

Selective Longitudinal Studies

Important problems of child health, growth, and development can be studied effectively by longitudinal approaches. Two areas for selective longitudinal studies (over short or long periods) are recommended including: (1) specific long-term effects of profound environmental and nutritional insults and the additional effects of the adolescent growth spurt on physical growth and cognitive development and (2) the effect exerted on physical growth and maturation by pregnancy in females still in the adolescent growth spurt.

Physiology and the Environment

The renewal of cell constituents is constant. Different substances turn over at different rates, and the human body is in a state of physiological flux. This dynamic state allows adaptation to a changing environment and energy expenditure needs. Investigations on human physiology may lead to new information to improve health. Specifically, research is needed on the neuroendocrine and nutritional feedback loops of the body, which maintain a constant internal milieu throughout a wide range of environmental extremes. The peripheral signals and the central receptors responsible for the homeostasis of systems such as mineral stores, intra- and extracellular ionic concentrations, and cellular elements of the blood, are only beginning to be elucidated. Work remains to be done in this area, especially in regard to the central nervous system and its electrical and neurosecretory aspects. The interactions of hormones and neurohormones with their protein receptors also need further study.

Prenatal Growth

Although the concept of growth as a continuum from fertilization is fundamental, the real unknowns in growth and development occur prenatally. Several areas should be investigated including:

- The growth and development of the normal fetus. Growth standards have not been developed for the first 40 weeks of fetal life. Extant fetal growth curves are based upon measurements of fetuses born too soon or too small, and are not representative of the growth of a normal fetus that develops to a healthy full-term infant. Priority should be assigned to research in this area. Fetal growth curves of normal populations should be established by use of ultrasonography.

- The growth and development of fetuses that are born too soon or too small. Those in the too-small category, or small-for-gestational-age infants (SFGAIs),[1] have their own outcome curve. At one end of the curve are those who catch up completely, and at the other, those who never do. There is a need to investigate the different possible causes of SFGAI including the gestational timing and duration of operation of adverse factors and to give priority to research on intrauterine growth retardation.

- Prenatal growth and postnatal growth--particularly of the same individuals. In this area of research, a selective, longitudinal-study approach is appropriate.

- Basic mechanisms of prenatal growth involved in fetal endocrinology, including research on biochemical factors, hormones, inducers, and receptors. This work should involve molecular biological aspects, such as structure-function relationships, identifications, isolation, and purification of receptor proteins, study of tissue inducer-receptor kinetics, and postreceptor events in regard to further fetal differentiation and growth.

- Factors in addition to nutrient intake during pregnancy, such as fetal growth factors, maternal nutritional state prior to pregnancy, maternal smoking, drug or alcohol intake during pregnancy, the role of the placenta as an organ concerned with maternal infection, maternal-hormonal and immunological factors, and fetal growth, and particularly its place in the maternal-fetal complex and its function in maternal-fetal nutrition.

- Genetic and hormonal control of the factors regulating fetal growth. It is known, for instance, that insulin stimulates fetal growth, but it is not known whether its action is related to somatomedin or how somatomedin synthesis and secretion are controlled.

- Epidemiological research on early identification of pregnancies at risk for IUGR.

Critical Periods

It is becoming clear that there are periods in human growth that are critical for the ultimate healthy maturation of specific organs or tissue. Insults or lack of essentials--nutrients, for example--can lead to irreversible deficiencies. This is apparently particularly so in the

brain. There is a lack of hard data on this area, and research on critical periods and outcome needs to be supported. It appears that hormones can exert their effects only within a narrow developmental period of time. In animal models, for example, exposure to altered ratios of androgens and estrogens for just a few days in late fetal life may permanently change sexual behavior patterns later in life, from male to female, or vice versa. The elucidation of this basic process is just beginning, and there is a need to understand why and how these hormones and other tissue organizers act only at particular times during development. It is important to determine if the hormonal action can be altered developmentally by intervention.

Growth Failures

Newly born infants and children who fail to grow at normal rates may be unusually susceptible to illnesses of various kinds, and they may also be more likely to experience impaired psychomotor and psychosocial development. The condition is heterogeneous. Contributory causes are many, including psychosocial environmental factors, inadequate nutrition, impure water supply, lack of sanitation, pervasive chronic and acute infection, as well as genetic and hormonal disorders. How these factors operate, singly or together, to cause failure to thrive remains unknown. In some cases, abnormally low levels of growth hormone have been identified; almost dramatically, these low levels rebound when such children are removed from a deleterious environment.

— Of the cohort of 3.3 million infants born in the United States every year, about 100,000 will fall at or below the third percentile of height for age. Of these children, an organic cause can be identified in fewer than 20,000, and nearly 30,000 will come from severely deprived backgrounds. In England, social deprivation has been found to be the most common pathological cause of retarded growth.[11]

In regard to biological causes of growth failure, more research is needed on the large heterogeneous group of children with NVSS. With the availability of greater quantities of human growth hormone, clinical trials will be necessary to ascertain dosages and regimens of treatment.

Developmental Genetics

There are good and well-documented polygenic systems in human growth and development--for example, finger ridge counts, and chromosome inactivation and sexual differentiation mechanisms. Patterns repeatedly appear suggesting a

role for the X-chromosome in female differentiation in the XX-chromosome situation, and the effects of X-linked genes on bone and teeth formation, with a suggestion, too, of an effect on the development of the adipose organ.

There are at least 59 major mutants on the X-chromosome. Some alleles are polymorphisms, in particular the Xg blood group and three types of color-blindness.[12] There is a need for longitudinal growth studies to demonstrate through linkage tests with well-established marker genes, the nature of X-borne inheritance of growth patterns in the human.

In more general terms, there is a lack of data on developmental genetic factors in abnormal growth patterns. Followup studies on the outcome of the intrauterine growth-retarded fetus-infant, for example, have not determined whether such infants have inherited recessively a metabolic or an immunological deficiency, in which case other infants born to the same parents would have a higher chance of being similarly growth-retarded in utero.

Research in somatic and physiological growth has drawn from relatively unsophisticated mathematical models for providing information. The models have now been improved considerably and can be applied to developmental genetic research. Mathematical models are needed to identify nature-nurture controls in human somatic and physiologic variability.

Obesity

The roles played by peptide neurotransmitters in the hypothalamus in controlling hunger, satiety, core body temperature, thermogenesis, and energy balance of the body need attention. Cases of morbid obesity, in which individuals weigh more than twice their ideal weight, should be studied to determine if they represent situations similar to animal models of genetic obesity. In some animal models, the molecular satiety signal is absent or defective, and in others, a proper signal is sent but is not perceived by the brain. The existence of similar genetic defects in some cases of human obesity seems likely. Research is needed on the control mechanisms that maintain the lipid content of fat cells within a narrow range around a mean of 0.4 microgram per cell. A search should be made for the control of the proliferation of fat cell populations. Most individuals maintain a population of about 30 billion adipocytes, but morbidly obese individuals may have 100 billion or more. The stimulus for the proliferation of fat cells is unknown, but it appears to be related to an ideal fat cell size. How this fat cell size is monitored by the body,

either centrally or peripherally, remains unknown. More research is needed on differential enzyme activity in adipocytes of obese and lean individuals, especially ATP-ase, thymidine kinase, and lipase.

Developmental Endocrinology

Research should be encouraged in the following areas:

- The control of growth. Particular attention needs to be given to control in fetal growth, the hormonal factors involved, and control exerted by the cerebral cortex and the hypothalamus. Attention should be given also to the factors involved in the mid-growth spurt at approximately 5 to 6 years of age.

- Catchup growth, with special emphasis on nutritional and hormonal factors that affect postnatal growth rates of premature infants.

- Adolescent growth, in which profound individual differences can be observed in timing, sequential events, and rates of change. In particular, the extent and role of changes in levels of neurotransmitters in the brain and hypothalamus during growth.

- The onset of puberty. Certain parts of the brain have only recently been characterized as endocrinologic in nature, particularly the hypothalamus and the pineal organ. Other parts of the brain seem to act as biological clocks that signal the hypothalamus when to alter its feedback sensitivity to steroid hormones.

- Growth failure caused by factors other than hypopituitarism; for example, by head injury or radiation to the head.

- The endocrinological, biochemical, receptor, and immunological factors that may be involved in children who fall below the third percentile for size and whose condition is sometimes labeled "constitutional growth failure."

- The response of the neuroendocrine system to nutritional, thermal, antigenic, and other environmental challenges in fetus, infant, and child of various ages.

- Chemical definition and structure-function studies of growth factors, such as epidermal growth factor (EGF), nerve growth factor (NGF), and the somato-

medins. It is now known that growth hormone exerts its effects through other insulin-like polypeptides called somatomedins A and C which are manufactured in the liver. Some dwarves, called Laron dwarves, make growth hormone but no somatomedins. These growth factors stimulate DNA synthesis and cell proliferation, but their mechanisms of action are known in only a general way.

Mechanisms of Cerebral Control

A promising interdisciplinary venture involves the search within the CNS for mechanisms that control a variety of complex physiological processes. Recent advances in neurophysiology and neuropharmacology have begun to reveal how the CNS regulates eating and drinking behavior, gastrointestinal function, metabolic fuel consumption, fat storage, body composition, rates of growth, pubertal onset, sexual behavior, and attainment of final stature and physique. The use of sophisticated experimental techniques has disclosed the primacy of central control over many of these apparently peripheral somatic processes.

Scientists understand that the locus of the control of the onset of puberty is not in the sex organs but in the brain. Puberty appears to begin with rhythmic alterations in neural impulse frequency that originate within certain parts of the midbrain and are translated sequentially into chemical neurotransmitters, polypeptide hypothalamic releasing factors, gonadotropins, and finally sex steroids. This cascade of translation comprises a hierarchy of control which is able to integrate many different kinds of signals that originate from both outside and inside the body. These signals relate information about such varied functions as degree of ambient lighting, nutritional state, level of thyroid hormones, and the presence of airborne pheromones. The search for the central origins of puberty provides a model for future interdisciplinary studies on the cerebral control of lactation, nutritional intake, hunger, satiety, habituation to customary cuisines, obesity, and anorexia nervosa.

Good models now exist for the study of microelectrical, neurochemical, and hormonal factors both at the cellular and molecular levels. Research on normal and abnormal patterns of growth and development at these levels will illuminate many currently unknown mechanisms of growth and development.

II. Developmental Behavioral Biology

Developmental behavioral biology--or psychobiology--includes the study of brain-behavioral relationships that

mediate social, emotional-affective, and sensory-perceptual behaviors. Genetic, biochemical, physiological, and hormonal bases of developing behavior are included as well as certain disease states. Six broad subject areas are representative of, and encompass, behavioral biology, as follows:

- Plasticity of developing neural tissue and its relationship to behavior;
- Sensory development and biological growth;
- Brain mechanisms and motor development;
- Electrophysiological correlates of cognitive development;
- Psychohormonal influences on development; and
- Developmental behavioral genetics.

Plasticity of Developing Neural Tissue

Current State of the Science

Research has shown that plasticity rather than rigidity is the general rule of brain structure. Early studies in this area were conducted mainly with rodents, but more recently, many small mammals, primates, and humans have been used as subjects.[13] Various environmental and other factors at particular periods of early development have been shown to have general and lasting effects on brain structure.

Research in the last decade has focused upon: the brain's susceptibility to alterations from specific environmental influences during different periods of development; the sequential nature of the timing of events; the range of possible behavioral outcomes; the specific brain structures altered; and the nature of developmental structural mechanisms involved. The structure of the corpus callosum of the mature rat with a history of squint, for example, is large and diffuse. The characteristics are similar to those found in the corpus callosum of immature rats. In a wide variety of organisms, a number of specific neural-behavioral developmental relationships have been shown. There is a developmental decline, for example, in the number of dendritic spines in the striate cortex of the visually deprived monkey at 9 months' postnatal age. Similarly, it has been suggested[14] that humans with trisomy 21 show no developmental pruning of dendritic spines with age. In addition, the failure of the human fetal cortex to invaginate appears to

result in systematic alterations in cortical cells. With the use of Golgi staining and measures of spininess, general brain pathology in human retardates has been shown.[15,16] Alterations in human albino visual sensory areas have been similarly shown.[17]

In general, most demonstrations of a relationship between specific brain environment and sensory-behavioral development have occurred in sensory or motor neural tissues. These results have yielded fairly exact developmental specifications of the range of environmental effects on sensorimotor behaviors. Also, in such cases, localized specific changes in brain morphology as well as more general changes in tissue parameters have been described.

Directions for Future Study

For the most part, animal research applied to analogous human cases has provided the specific neural models, mechanisms, and morphology involved in developmental environmental-behavioral relationships. This circumstance suggests the need for an approach to the study of developmental brain-behavior relationships. Specific disorders could be examined anatomically in light of existing animal models. Discrepancies in structure between human and animal models should be reexamined: (a) with regard to the evolutionary history of the species, (b) with a variety of dissection techniques, and (c) across a range of environmental rearing conditions.

Behavior-brain relationships other than those from gross developmental disorders can also be examined. It has been shown in mice, for instance, that abnormal migration of cells can lead to poor hippocampal organization.[18] Variations in behavior in these mice need not necessarily be considered clinical. Brain assays of patients, particularly of sensory and motor areas that involve known functions, in conjunction with their developmental histories and analogous animal models, may provide significant data in this area. Since few exact developmental models of brain malleability have originated solely from human brain-behavior demonstrations, the incorporation of animal models is essential.

Additional normal developmental anatomical data in animals, and especially in humans,[19] should be collected with available standard techniques, stored, and made available for easy dissemination.

Increased effort should be directed toward work with rhesus monkeys. They are not significantly more costly than other models, are easily manipulated behaviorally, and have excellent anatomy for study vis-a-vis humans.

Sensory Development and Biological Growth

Current State of the Science

Recent research findings in developmental psychophysics include demonstrations of human infant visual preferences and of brain-environment-behavior developmental interactions in animals. Convincing methodologies for developmental sensory assessment have emerged concomitant with demonstrations of developmental environmental influences on sensory phenomena of clinical significance.[20-23] In humans, sight and hearing, primarily in infancy and childhood, have received the most recent and successful attention of researchers.

It has been demonstrated that the very young human infant selects visual patterns of a certain size and density. Related research developments include: the description of brightness increment thresholds; the demonstration of the early presence of color vision;[24] the demonstration of visual acuity and some indication of its development; the elucidation of developmental functions and increasing sensitivity to contrasts from birth to 1 year;[25] and study of developmental specification of spherical and astigmatic errors and stereopsis. Early astigmatism, strabismus, and other developmental optical errors have been related to human and animal development and clinical interventions.[26,27] A variety of convergent methodologies has been used to allow exact and appropriate developmental diagnosis.

The application of brainstem-evoked potentials, used developmentally in conjunction with behavioral measures, has provided, within a clinical setting, an assessment of auditory frequency thresholds by age.[28]

Directions for Future Study

Large, longitudinal samples measuring visual acuity, binocularity, astigmatism, and the full contrast sensitivity functions should be collected, especially between birth and 6 years--a period in which normative data are scanty--to establish normal variability and possibly more subtle predictors than heretofore possible. The predictive value of low or midrange spatial frequency loss, for example, is related to some pathologies, such as multiple sclerosis[29] and certain spherical errors.[30] When these deviations in vision are developmentally manifest is unknown. Temporal as well as spatial frequency responses for vision should be described more accurately.

The collection of animal, especially primate, developmental behavioral visual sensory data should continue, since they have proven to be parallel to human adult data.[31]

Moreover, changes in brain structure with early visual manipulation can also be studied. Appropriate instrumentation and modification of instruments for early developmental visual assessment should be encouraged. Collaborative cross-disciplinary investigations involving sensory psychologists, clinicians, human pathologists, and animal researchers have been fruitful and should be encouraged.[32]

Auditory-evoked responses, validated behaviorally, could provide a means to assess exact auditory psychophysical functions. Also, developmental psychophysical investigation of smell, taste, temperature, touch, pain, and the vestibular and proprioceptive senses is needed. Knowledge of sensitivity of the developing organism in these modalities has become important in socioeconomic areas relating to stress, early parent-child bonding, nutrition and obesity, emotionality, and individual developmental differences in such sensitivities. There are no human data on most of these modalities between the first 6 months and school age.

A number of research areas in perceptual development are particularly promising. Perception of events,[33] relationships of figures to background and principles of grouping,[34] and perception of number[35] are examples of processes that, during infancy, may lie close to the sensory neural substrate underlying simple sensory rather than cognitive detectors.

Brain Mechanisms and Motor Development

Current State of the Science

Although few data exist relating specific brain loci to specific motor behaviors, developmental behavior norms are available,[36] as well as data on certain individual differences. Concern has recently shifted towards emphasis on the mechanisms of motor skills and also on the extent to which a wide variety of individual differences in motor skills influences the individual's adaptation to his environment.[37-39] The way in which an individual simultaneously performs a different task for each hand, for example, is a complicated function of individual biological differences in interhemispheric interaction.[39,40] Developmental mechanisms of motor acquisition have been studied in ways that allow inferences about relative hemispheric contributions to these processes,[41,42] but more information is needed on such subtle interhemispheric mechanisms.

Poor performance on skilled motor tasks can relate to other developmental problems: Poor readers do not do well on bimanual tasks and show more mirror movements even if they have a normal overall IQ. Children with agenesis of

the corpus callosum show similar behavioral effects. Early soft neurological signs (that is, signs not fully associated with neurological deficits)[43-45] are felt by some researchers to be all motoric in nature, with about one-half of them becoming pathological only if they persist beyond a certain age. Since satisfactory longitudinal studies have not been conducted, how these soft signs relate to later behaviors is unknown.

Endocrine disturbances, such as a high potassium-low calcium balance, in developing infants and children can cause disorganized motor patterns. The same disorganization is found in infants with hyperbilirubinemia. The long-term effects on learning of being in prolonged states of this kind have not been closely studied.

Recent attempts have been made to categorize the spontaneous movement patterns (stereotypes) observed in developing infants.[46] This approach is different from the reflex elicitation methods used in the past[36] and is rooted in current ethological theory concerned with action patterns at different levels of the brain at different stages of development.

Stereotypic behavior patterns provide a new way to describe developing human motor behavior theoretically. The patterns are often repetitive and invdluntary. A new approach to the description of both voluntary and involuntary motor activity stems from work in physical biology.[47] This work has been extended to the development of motor behavior.[48] Basically, motor activities are limited by such constraints as length of various limbs or operation of joints. The constraints change developmentally, in ecologically valid ways. Only a beginning has been made, however, in describing in this framework the developmental nature and norms of motor skills in humans.

Directions for Future Study

Developmental, normative human data on simple and complex voluntary and involuntary motor activity should be collected. The importance of these data stems from specific theories of motor development that are being applied to humans for the first time. The theories (ethological, physical, biological) allow a new, more general, and exact specification of motor development and offer a tie to brain maturation.

High-speed photographic and computer analytic displays can be used to investigate the development of real-time synergistic relationships of diverse motor activities. The sensitivity of these displays to rapid and minute changes in

motor coordination could provide access to the nature of subtle motor development in both normal and clinical cases. Modeling of these activities can be greatly facilitated through the development of appropriate computer graphics procedures.

Support should be given to studies of motor development that go beyond behavioral norms and are related to brain mechanisms, including metabolic and endocrine factors underlying normal and abnormal states. Longitudinal observations of varying duration should be made to ensure an understanding of the effects of lack of motor activity on human development in normal and disease cases. Norms for naturally occurring biological groups should be established for complicated motor tasks. More followup studies should be conducted on infants with soft signs. Systematic research on the development of simple and complex human behavior patterns may fit in well with developmental data of experimental biology.

Understanding the cerebellum's functions is crucial in theoretical models of the brain's mediation of motor activity. Direct relationships between cerebellar functioning and behavior can probably be best accomplished with the use of known clinical cases of abnormal cerebellar functioning.

Detailed in utero ultrasonographic examination of developing motor patterns in normal and abnormal cases would be of clinical and theoretical significance.

Electrophysiological Correlates of Cognitive Development

Current State of the Science

Under a wide variety of tasks, electrophysiological measures can be obtained that index distinct brain correlations with cognitive processes. Recognition memory, selective attention, search behavior, and expectancy have repeatedly been shown to correlate with distinct components in the brain's electrical activity.[49] A spatiotemporal mapping of the brain's activity involving these processes has been documented in adults. Electrophysiological measures have recently been used to study the developmental nature of these cognitive processes.

Recording of electrophysiological responses has a number of advantages: (a) it reveals distinct patterns of the brain activity to task performance and reflects the participation of specific brain regions to given task condi-

tions; (b) it is efficient in obtaining data relative to behavioral methods, in particular with infants and small children; (c) the development of cognitive processes can be assessed throughout the entire lifespan in humans using identical tasks; (d) scalp recordings are nonintrusive and can measure the temporal course of mental processes on the order of milliseconds--much more rapidly than can behavioral methods; and (e) abnormal as well as normal brain functioning can be detected with appropriate measures, which has clinical potential, especially for infants and young children where accurate and reliable assessment methods are needed.

Traditionally, brain activity has been measured under two experimental conditions--background electrical activity, recorded in an electroencephalogram (EEG) while the subject is usually resting or asleep, and evoked potentials (EPs) when the brain responds to an external probe stimulus, such as a flash of light. Most developmental studies have been limited to small samples. In addition, laboratories have differed in the application of stimuli and electrode placements, and in analysis of data. Efforts are underway to establish standards for the collection, analysis, and publication of electrophysiological data.[50,51]

One of the advances in developmental electrophysiology has been the determination, based on large samples of children, of quantifiable developmental norms (population means and standard deviations) for EEG data[52] and for EP data.[53,54] They have been collected while children are in a passive state. A recent research program[55] is investigating the normative base of more active EP tasks. In addition, the quantitative EP measures are being analyzed in conjunction with standard psychometric IQ measures and nutritional information to provide a more integrative view of brain-behavioral outcomes. Preliminary results suggest a possible relation between abnormally high levels of lead and difficulties in intellectual and brain functioning.

Because of the difficulties of data collection, developmental research with infants is scanty and with preschoolers almost nonexistent. Electrophysiological study of the development of memory and attention during infancy and its relation to subsequent cognitive development has started.[56,57]

Directions for Future Study

Procedures should be standardized for developmental electrophysiological data collection and analysis. With the decreasing cost and increasing efficiencies of small computer systems, calibration and analysis procedures should be

standardized for all researchers. In addition, regional facilities should be considered to gather substantial data bases through the collection of developmental norms across a wide range of tasks, provide services for individual researchers, and serve as a data network center for the storage and transmission of data between laboratories.

Developmental norms should encompass a convergent perspective and incorporate data from other areas, such as the IQ measures and nutritional norms. Since it is essential that these data be accessible in a form that can be used by individual researchers, there is a need for a data bank network centered at regional facilities.

Along with the standardization process, research efforts should be devoted to particular subpopulations of infants and children, such as Down syndrome children and children with learning disabilities. By adding the results from more active challenges to results obtained during more passive conditions, a neurometric assessment may be conducted that identifies specific deviations in brain functioning.

Targeted dimensions of the electrophysiological correlates of cognitive functioning should include such areas as the developmental changes of selective attention, memory, linguistic comprehension, and expectancy.[58] A large electrode array covering the standard 19 areas of the EEG montage could yield task-to-task alterations in the spatio-temporal characteristics of developmental brain functioning. In addition, the incorporation of recent applications of single trial analysis of EP data in infants[59] and young children may result in shortening experimental sessions. Testing sessions of a reasonable length will result in more clinically useful applications of electrophysiological measures for infants and preschool children.

Psychohormonal Influences on Development

Current State of the Science

Until the 1960s, research on psychohormonal interactions with behavior and behavioral development was concerned mainly with the influence of sexual and maternal factors and was conducted almost entirely on rodents.[60] More recently, developmental psychohormonal interactions with behavior have been examined in a range of species, including humans, and research has focused on a greater variety of behaviors.[61] There has been an increasing interest in cross-species comparisons and the application of animal psychohormonal models to human phenomena.[62-65] An increasing focus in these cross-species comparisons has been on sexual and

maternal behaviors, especially on the mechanisms of maleness and femaleness. A far larger range of sex differences has been examined, particularly concerning humans.[65-67]

Masculinization (external genitals altered and no development of ovarian cycles) has been demonstrated in young female guinea pigs,[68] with no reversibility of these effects with subsequent administration of estrogens and progesterone. It was concluded that the early hormones had altered the brain's structure. The conclusion has now been anatomically demonstrated.

Prenatal masculinization has been demonstrated in rats as a result of a number of conditions involving exposure to male hormones, including the simple condition of a masculinized female fetus developing between two male fetuses during the fetal period.[69] The behaviors that develop postnatally in prenatally masculinized animals may occur without any unusual concurrent hormonal support. It is likely that the presence of psychohormones during specific periods of fetal development can permanently affect the structure of the brain. This alteration will greatly bias the nature of the individual's later perceptual and learning experiences. It has been shown,[70] for example, that a fledgling male bird who does not yet sing, when exposed to a particular dialect, will subsequently sing that dialect as an adult if testosterone was present at his initial exposure to the dialect. In general, the basic pattern of and predisposition towards human sexual behavior appears, at least in part, to be determined in the brain as a result of early hormonal exposure. In many respects, these early prenatal influences take precedence over concurrent influences, hormonal and(or) behavioral, during infancy and childhood.

Directions for Future Study

Research to date has focused on studies of the biochemistry and anatomy of intracellular, extracellular, and more global variations in brain structure as a function of hormonal levels. It is important now to focus on behavioral effects. In humans, careful developmental measurement should be undertaken to establish the exact variation in psychohormones that are present at each age. Independently, species-specific or universal developmental changes in human behavior should be collected. Correlations should be examined between these two sets of data. Animal research should contribute general principles to test observations and correlations in humans. Mammalian and primate models should not be considered the only ones of value for human applications. Studies of insect metamorphosis, for example, have shown that hormones can inhibit development until a specified time.

Emphasis should also be placed on research on the interaction between hormonal influences on physical changes and the manner in which these physical changes interact to determine the nature of an individual's experiences with the world. This process is evident in the development of gender role. Gender identity is determined in part by an interaction between the individual's perception of his physical structure and his interactions with the social world.[65] Also since some recent animal evidence shows male-female differences in certain brain nuclei, research on human developmental anatomy may confirm evidence of male and female anatomical brain structures.

Studies on psychohormonal effects on human behavioral development should extend beyond gender-specific behaviors. Cortisol, for example, has been shown to be a potent indicator of stress in rats, monkeys, and other mammals, and its level may reveal forms of stress that are different from what can be assumed from other indicators.[71]

Developmental Behavioral Genetics

Current State of the Science

Behavioral genetics research expanded rapidly during the past decade.[72] In human behavioral genetics, twin and adoption studies are increasing. Studies have continued in the area of the single gene and chromosomes. For example, Tourette syndrome, which involves symptoms such as temper outbursts, echolalia, and muscular tics, is being elucidated. The genetics have been established, and work is under way on mechanisms. Other emotionally or intellectually debilitating syndromes include at least 200 forms of mental retardation that can be caused by single genes, and more are being identified.

A second and prominent line of inquiry is the statistical study in large populations of the effects of manipulations of the environment on individual differences in behavioral reaction. Reaction can involve complex traits based on underlying single or polygenic mechanisms.[73] Recently, study of normal individual variation has made use of developmental adoption studies. Adopted children have shown increases in IQ but do not reach the mean IQ of biological children reared in the same family, nor does their IQ correlate with adoptive parents or with a beneficial environment beyond a moderate threshold.[73]

Examination of male/female differences is also under way, which uses neither pedigree nor adoption strategies,

but careful analysis of brother/sister comparisons on course grades, aptitudes, and allocation of resources.[73]

Genetic studies of human developmental behavior often attempt to identify individuals who are the biological sources (probands) of such complex traits as hyperactivity, intelligence, height, or even criminality, that may be familially transmitted. The underlying responsible genetic factor in the latter instance may result in either poor control of impulses or inability to modify behavior in response to punishment.

Directions for Future Study

Attention should be focused on the reaction range of normal as well as abnormal individuals, for simple and for complex traits. Techniques such as adoption studies, in addition to pedigree studies, are necessary to describe reaction range developmentally.

Attention should be focused on detailed descriptions of environmental differences in reaction range studies, such as adoption or sex difference studies. Examination of complex traits, such as criminality, sex, or intelligence, should continue and should focus on simpler, underlying components.

Developmental quantitative models that take into account normal and abnormal individual differences in reaction to environmental interventions need to be developed. Every effort should be made to support large, suitable samples, representative of the entire population variance, for this research.

Developmental behavioral geneticists must receive training in a variety of subjects, ranging from psychology to biology to quantitative methods.

III. Learning and Cognitive Development

The influence of Jean Piaget on the study of cognitive development was dominant during the 1970s, particularly in the early part of the decade. Since his early work, many research questions have been clarified, and concern has shifted from repeated demonstrations of what children and adolescents are not capable of doing, because of limited capacity, to what they are capable of doing, given different and perhaps more appropriate task situations and(or) more subtle dependent measures. The metaphor has been increasingly the "competent" infant, child, or adolescent.

In a second major shift, there has been less concern with the identification or explication of structural aspects of thinking presumed to be used by the child, and greater attention to the content of knowledge or skill to be acquired and to the performance and learning factors involved in those acquisitions.

Also, a reexamination of traditional issues in the psychology of learning is in progress and is occurring in tandem with a more sophisticated analysis of cognitive activity in general and of children's developing cognitive skills in particular. Is the child just a small human learner, a "universal novice," who is generally less experienced, and hence, less likely to be successful in a wide variety of tasks? Or are there truly "developmental" limitations on what the child can do and(or) learn at particular periods?

Nature of Developmental Acquisitions

Complex Cognitive Learning

Current State of the Science

Basic questions in this area are: What components of performance of complex cognitive activity can be identified? Which of them are most central to development? How are they acquired?

Research has proceeded on two separate but related levels. First, there have been a large number of studies that identify important, previously ignored components of performance. In early stages of this research the role of memory was called the transitive inference task.[74] In the standard interpretation of this task, young children were seen as poor reasoners because they were unable to judge that if A>B, and B>C, then A>C. Upon investigation, however, it was discovered that many of the subjects also failed to recall the AB and BC relationships. In a more recent study, a strategy rather than a process was identified. Research on "empirical rule-assessment" demonstrated that it is possible to classify children and adolescents according to Piagetian tasks solely on the basis of the pattern of their errors.[75] Knowledge of content as an information-processing component has been described in a demonstration that skilled child chess players have a better memory for chess positions than unskilled adult chess players.[76] These examples are from a large literature on the role of specific factors in the performance of complex cognitive tasks. Basic research on such topics as memory development represents a crucial component of this approach.

The second level, on which there has been less research, is what has been called "aggregative models."[77] These models attempt to describe the processing of information through more than one component of the system. This is a complex enterprise, and most effort thus far has focused on formalized tasks. It appears increasingly important to have an adequate model of complex performance prior to highly accurate specification of key developmental components. This need is being recognized in research on the acquisition of reading skills. The act of reading involves not only simple processes, such as word decoding and semantic retrieval, but also complex skills, such as story recall and comprehension monitoring. Since these and many other components are central to the task, how each operates and is acquired, and how they are interrelated should be known.

A third research area is concerned with individual differences as they interact with developmental issues. It includes identification of differences in normal as opposed to poor or disabled readers, and more generally, the role that individual differences at the component or aggregate level play in influencing performance on complex tasks. Individual differences have been observed, but a consistent picture of the overall source of such differences has not yet emerged.

Directions for Future Study

All of the components of the learning process should be examined simultaneously in order to achieve insight into the process of learning a particular task. It is crucial to investigate sufficiently rich and complex cognitive learning questions in order for findings to be generalizable.

Three kinds of research on children's learning and cognitive development need attention.

1. An important area is the identification of performance components of complex cognitive activity as well as the learning components. Studies that address the question of how such components are acquired, either naturally or through direct training, should be encouraged and should address the manner in which the acquisition of these components contributes to overall success on the targeted ability. They should also be addressed to the acquisition of skills of sufficient intrinsic interest, both theoretical and practical, to merit concentrated research attention.

2. Studies that validate the construct of these components are needed. The operation of theoretically similar components in different tasks should be examined. Validity studies should also examine the connection between different levels of skill on the component and skill on the complex task of which it is theoretically a part.

3. Studies are needed that go beyond the examination of hypothesized components in isolation, and develop and test aggregative models of the complete skill under investigation. Broad, multivariate models are necessary to identify the relative importance of the various components and interactions among the components.

Cognitive Monitoring

Current State of the Science

Although a number of proposed components of skilled cognitive activity have received attention, one that has often been singled out is "metacognition"--that is, the individual's knowledge of his/her own cognitive processes. Highly related are such constructs as the "executive monitor," or control processes. This construct focuses on the individual's conscious control of his/her own information-processing activities, and particularly on the coordination of processing, strategy, and knowledge to achieve the most effective performance. The construct is conceived of as a higher-order skill in thinking than, say, retrieval from memory, in that it guides the retrieval in such a way as to be as effective as possible.

The development of metacognitive activity has been examined.[78] The major focus to date has been on "metamemory," although there has also been exploration of such components as "metaattention" and "metalinguistic awareness." Much of the research has concentrated on the demonstration that such components actually exist and are identifiable, on devising measures that can isolate the components, and on developmental changes.

Directions for Future Study

Studies are needed on the causal relationship between metacognitive ability and skilled cognitive performance to determine if metacognitive ability can be acquired through training.

Intellectual Socialization

Current State of the Science

Specific research questions can be summarized in three broad formulations: How do formal and informal socialization practices influence children's learning and cognitive development? How do different socialization practices among families or social groups lead to differences in cognitive development? And what are the expectations of adults about the cognitive development of children of different ages, and how do these expectations affect children's learning and development?

Research has been conducted on the first two questions.[79] A number of important differences have been observed in socialization practices, but it has proved difficult to associate them with specific cognitive outcomes. Early informal intellectual socialization in the home appears to be far more concordant with formal socialization in the school for middle-income nonminority children than for others. Evidence suggesting that much of the latter group's difficulty in school and afterwards is traceable to discordant socialization practices deserves additional attention. This need is especially important in light of the numerous demonstrations of the effect of adult expectations on children's learning.[80]

Directions for Future Study

Specific connections between socialization practices and particular cognitive acquisitions should be identified. Both observational studies in natural contexts and training studies may be appropriate.

It is important to identify strategies that children use in changing from one set of social expectations to another, particularly in the case of a discordant transition, such as a child entering a school that is culturally different from the home. What "unlearning" as well as learning must occur for him/her to succeed or cope?

Varieties of Content To Be Acquired

Cognitive Development as the Acquisition of Culture

Current State of the Science

Research on cognitive maturity is important to understanding general principles of cognitive development and children's learning. A useful perspective is to regard the achievement of culture as the principal goal of cognitive

development and to regard "mind" as a cultural achievement.

Psychologists[81] and anthropologists[82] have studied cognitive enculturation. Recent research has demonstrated the interrelatedness of cognitive developmental theories and findings to formal school learning. They have also demonstrated that these theories do not apply to individuals with limited exposure to formal learning situations. Such research also shows that categories for cognition are not necessarily applicable to all cultures.[83]

Directions for Future Study

Cross-cultural work should continue. Differences within the society should be examined from the perspective of enculturation. Of particular importance is a need to focus on the theory that an individual who is cognitively incompetent within the culture of the standard school setting might be quite competent in the culture of his/her home community. Discovering the basis of this competence, particularly as it might be made relevant to current school and career settings, is important.

Cross-cultural studies should be performed from an anthropological perspective. Of special importance is understanding how children deal with culturally imposed cognitive demands of the standard classroom when their prior enculturation is divergent.

Structure of Knowledge

Current State of the Science

Central to understanding the acquisition of a new skill or knowledge is an understanding of its structure.[84,85] The understanding of structure is a prerequisite for literacy, basic quantitative skills, and communication skills.

Research on scientific reasoning tasks has suggested that greater specificity about partial achievements of a component of culture is needed.[75] The process of moving from little or no knowledge, to partial knowledge, to mastery must ultimately be traced in terms of the nature of the structure of that knowledge.

Directions for Future Study

Studies that elucidate the nature of knowledge within a particular field should be encouraged, including specification of fragmentary or incomplete knowledge, since the

latter is germane to developmental studies. Research in this area will require interdisciplinary efforts.

Social Cognition

Current State of the Science

Social cognition overlaps with social and personality development, and it is an important area. A descriptive data base has been produced on empathy, egocentrism, role taking, friendship, and social problem-solving.[86,87]

Directions for Future Study

Social cognition in action rather than in laboratory or paper-and-pencil tasks should be examined. The highly reflective aspects of many current tasks may not readily characterize on-line social cognitive activity, in which the monitoring of others' activities requires considerable processing. A major question to address is how social cognition develops in social contexts.

A better understanding is needed of the kind of information processing that occurs in social cognition. Application should be made of research findings in both social psychology and cognitive psychology. One promising example is concerned with episodic memory and the use of scripts, plans, goals, and story structures. Another is concerned with attribution theory, within which a number of important questions related to social cognitive development arise.

Affective and Motivational Influences

Current State of the Science

There is a lack of data on the role of affective and motivational factors in children's cognitive activity. If an executive monitor of some sort successfully allocates resources to a cognitive problem, part of the monitoring must be decisions about where to allocate resources. Some current work on learning disabilities has focused on attentional deficits.[88] For many children with a history of difficulty on complex cognitive tasks, attentional problems may in fact be based upon an unwillingness to engage cognitive abilities as successfully as they otherwise might. On a general level, studies have been undertaken on the development of mastery motivation in children and its relationship to cognitive achievements, and have demonstrated apparent monotonic decline through the school years in motivation to master school learning.[89] The implications

of this finding for learning and for cognitive theories of development are significant.

Directions for Future Study

Basic definitional and descriptive research is needed to identify the nature of affective and motivational frameworks surrounding cognitive accomplishments in childhood. How do they develop, and do the relationships change as a function of development? How do differences in motivation among children develop, and in what ways do they affect children's intellectual development and performance?

Specific Developmental Periods

Infancy

Current State of the Science

Two scientific advances have fostered rapid growth in the knowledge of infant perceptual and cognitive development. One is the refinement of measures, such as heart rate deceleration and acceleration, and eye movements, that allow even very young infants to "tell" what information they are or are not processing and with what effort. The second is the extension of this methodology to look at "higher" levels of cognitive activity as well as more basic sensory activity.[90]

Directions for Future Study

There is an insufficient understanding of how much the infant can do. Continuing discoveries have given insight into the "competent infant," and studies should be continued.

Childhood

Current State of the Science

Insights have resulted from research that gives careful attention to the kinds of responses young children are capable of and that finds ways to allow them to show their competencies. Childhood is an important period of cognitive development in that it represents the transition from a sensory-motor-based cognitive system to one that is symbolically based. It has been examined from the perspective of language development, but has only recently been studied for the development of other skills. Unsuspected areas of competence have been identified,

including number development,[91] communicative ability,[92] and memory development.[93]

Another relevant area of competence is perceptual-motor development. The question of the enduring effects of early perceptual experience continues to be a fruitful approach, particularly in speech comprehension; and recent investigations that apply more sophisticated theories of motor behavior to the study of motor development have produced insights into the organized nature of skill acquisition.[47]

Directions for Future Study

The recent emphasis on the competence of children has been productive, and continued study of the range of their skills is necessary. Exploratory studies should be encouraged on development other than language development, as should continuing research to provide a descriptive data base in areas already being worked on. Especially to be encouraged are analyses of perceptual motor development, particularly as these analyses connect with more perceptual orientations and their development.

Adolescence

Current State of the Science

During preadolescent and early-adolescent years, individuals become more facile with complex abstract reasoning, and such reasoning is increasingly expected of them in school settings. A refinement of definitions of abstract thinking and an improvement of methods of assessing that ability, together with the descriptive data base, enhance the prospects of understanding more about the acquisition of these skills.

Directions for Future Study

The transition from concrete-based reasoning to abstract, formal analysis is critical, especially since formal analysis is required by a technologically oriented culture. Existing data indicate that probably not much more than half of the adult population ever become adequately skilled in this kind of thinking. Use of detailed analytic tools makes it likely that researchers will obtain an understanding of both the successful acquisition of these skills and the reasons behind failures to acquire them. It has been suggested that there is no *a priori* reason to assume that early childhood is a better time for intervention than early adolescence,[94] and a more detailed understanding of the adolescent cognitive transitions could confirm that observa-

tion. A concentrated effort to understand the acquisitions of formal reasoning by some, but not all, adolescents and adults should be considered a major priority for research.

IV. Language Development and Communication

Major changes have occurred in the study of normal language development. Advances in American structural linguistics, transformational grammar, generative semantic formulations, and pragmatics have had successive impacts. In linguistics, advances in phonology, and in psychology, advances in speech perception have filtered into the work concerning language and communication of children. In addition, researchers have become sensitive to the range of linguistic structures and acquisitional processes to be found in languages other than English.

Information from studies of children with communication disorders such as hearing impairments or severe language delays has served to address the question of critical periods in the acquisition of language. Research has also been directed toward improving rehabilitation strategies for handicapped children. Efforts with behavior modification have been sometimes combined with linguistic and psycholinguistic developments. Research on reading has been influenced by recent advances in linguistics and psycholinguistics as well as by advances in the study of information processing in psychology.

The "language" of the chimpanzee has been studied with a focus on the question: Does language have biological substrates in the human? That is, does the ability to learn and use language depend on innate abilities specific to humans, or does it rest on more general cognitive abilities that may be present in other species?

Phonology

Current State of the Science

Phonological development is concerned with linguistic phenomena that are subsumed under two subdisciplines: phonetics, which, independent of a particular language system, is the study of the acoustic, articulatory, and perceptual aspects of speech sounds; and phonology, which is concerned with the linguistic relevance of phonetic phenomena within particular languages. Phonological development is studied through (a) naturalistic "diary" studies of the longitudinal development of a single child; (b) cross-

sectional normative studies of articulatory skills, and more rarely, of perceptual skills in groups of children; and (c) in the last decade, controlled laboratory examination of specific phonological phenomena in infants and children.

Studies of the production of English speech sounds by children from about 3 to 8 years of age show that most children learn to produce the inventory of speech sounds during the first 5 to 8 years of life.[95,96] Although the sequence of acquisition is quite regular for broad classes of sounds, diary studies show considerable individual differences in the details of acquisition of sounds with distinctive features. There is also considerable individual variability in the production of particular speech sounds as a function of the phonetic and lexical context in which they occur, and variation over time in the production of specific sounds within a word as a function of the phonological system as a whole. Research on the effects of contextual variables on the production of speech sounds and on the role of a phonological system as a whole on production of specific sounds is in formative stages.[97] Only a few studies of phonological development in languages other than English have been conducted, and the relative contribution of universal and language-specific factors in articulatory development is not known.

Laboratory studies that examine the "psychological reality" of distinctive feature descriptions have investigated the production patterns of normal children and of children whose articulation is late.[98] Because of the difficulty of obtaining reliable data from infants and children, the development of phonological perceptual skills has received less attention than have production patterns. In the last few years, however, several paradigms have been developed to test speech perception skills of infants under 1 year of age. Studies with 1- to 4-month-olds indicate that "prelinguistic" infants, with respect to perceptual sensitivity to some acoustic dimensions, show discontinuities that are consistent with adult speech-sound categorization[99,100] and that are independent of exposure to a target language in which the particular acoustic contrast is present.[101] It cannot be concluded from these studies, however, that infants are born with special speech perception mechanisms. Such sensitivities have been shown in animals[102] and they have also been shown for nonspeech sounds.[103,104] These findings suggest that speech processing utilizes general auditory psychophysical processes that are not in themselves linguistic processes. It has been shown, however, that 1-year-old infants have perceptual constancy for some speech-sound categories over variations in phonetic context, voice pitch, and speaker identity.[105] This work and studies like it provide important information about the development of selective perceptual skills necessary for phonological perception.

One of the questions in current theories is the relationship of children's phonological perception and the ability to produce appropriate speech sounds. Some investigators have found that the child perceives, as an adult perceives, all the contrasts of the target language before production development begins.[106,107] Others theorize the child as having an internally consistent phonological system that is a reduction or simplification of the adult system.[108,109] Other theories suggest that phonological perception and production develop gradually over several years, and that in general, perception precedes production.[110,111]

Problems in studies of speech-sound identification and categorization by 1- to 6-year-old children include statistical adequacy, lack of stimulus control, and inadequate controls for cognitive and attentional factors necessary for interpreting failures. The evidence suggests that there are developmental changes throughout the first few years in the child's ability to differentiate lexical items on the basis of distinctive feature contrasts. The data, however, are fragmentary and often contradictory. As with production, there may be a general sequence of acquisition, but the details are not known and there appears to be a great deal of individual variation across children. In both perception and production, research on children between 18 months and 3 years of age, which is the period when the greatest changes in phonological behavior take place, is limited.

Directions for Future Study

It is important to conduct longitudinal studies of the development of phonological perception and production with groups of children in which rigorous experimental testing techniques are used in conjunction with naturalistic observations.

Computer analysis procedures and analysis-by-synthesis techniques, used in the study of adult speech, should be applied to developmental investigations of articulation.

Cross-language studies of children as they learn their first language are needed in order to help answer important questions of theory concerning the role of language-universal phonetic properties and of language-specific properties of phonological development. Studies concerning phonological development of children who are learning more than one language are also important. The recent introduction of large immigrant populations to the United States creates a need and also an opportunity for careful research.

Phonological development beyond the acquisition of speech-sound inventories should be studied to show the

development of the higher order of organization involved in combining and sequencing sounds. It is especially important that such investigations include studies of the development of phonological awareness, for this awareness appears to be necessary for learning to read and write in an alphabetic system.

Acquisition of Word Meaning

Current State of the Science

Before grammar became the central issue in language development, the essence of language was generally held to be the linguistic sign per se--that is, the word. How children learn that certain sounds have meanings and how they learn the conceptual properties signified by a stream of sound remain central problems. This is a concrete example of concept formation, and in literature for adults, word meaning and concept are often taken to be the same thing.

A prominent theory of word meaning has been the semantic feature theory,[112] derived from a linguistic approach whereby words are grouped for analysis according to semantic features. Namely, children learn words by including one or two features and gradually adding others.[113] A child's initial meaning for dog, for instance, might be "four-legged." The child would thus apply dog to four-legged creatures in general before learning more defining features. In a contrasting major theory,[114] children define words at an early stage according to the function of the referents, and meaning emerges from abstract to more contextually specified descriptions.

Investigators have studied such theories and focused on phenomena such as overextensions in use. Findings suggest that while children sometimes apply too few semantic features, it is also common for them to apply too many.[115]

Children's early word definitions may tend to be more perception-based than function-based, but because many things with similar functions are also perceptually similar, this distinction has been difficult to study. Eventually, word meanings involve both functional and perceptual aspects[116] as well as other kinds of meanings.[117] Recently, investigators have devoted attention to children's context-bound definitions and uses of words.[118,119]

Methodological problems have arisen in this area of study. One problem is that children not knowing an answer may guess systematically. For example, if asked to point to the big member of a pair or to a little one, even if they have no idea of the meanings, they may always point to the

big one. It looks as if they think little and big have the same meaning, when in fact they think nothing in particular. Such strategies often seem task-specific, and one can get different responses to the same words.[120] This problem is similar to the problem of children's uses of task-specific strategies in studies of syntactic development.

Another methodological problem is that children's overextensions may result in an overestimation of the spread of children's word definitions. A child, for example, may apply the word "apple" to a number of round objects. If the child is asked to point to the apple, however, the child consistently chooses correctly.[121] This action suggests that the child appreciates the correct meaning, but will use the word inappropriately if no better word is available; it is also possible that the child is actually encoding something like "is like an apple."

The truth may be even more subtle, according to developments in prototype theory. Evidence suggests that young children's use of words have predictable hierarchical structures from the appropriate referent to reasonable overextensions.[122] It has also been found that children use words to refer to particular aspects of their current meaning or to refer to other similar things.[117] All this suggests prototypical organizations for word meanings, found in fact in word meaning for adults.[106] Prototype theory may provide an important approach to the study of word acquisition, along with other studies of how children actually fit new words into an already existing system of meaning.[118]

Directions for Future Study

Important areas in the study of word meaning also apply to research in many aspects of language development.

The study of language development as embedded in cognitive development should be encouraged. Although language is a rich example of complex cognitive functioning, language and cognitive development have been studied almost entirely in isolation. Analysis is needed of whether the categories emerging in language development are isomorphic with other cognitive skills.

Individual differences in language acquisition should also receive increased attention,[123] especially as these are interrelated with individual differences in other cognitive skills.

Research that links naturalistic and experimental methods should be encouraged.

Grammar

Current State of the Science

The study of the process of perceiving the relationship of words to each other is based upon descriptions of related structures of language and the theory that the surface structure of language represents only part of the knowledge possessed by a native speaker.

Does a child construct a private system of rules of grammar that have syntactic strings often far removed from surface expressions? The child has been pictured as constructing complex formal rules to convert underlying strings, called deep structures, into surface structures. Since the child has to infer syntactic structures not heard, the supposition has been made that the child must have innate linguistic equipment.

Advances in linguistics and psycholinguistics have modified these earlier "transformational" formulations. In psycholinguistics, predictions about developmental sequence based on transformational models have not been upheld.[124-126] In linguistics, investigators incorporated semantic, and eventually pragmatic, factors more directly into their descriptions of grammar. The newer descriptions treated language not only as having a self-contained formal set of rules of grammar, but also as having semantic and pragmatic characteristics as well.[127,128] Subsequently, many linguists began to investigate the utility of descriptive grammar that depends less heavily on structure-changing transformational rules. Regularities in language formerly explained by transformational rules were increasingly explained by other theories.[129-131]

A number of investigators in the area of language acquisition independently began to use semantically based approaches, closely related to cognitive categories, for the analysis of early speech.[132,133] These analyses continue to be valid, although recent work has shown that children may use very small semantic categories and even rules based on the understanding of the grammatical behavior of single words. Although there is still some controversy, it seems unlikely that highly abstract formal categories such as subject and predicate, or noun and verb, underlie early utterances.[123] Nevertheless, cognitive categories and semantic categories seem highly related, and descriptive grammars of children's earliest perception of language can be constructed without recourse to formal linguistic categories of the type used by analysts in the early 1960s or by transformational analysis.[134]

There has also been an increased interest in pragmatic analyses. Working backward from adult to child, investigators have begun to identify the role of pragmatic analyses in children's construction of grammatical phenomena.[92,135]

The child seems not to infer underlying syntactic strings different from surface strings, or to use unanalyzable abstract formal categories, but rather, to notice regularities in the relations of surface strings to each other and in related meanings. Categories seem to be constructed by the child for the description of speech on the basis of general cognitive categories.

Studies of cognitive constraints on the learning of language have been of two kinds: the effects of general cognitive information-processing constraints and the constraints on the content the child can analyze from speech. In analyses of information-processing constraints, investigators have attempted to show, for example, that children's linguistic performance evidences the effects of strategies like those shown in general cognitive processing.[136] Specifically, they have questioned whether the child's limited short-term information-processing constraints might affect grammatical analysis and performance.[137] Concerning constraints on content, some investigators have attempted to show that the meanings children attach to grammatical constructions, such as past tense, may be limited by general difficulties with cognitive processes[138] or difficulties with analyzing causal sequences.

Studies of mother-child interaction have been used to evaluate the theory that the child's linguistic diet is ill-formed, fragmentary, full of errors and run-ons, and generally unpromising. In fact, early studies have shown otherwise. Parents' speech to children in American middle-income cultures is generally simple, short, and grammatical. It has been shown,[139] however, that parents do not give verbal approval or disapproval of the formal grammatical correctness of children's utterances, nor do grammatically acceptable utterances necessarily have clearer meaning than ungrammatical ones. Considerable cross-cultural variation has been observed in the nature of mother-child speech.[140] There are cultures, for example, in which parents consider the child's beginning to talk an imposition, and they discourage the child from talking around them. In many cultures, children learn language from other children or wherever they can. Thus, the emphasis on the delicate interplay of mother and child in communication and its importance to the child's learning of language is likely to be overemphasized in studies of middle-income Western cultures.

The importance of cognitive categories in grammatical formulation, the relation of pragmatics to grammar, and the relation of general cognitive abilities to the acquisition of the grammar of a language seem likely to remain continuing concerns in the study of the acquisition of grammar. There is a growing interest, as well, in "closer-to-surface" descriptions of complex grammar. Although different languages have a different syntax for expressing an identical meaning, children seem to be able to master different languages skillfully.[141] Linguistic rules do not directly reflect thought sequences, and children do not have difficulty with this formal quality of language. Additionally, investigators[142,143] have contended that analyses of formal categories must take into account sequential properties of morphemes per se as part of the nature of adult syntactic categories and also as part of children's constructions of such categories. Major syntactic categories, such as noun and verb, are receiving prototypical analysis incorporating both semantic and formal factors.[144,145] A number of analysts are beginning to question whether cognitive and semantic categories are congruent. Knowledge of the process of acquisition of grammar may itself bring about some redefinition of the relevant cognitive conceptual boundaries, at least in linguistic acquisition.[146]

Working from a different perspective, recent research with chimpanzees has addressed the issue of whether language is a uniquely human ability. Chimpanzees are not able to master human-like oral articulatory systems, but they have been taught sign language,[147] to play a game with tokens,[148] and to use a typewriter. It seems likely that chimpanzees can use signs to communicate meanings. There is some question, however, concerning their linguistic abilities. It is not clear, for example, to what extent chimpanzees engage in clever operant behavior and capitalize on subtle cues to guide responses rather than really communicate; although it is reasonable to assume that they sometimes communicate meanings. The evidence that chimpanzees use semantic-based rules has been analyzed and found lacking; their performance can often be accounted for by specific sign-situation routines, implicit coaching or imitation, or other means.[149]

Finally, a number of general and methodological issues affect the study of children's acquisition of grammar. Although experimental procedures are necessary to study many problems, investigators have come to depend upon naturalistic observations. The investigation of linguistic acquisition in other cultures is important. At the same time, detailed observations on the course of development in a commonly used language, such as English, continue to have great value.[123]

Directions for Future Study

Long-term studies should be conducted according to generally established models of data collection. Speech samples should be collected that can be used by many investigators. Particular attention should be channeled into data collection programs that meet basic standards with respect to contextual information, transcription, and related issues.

Cross-cultural studies should be encouraged. To establish the degree to which the data base may attribute English-like properties to the human mind, examination of language development in non-English speaking populations is essential. Comparative studies should be used not only to replicate findings with regard to English-speaking children but, more important, to describe the course of development in other cultures and languages.

Theoretical integration is needed in the field of developmental psycholinguistics. Theories are needed that accommodate semantic, formal, pragmatic, and individual lexical analyses together in the same construction.

Increased efforts must be made to understand linguistic organization at different stages of development. Studies should be encouraged that investigate later developments and more complex and more formal systems, since these comprise the heart of grammatical systems used by the mature individual. In addition, studies of comprehension in "pregrammatic" infants and toddlers would provide information about the earliest behaviors that underlie grammatical development.

Pragmatics

Current State of the Science

Studies of children's ability to communicate messages to others[150] are a part of pragmatic development. Such studies have recently shown that children are more sensitive to their listeners' needs than had previously been thought. They talk more simply to younger children than to peers or adults,[151] describe referents more clearly to a blindfolded listener than to a listener who can see,[152] and show many other signs of being able to take the listener's informational needs into account.[153] The nature and extent of this early communicative ability is still being studied.

Investigators of pragmatic development are interested in the degree to which children are able to communicate needs and ideas before language itself is used,[154] or when their linguistic resources are scarce.[155] Investigations of

what children know about how and when to use certain modes of address are increasing, but to date, much of the work has been only descriptive. In addition, while the speech of children of different ages has been studied in a variety of situations, only a small number of studies have actually attempted to identify the developmental processes that underlie pragmatic abilities. More needs to be known about the relationships among a child's ability to recognize what is appropriate speech in different situations, the way in which he or she actually uses language in these situations, and the ability to use what he or she knows about language to make social inferences.

Directions for Future Study

Present work demonstrates that children's understanding of social situations and the social and communicative needs of others emerges earlier than had been thought. Investigations are needed of specific hypotheses about the processes that underlie children's communicative skills and the effects of communicative adjustments on social interaction.

Developmental studies that employ quantitative methods to study the acquisition of communicative competence should be encouraged. Such studies should include children of different ages--toddlers, preschool children, and school-aged children.

Effort should be devoted to the systematic analysis and validation of a uniform set of pragmatic-social constructs.

The integration of research concerned with pragmatic development and other areas of social and cognitive development will allow greater understanding of the development of competent communication and its contribution to behavior. There is a need to integrate formulations of the child's general social knowledge and motives with the linguistic acts that aid or represent them.

Reading

Current State of the Science

Many theorists have concentrated on the question of how children analyze the basic perceptual configurations of individual letters.[156,157] At the "word" level, investigators have asked how children become faster at recognizing old words, both faster and more accurate at decoding new words, and better at higher level processes such as comprehension of complex discourse. Developmental studies have addressed the size of the orthographic unit, the degree to

which developmental sequences in processing occur, and the way in which children learn the systems that govern sound-grapheme correspondences. The nature of the advances in a child's word-processing that permit more rapid reading and increased comprehension are not yet well understood.

While research has identified a number of processes that skilled readers use, the organization of the processes is not well understood. Sophisticated laboratory experiments and more naturalistic observations may provide the needed integration. In addition, technologies are being developed that can trace with exactness a reader's eye movements through texts.[158]

In recently proposed "top-down" analyses of reading, it is assumed that the reader predicts new content from previous context and general knowledge--that is, if skilled readers do not fixate every word, they rely on expectancies, and the activation of related meanings makes words easier to recognize individually.[159]

Research on reading difficulties is in a preliminary stage. It is not clear, for instance, whether reading disability is an identifiable disorder or merely the low end of a normal distribution. If reading disability is a definable category, the extent to which it is homogenous and specific to reading is still not clear.

Directions for Future Study

Basic research on reading and, specifically, on how children learn to read should be continued. Technological advances in the various information-processing subfields should improve the depth of these analyses and enhance results.

Integrated approaches to the understanding of reading appear particularly promising. Other integrated approaches should be examined more closely also, such as simultaneous investigations of the reading process and other types of language behavior.

Research on reading-disabled children needs to go beyond contrasts between normal readers and disabled readers. Studies directly addressing the extent to which children labeled as "reading disabled" are a homogeneous population should be encouraged. Research that allows analysis of data from both individual subjects and group comparisons would be particularly useful. Longitudinal studies with "high-risk" populations would also provide needed information, as would cross-cultural research.

Current State of the Science

Differences in Dialect

Children who speak a dialect or language other than standard English can experience many difficulties in the United States. It is not clear whether such children should be taught to read in their own language and later shift to the standard tongue, or whether instruction should begin in the standard tongue as soon as possible. Almost all research on language development has used white children of middle-income families. Research with children from various ethnic groups and income levels is needed not only to validate previous studies but also to identify the major issues in communication for a child growing up in a bilingual community or one that does not use standard English.

Children With Hearing Impairments

Communication with American Sign Language has begun to receive detailed study.[160] American Sign Language is a complex and orderly system, with many of the properties of human spoken languages despite its different means of transmission.

Many deaf children, when not exposed to a sign language, apparently begin to devise a sign language of their own, and studies of them have been undertaken.[161] Present evidence indicates that these children make up signs for various types of actions, a system that seems to have some commonalities with the semantic-based categories used in children's early speech.

Communication Disorders

While interest in children with communication disorders has increased in the last few years, research in this field, like that on reading disabilities, is in a preliminary stage. Speech therapists, educators, and clinicians in the field of communication disorders have recently shifted their focus from articulation problems to language disorders, which is a term with a number of meanings. Poorly defined and sometimes extremely heterogeneous subject populations have posed a major difficulty in interpreting research findings in this area. In addition, recent evidence suggests that mild and severe language disorders may actually be very different kinds of problems. Mild language delays are common. They generally involve production more than comprehension, have a good prognosis with or without intervention, and take on significance when they are associated with behavioral and emotional problems. Severe language

disorders are most often associated with mental retardation or other cognitive deficits, such as autism. In the rare cases where severe language delay occurs in a child of otherwise normal abilities, language comprehension and production are equally affected, and the child's prognosis for normal use of language as an adult is poor. Epidemiological data also distinguish children with mild problems from those with severe language disorders.

Although many diagnostic and treatment programs for children with language disorders have emerged in the past decade, little empirical validation or standardization has been performed. Behavioral techniques have been the most carefully evaluated interventions, and the integration of developmentally based sequences with proven behavioral teaching methods seems to be a particularly promising area. With increasingly sophisticated research, finer distinctions may be made among problems in basic knowledge about language, in acquiring language, and in using language. As part of the increasing integration of psycholinguistics with general social and cognitive development, studies of the relationship among communication problems and other aspects of development will become important.

Directions for Future Study

Subjects for research should be drawn from diverse populations that represent a local area. Specific tasks and observational methods should be appropriate for children from different backgrounds.

Studies of bilingualism and nonstandard English should continue to receive support.

Research on hearing-impaired populations can provide information useful in answering basic questions about the nature of language as well as provide suggestions for education. Basic and applied research with hearing-impaired populations should be encouraged.

Research on language disorders in children is needed at all levels, but should target clearly defined subject populations. Current knowledge about language disorders in children is limited, and a wide range of work, from detailed descriptive studies to highly controlled experimentation, is needed. The use of control groups of normal children and children with equivalent cognitive levels should be encouraged. Research is needed to identify the particular linguistic deficits underlying language disorders, as well as research on relationships among language disorders and other aspects of development.

V. Social and Emotional Development

Current State of the Science

The Infant and Young Child

The interactive capacities and competence of the infant in the first year of life have been extensively studied, and many areas of progress have been associated with the concept of the infant as an "active" organism. Numerous studies demonstrate the infant's social responsiveness and interactive capacity, its readiness for communication long before the emergence of language, and its responsiveness to the environment.[162] Most of these capacities have been shown to be present in some form from early infancy. Responsiveness or reciprocity has been established as central in the infant-caregiver attachment process through a series of human and primate studies.[163-165] The beneficial consequences of a responsive environment and the negative consequences of unresponsive environments have been illustrated.

Advances have also been made in the knowledge of social development throughout the first year. Partly because the observational models underlying much of this research are transferable, considerable work has been carried out cross-culturally.[166] This work has shown that development in the first year is best characterized by changing patterns of behavioral organization. Five-month-olds, for instance, reach for any object placed in front of them and put it in their mouths; 10-month-olds delay in the face of novel objects and grasp them only after study. Five-month-olds are relatively uninfluenced by situational context, home or laboratory, comings and goings of caregivers and strangers; 12-month-olds may be frightened in the laboratory by a novel event that delighted them at home. In general, year-old infants use the caregiver as a base for exploration. In the presence of the caregiver, novel objects or persons can be tolerated, and contact with the caregiver quickly terminates distress and promotes a return to exploration. The year-olds' behavior thus can be seen in terms of interacting behavioral systems--wariness, affiliation, exploration, and attachment.[167]

Research on the toddler has been facilitated by the use of observational measures--the toddler being a particularly difficult laboratory subject. Longitudinal and cross-sectional studies have focused primarily on the toddler's social and exploratory skills, such as problem-solving, reactions to novelty, and early interaction with age-mates. One of the more important findings in social development concerns changes in the infant-caregiver relationship. Rather than waning, this relationship is now seen as evolving or becoming transformed. The seeking and main-

taining of physical contact diminishes, but psychological contact is maintained through visual regard, vocalization, and the sharing of play.[168,169] Even when toddlers do not seek visual contact with the caregiver, they are reassured by the opportunity to do so.[170] Increasingly during the toddler period, the child moves toward utilizing his or her own resources first, then falls back on the caregiver when necessary. At the same time, the role of the caregiver shifts from nurturance and comforting to guidance and limit setting. The relationship changes dramatically during this period, but it does not become less important.

There have also been efforts to broaden the study of social development beyond mother-infant interaction. It has been documented, for example, that infants are attached to fathers as well as mothers, that such relationships may be different in important ways, and that individual differences in one dyad will not always be predictive of another. Capacities for engaging in constructive interaction with age-mates have also been shown to be greater than previously believed.[171] Investigators are now moving toward the study of the larger family network and extrafamilial factors, including social support systems and changing life stress.

The impact of out-of-home care as an example of extrafamilial influence has attracted considerable attention. To date, one can conclude that in general, day care does not have negative effects and may have beneficial effects. There are complexities, however. Timing of onset of substitute care and its amount and quality, as well as the ongoing quality of home care, must be considered.

Research on the preschool child is centered on prosocial behavior, social cognition (role-taking), and peer effectiveness, and peer group organization. The origins of such capacities as empathy, sharing, and aggression have been outlined extensively, and there has been an effort to link such behavior to underlying cognitive processes and to experiential history. A great deal has been learned about the development of role-taking skills, but much needs to be learned about when and how such skills are (or are not) translated into social action. Progress has been made in the area of peer interaction and peer competence, where important assessment techniques have been developed. Much work with these new tools is in progress, with the organized nature of the preschool peer group already established.[172]

Middle Childhood and Adolescence

Social and emotional development in middle childhood has not been a major subject of research. To some extent, this lack of activity stems from a classical supposition that no major transformations take place during this time

and that middle childhood is a latent period.[173] It is also difficult to study the school-aged child outside the classroom, and the bulk of recent research progress has occurred with school-related issues. Advances have been made in relating achievement activity to dimensions of cognitive development, particularly of the child's increasing differentiation of ideas about success and failure. These studies are largely descriptive and do not treat the issues in terms of the social context.[174] Similarly, considerable progress has been made in charting the development of the child's understanding of morality as well as of social events and the nature of persons. Most of these studies, however, have focused on children after school entrance, and most are descriptive efforts to relate one variable to a limited number of others--based on paper-and-pencil tests. More needs to be known about the manner in which the child's changing understanding of the social universe alters behavior with peers, teachers, and family members, and how these changes interact with the growth of the concept of self.

Adolescence remains the least studied period in social and emotional development. Primarily, the literature consists of self-report studies of achievement, social relations, autonomy, identity, and sexuality. It does not address the changes in social experience within the family and the peer culture occurring with the onset of puberty--and how these affect both cognitive and affective behavior. There is also very little that is a truly ecological literature of adolescent development. Conceptual bases for such research and appropriate methodologies exist,[175] and work in this area should be encouraged.

Models and Perspectives

Advances have been made in the past decade in the theoretical models and perspectives employed in studying child social behavior. It is now recognized that development is an integrated process and that cognitive, affective, and social aspects of development must be studied together. Numerous books and papers have appeared on social cognition, cognitive/motivational interaction, and the organization of behavior.[176] Similarly, there has been considerable work on the influence of socialization on cognitive development. Investigators are now in a better position to understand how early emotional experience can affect later cognition and social behavior.

Moreover, child and environment are viewed as mutually influential in an ongoing way, with the influence of one depending on the other. Reciprocal models of causation (mutual influence) are supplanting linear models (unidirectional effects).

In many respects, investigators are now questioning the following assumptions:

- Individual differences are manifest in terms of stable traits (identical behavior over time);
- Prerequisites for a certain advanced form of behavior must be in the same domain;
- All aspects of development must be influenced by environment and heredity to the same degree;
- Development must either be continuous or discontinuous; and
- When a child acquires some capacity is more important than the quality and organization of the behavior or interaction over time.

Complex models of social and emotional development are now being used. An important advance has been the movement beyond discrete behaviors, which often can be understood only when their ties to common goals or meanings are identified. When, for example, members of the Gusii culture believe that young infants need a period of basic care but no play, such a culturally shared value has implications for behavior.[177] Outside a cultural context, such parent behaviors make little sense.

Researchers are focusing on individual differences in organizing behavior. Self-image, social competence, and self-control are concepts contained in a network of organized capacities, attitudes, and expectations. Investigators now emphasize patterns of multiple relationships over time rather than correlations.

Directions for Future Study

The Consequences of Early Experience

There have been numerous demonstrations of both the effects and the noneffects of early experience on later development, and although some aspects of functioning are relatively more buffered from early negative experience, such as the recovery of IQ, others appear more susceptible to ongoing consequences.

The study of the consequences of early experience is complex. Investigators have sufficient data to observe that consequences cannot be demonstrated at the level of specific parenting practices, such as age of weaning or breast as opposed to bottle feeding, and of specific individual

variable outcome, such as amount of crying. Studies need to be centered on the overall quality of care and the organization of the child's behavior in the face of major adaptational tasks, and should take into account the specificity of effects, transformation of effects, and indirect effects. (In this usage, specificity[178] refers to the idea that a social experience may have clear-cut consequences in some aspects of functioning and little effect in others. Transformation of effects refers to the lack of isomorphism between cause and effect; aggressive behavior, for instance, may have its roots not in parental punishment in the first year but in parental unavailability or indifference. An indirect effect refers to the idea that consequences may be delayed or become manifest only under some circumstances.[179]) The most compelling notion here is that consequences of early negative experience and maladaptation may become obvious only under later conditions of stress.

Questions about day care provide an example of this kind of concern.[180] Research of some complexity and scope should be conducted in this area in order to evaluate the consequences of day care.

Mutual Influence of Child and Parent

In the 1970s, a great range of studies showed conclusively that the infant or child has an effect on its caregivers. A basic issue for the 1980s is to uncover the process of ongoing mutual influence--the interaction between endogenous infant factors, family situation, and parental expectations and competencies, a significant aspect of which is the degree of "match" between infant and caregivers or family circumstances. What combinations of these factors have positive and negative outcomes, and in what ways?

Although parent reports of child temperament have been found to be quite stable and even useful in predicting later problems in extreme cases, no one has shown these reports to be related to individual differences in behavior. Investigators need to understand the multivariate origins of these parental assessments, including parental personality, expectations, attitudes and life situation, as well as child behavior. Moreover, it is important to understand how these perceptions both influence child behavior and are shaped by endogenous child factors in continual interaction.

More should be known about the consequences of a particular child's position within the family. There are great between-child differences within families, perhaps even greater than between families. While this observation is consistent with genetics, it is also in keeping with a "systems" view of the family. The second child's family is not the same as the first child's family. Particular children

may be assigned to roles that they do or do not fit. Research is needed that goes beyond examination of family size or parent education to the study of family processes as these interact with characteristics of particular children. Questions of mutual influence should be addressed in infancy and early childhood, and particularly in the transition to adolescence, when parental expectations, attitudes, and life situations interact continually with child characteristics and behavior, which are themselves changing in response to both maturation and experience.

Extrafamilial Influences

Much of what is known about children's adaptation to school is related to academic achievement. There is a lack of knowledge about the child's experiences in school and the role of school in socialization. The onset of schooling is itself the major transition occurring in middle childhood, and little is known about the impact of early school experiences on the developing self-system, the alterations produced in family and peer interaction, and the changes taking place in social communication and competence.

Factors outside the family that influence child behavior and development range across many levels of analysis, from socioeconomic and cultural changes to life stresses experienced by a particular family, and from grandparents to peers.[181] How do life stresses, socioeconomic change, and changing cultural values impact on the relationship between parents and how do such influences in turn impact on parenting behavior? How do peer and parenting influences interact? In what way does the early parent-infant relationship influence later peer relationships?

Maturation/Experience Issues

Theories stressing adolescent rebellion and detachment from the family are proving to be of limited applicability.[182] In addition, most studies of adolescent sexuality deal with changes as reported by children or their parents after puberty. Few studies exist concerning changes in family interaction patterns and peer relations spanning the period from before puberty to after and how these interact in the growth of social competence. Little is known about the young adolescent's use of time in nonschool situations and the changes in these experiences that are coincident with biological changes.

Evidence points to early adolescence as a period of transformation in social relations--with the family and with

friends--rather than a period of the dissolution of early relationships. Broad-based studies, utilizing data focused on social processes existing in the family, the peer group, and the school, as these cycle through time, are needed to address the nature of adolescent development.

References

1. Charney, E. et al.: Childhood antecedents of adult obesity: do chubby infants become obese adults? N. Engl. J. Med. 295: 6-9, 1976.

2. Stunkard, A.J. and Burt, V.: Obesity and the body image: age at onset of disturbance. Am. J. Psychiat. 123: 1443-1447, 1967.

3. Stunkard, A.J. and Burt, V.: Influence of social class on obesity and thinness in children. J.A.M.A. 221: 579-584, 1972.

4. Garn, S.M., Cole, P.E., and Bailey, S.M.: Effect of parental fatness level on the fatness of biological and adoptive children. Ecol. Food Nutr. 6: 91-93, 1977.

5. Kulin, H.E. and Reiter, E.O.: Delayed sexual maturation with special emphasis on the occurrence of the syndrome in the male. In Grumbach, M.M., Grave, G.D., and Mayer, F.E. (Eds.): Control of the Onset of Puberty. New York, John Wiley & Sons, 1974. pp. 238-257.

6. Federman, D.D.: Abnormal Sexual Development. Philadelphia, Saunders, 1967, 206 pp.

7. Gorwitz, K. et al.: Prevalence of diabetes in Michigan school-age children. Diabetes 25: 122-127, 1976.

8. N. Freinkel: Personal communication.

9. Harris, H.: The familial distribution of diabetes mellitus. Ann. Eugen. 15: 95-119, 1950-1951.

10. NIH contract NO1-HD-8-2946, "Genetic Linkage Analysis of Juvenile Diabetes," José Barbosa, Principal Investigator, Department of Medicine, University of Minnesota, Minneapolis 55455.

11. Parkin, J.M.: Short stature. Br. Med. J. (6018): 1139-1141, 1976.

12. MsKusick, V.A.: On the X-Chromosome of Man. Baltimore, Waverly Press, 1964, 140 pp.

13. Lund, R.D.: Development and Plasticity of the Brain: An Introduction. New York, Oxford University Press, 1978, 370 pp.

14. Marin-Padilla, M.: Structural abnormalities of the cerebral cortex in human chromosomal aberrations: a Golgi study. Brain Res. 44: 625-629, 1972.

15. Purpura, D.P.: Normal and aberrant neuronal development in the cerebral cortex of human fetus and young infant. UCLA Forum Med. Sci. 18: 141-169, 1975.

16. Purpura, D.P.: Factors contributing to abnormal neuronal development in the cerebral cortex of the human infant. In Berenberg, S.R. (Ed.): Brain: Fetal and Infant. The Hague, Nijhoff Medical Division, 1977. pp. 54-78.

17. Guillery, R.W., Okoro, A.N., and Witkop, Jr., C.J.: Abnormal visual pathways in the brain of a human albino. Brain Res. 96: 373-377, 1975.

18. Sidman, R.L. and Rakic, P.: Neuronal migration, with special reference to developing human brain: a review. Brain Res. 62: 1-35, 1973.

19. Yakovlev, P.J. and Lecours, A.: The myelogenetic cycles of regional maturation of the brain. In Minkowski, A. (Ed.): Regional Development of the Brain in Early Life. Philadelphia, F.A. Davis Co., 1967. pp. 3-70.

20. Dobson, V. and Teller, D.Y.: Visual acuity in human infants: a review and comparison of behavioral and electrophysiological studies. Vision Res. 18: 1469-1483, 1978.

21. Kessen, W., Haith, M.M., and Salapatek, P.H.: Human infancy: a bibliography and guide. In Mussen, P. (Ed.): Carmichael's Manual of Child Psychology, Vol. 1, 3rd Ed. New York, Wiley, 1970. pp. 287-445.

22. Salapatek, P. and Banks, M.S.: Infant sensory assessment: vision. In Minifie, F.D. and Lloyd, L.L. (Eds.): Communicative and Cognitive Abilities--Early Behavioral Assessment. Baltimore, University Park Press, 1978. pp. 61-106.

23. Spears, W.C. and Hohle, R.H.: Sensory and perceptual processes in infants. In Brackbill, Y. (Ed.):

Infancy and Early Childhood. New York, Free Press, 1967. pp. 51-121.

24. Teller, D.Y., Peeples, D.R., and Sekel, M.: Discrimination of chromatic from white light by two-month-old human infants. Vision Res. 18: 41-48, 1978.

25. Pirchio, M., Spinelli, D., Fiorentini, A., and Maffei, L.: Infant contrast sensitivity evaluated by evoked potentials. Brain Res. 141: 179-184, 1978.

26. Banks, M.S., Aslin, R.N., and Letson, R.D.: Sensitive period for the development of human binocular vision. Science 190: 675-677, 1975.

27. Mohindra, I., Held, R., Gwiazda, J., and Brill, S.: Astigmatism in infants. Science 202: 329-331, 1978.

28. Hecox, K.: Electrophysiological correlates of human auditory development. In Cohen, L.B. and Salapatek, P. (Eds.): Infant Perception: From Sensation to Cognition, Vol. II. Perception of Space, Speech, and Sound. New York, Academic Press, 1975. pp. 151-191.

29. Regan, D., Silver, R., and Murray, T.J.: Visual acuity and contrast sensitivity in multiple sclerosis--hidden visual loss. Brain 100: 563-579, 1977.

30. Hess, R.F. and Howell, E.R.: The threshold contrast sensitivity function in strabismic amblyopia: evidence for a two type classification. Vision Res. 17: 1049-1055, 1977.

31. Teller, D.Y, Regal, D.M., Videen, T.O., and Pulos, E.: Development of visual acuity in infant monkeys (Macaca nemestrina) during the early postnatal weeks. Vision Res. 18: 561-566, 1978.

32. Freeman, R.D. and Thibos, L.N.: Contrast sensitivity in humans with abnormal visual experience. J. Physiol. 247: 687-710, 1975.

33. Spelke, E.: Infants' intermodal perception of events. Cognitive Psychology 8: 553-560, 1976.

34. Salapatek, P.: Pattern perception in early infancy. In Cohen, L.B. and Salapatek, P. (Eds.): Infant Perception: From Sensation to Cognition, Vol. I. Basic Visual Processes. New York, Academic Press, 1975. pp. 133-248.

35. Fantz, R.L. and Fagan III, J.F.: Visual attention to

size and number of pattern details by term and preterm infants during the first six months. Child Dev. 46: 3-18, 1975.

36. Gesell, A.L. and Amatruda, C.S.: Developmental Diagnosis: Normal and Abnormal Child Development, Ed. 2. New York, Paul B. Hoeber, Inc., 1947, 496 pp.

37. Connolly, K. and Stratton, P.: An exploration of some parameters affecting classical conditioning in the neonate. Child Dev. 40: 431-441, 1969.

38. Hardyck, C.: A model of individual differences in hemispheric functioning. In Whitaker, H. and Whitaker, H.A. (Eds.): Studies in Neurolinguistics, Vol. 3. New York, Academic Press, 1976-1977. pp. 223-255.

39. Wolff, P.H.: The development of manual asymmetries in motor sequencing skills. Ann. N.Y. Acad. Sci. 299: 319-327, 1977.

40. D. Weber and P. Wolff. Personal communication, June 25, 1980.

41. Connolly, K.: Response speed, temporal sequencing, and information processing in children. In Connolly, K. (Ed.): Mechanisms of Motor Skill Development. New York, Academic Press, 1970. pp. 161-204.

42. Connolly, K.: Skill development: problems and plans. In Connolly, K. (Ed.): Mechanisms of Motor Skill Development. New York, Academic Press, 1970. pp. 3-21.

43. Prechtl, H.F.R.: The Neurological Examination of the Full-Term Newborn Infant. Philadelphia, J.B. Lippincott Co., 1977, 68 pp.

44. Touwen, B.C.L.: Neurological Development in Infancy. Philadelphia, J.B. Lippincott Co., 1976, 150 pp.

45. Touwen, B.C.L.: Examination of the Child with Minor Neurological Dysfunction, Ed. 2. Philadephia, J.B. Lippincott Co., 1979, 141 pp.

46. Thelen, E.: Rhythmical stereotypes in normal human infants. Anim. Behav. 27: 699-715, 1979.

47. Kugler, P.N., Kelso, J.A.S., and Turvey, M.: On the control and coordination of naturally developing systems. In Kelso, J.A.S. and Clark, J. (Eds.): The Development of Movement Control and Coordination. New York, John Wiley & Sons, in press.

48. Yates, F.E.: Physical biology: a basis for modelling living systems. Journal of Cybernetics and Information Sciences, in press.

49. Callaway, E., Teuting, P., and Koslow, S.H. (Eds.): Event-Related Brain Potential in Man. New York, Academic Press, 1978, 629 pp.

50. Donchin, E., Callaway, E., Cooper, R., Desmedt, J.E., Goff, W.R., Hillyard, S.A., and Sutton, S.: Publication criteria for studies of evoked potentials (EP) in man. In Desmedt, J.E. (Ed.): Attention, Voluntary Contraction and Event-Related Cerebral Potentials. Progress in Clinical Neurophysiology, Vol. 1. Basel, Karger, 1977. pp. 1-11.

51. Desmedt, J.E.: Some observations on the methodology of cerebral evoked potentials in man. In Desmedt, J.E. (Ed.): Attention, Voluntary Contraction and Event-Related Cerebral Potentials. Progress in Clinical Neurophysiology, Vol. 1. Basel, Karger, 1977. pp. 12-29.

52. Matousek, M. and Petersen, I.: Frequency analysis of the EEG in normal children and adolescents. In Kellaway, P. and Petersen, I. (Eds.): Automation of Clinical Electroencephalography. New York, Rayen Press, 1973. pp. 75-102.

53. Callaway, E. and Halliday, R.A.: Evoked potential variability: effects of age, amplitude and methods of measurement. Electroencephal. Clin. Neurophysiol. 34: 125-133, 1973.

54. John, E.R.: Functional Neuroscience, Vol. 2. Neurometrics: Clinical Applications of Quantitative Electrophysiology. Hillsdale, N.J., Erlbaum, 1977, 291 pp.

55. R.W. Thatcher.: Personal communication, June 25, 1980.

56. Courchesne, E.: From infancy to adulthood: the neurophysiological correlates of cognition. In Desmedt, J.E. (Ed.): Cognitive Components in Cerebral Event-Related Potentials and Selective Attention. Progress in Clinical Neurophysiology, Vol. 6. Basel, Karger, 1979.

57. Karmel, B.Z., Kaye, H., and John, E.R.: Developmental neurometrics: the use of quantitative analysis of brain electrical activity to probe mental function throughout the life span. In Collins, W.A. (Ed.): Minnesota Symposia on Child Psychology, Vol. 11.

Hillsdale, N.J., 1978. pp. 141-198.

58. Hillyard, S.A., Picton, T.W., and Regan, D.: Sensation, perception, and attention: analysis using ERPs. In Callaway, E., Teuting, P., and Koslow, S.H. (Eds.): Event-Related Brain Potentials in Man. New York, Academic Press, 1978, 631 pp.

59. Hofmann, M.J., Salapatek, P., and Kuskowski, M.: Evidence for visual memory in the averaged and single evoked potentials of human infants. Infant Behavior and Development, in press.

60. Beach, F.A.: Neural and chemical regulation of behavior. In Harlow, H.F. and Woolsey, C.N. (Eds.): Biological and Biochemical Bases of Behavior. Madison, University of Wisconsin Press, 1958. pp. 263-284.

61. Eleftheriou, B.E. and Sproth, R.L. (Eds.): Hormonal Correlates of Behavior, Vol. 1. A Lifespan View. New York, Plenum Press, 1975, 439 pp.

62. McGill, T.E., Dewsbury, D.A., and Sachs, B.D. (Eds.): Sex and Behavior: Status and Prospectus. New York, Plenum Press, 1978, 436 pp.

63. Beach, F.A.: Cross-species comparisons and the human heritage. Arch. Sex. Beh. 5: 469-485, 1976.

64. Beach, F. (Ed.): Human Sexuality in Four Perspectives. Baltimore, Johns Hopkins Press, 1976, 330 pp.

65. Money, J. and Ehrhardt, A.A.: Man and Woman, Boy and Girl. Baltimore, Johns Hopkins University Press, 1972, 311 pp.

66. Maccoby, E.E. and Jacklin, C.N.: The Psychology of Sex Differences. Stanford, Stanford University Press, 1974, 634 pp.

67. Diamond, M. and Karlin, A.: Sexual Decisions. Boston, Little Brown, 1980, 536 pp.

68. Phoenix, C.H., Goy, R.W., Gerall, A.A., and Young W.C.: Organizing action of prenatally administered testosterone proprionate on the tissues mediating mating behavior in the female guinea pig. Endocrinology 65: 369-382, 1959.

69. Von Saal, F.S. and Bronson, F.H.: In utero proximity of female mouse fetuses to male: effects on reproductive performance during later life. Biol. Reprod. 19: 842-853, 1979.

70. Nottebohm, F.: The "critical period" for song learning. Ibis 111: 386-387, 1969.

71. Hennessey, J.W. and Levine, S.: Stress, arousal and the pituitary-adrenal system: a psychoendocrine model. In Sprague, J. and Epstein, A. (Eds.): Progress in Psychobiology and Psysiological Psychology, Vol. 8. New York, Academic Press, 1979. pp. 133-178.

72. Fuller, J.L. and Thompson, W.R.: Foundations of Behavior Genetics. St. Louis, C.V. Mosby Co., 1978, 533 pp.

73. Scarr, S. and Kidd, K.K.: Developmental behavior genetics. In Haith, M. and Campos, J. (Eds.): Infancy and the Biology of Development. (Vol. II of Mussen, P. (Ed.): Manual of Child Psychology), in press.

74. Trabasso, T.: Representation, memory, and reasoning: how do we make transitive inferences? In Pick, A. (Ed.): Minnesota Symposia on Child Psychology, Vol. 9: Minneapolis, University of Minnesota Press, 1975. pp. 135-172.

75. Siegler, R.S.: Three aspects of cognitive development. Cognitive Psychology 8: 481-520, 1976.

76. Chi, M.T.H.: Knowledge structures and memory development. In Siegler, R.S. (Ed.): Children's Thinking: What Develops? Hillsdale, N.J., Erlbaum, 1978. pp. 73-96.

77. Simon, H.A.: Information processing models of cognition. Ann. Rev. Psychol. 30: 363-396, 1979.

78. Brown, A.: Knowing when, where, and how to remember: a problem of metacognition. In Glaser, R. (Ed.): Advances in Instructional Psychology. Vol. 1. New York, Halsted Press, 1978.

79. Bradley, R.H., Caldwell, B.M., and Elardo, R.: Home environment and cognitive development in the first 2 years: a cross-lagged panel analysis. Developmental Psychology 15: 246-250, 1979.

80. Rosenthal, R.: Interpersonal expectations. In Rosenthal, R. and Rosnow, R. (Eds.): Artifact in Behavioral Research. New York, Academic Press, 1969. pp. 181-277.

81. Cole, M. and Scribner, S.: Culture and Thought. New

York, Wiley, 1974, 227 pp.

82. Schwartz, T.: The acquisition of culture. Paper presented at the American Anthropological Association, Houston, 1977. Unpublished revision, University of California, San Diego, 1979.

83. Sharp, D., Cole, M., and Lane, J.: Education and cognitive development: the evidence from experimental research. Mono. Soc. Res. Child Dev. 44 (Nos. 1-2, Serial No. 178): 1-62, 1979.

84. Rosch, E.R.: Human categorization. In Warren, N. (Ed.): Studies in the Internal Structures of Categories. London, Academic Press, 1978.

85. Anderson, J. R.: Language, Memory, and Thought. New York, Halsted Press, 1976, 546 pp.

86. Shantz, C.U.: The development of social cognition. In Hetherington, E.M. (Ed.): Review of Child Development Research, Vol. 5. Chicago, University of Chicago Press, 1975. pp. 257-323.

87. Ford, M. E.: The construct validity of egocentrism. Psychol. Bull. 86: 1169-1188, 1979.

88. Ross, A.O.: Psychological Aspects of Learning Disabilities and Reading Disorders. New York, McGraw-Hill Inc., 1976, 191 pp.

89. Harter, S.: The development of mastery motivation. In Collins, W.A. (Ed.): Development of Cognition, Affect, and Social Relations. Minnesota Symposia on Child Psychology, Vol. 13. Hillsdale, N.J., Erlbaum, 1980, 304 pp.

90. Bornstein, M.: Two kinds of perceptual organization near the beginning of life. In Collins, W.A. (Ed.): Development of Cognition, Affect, and Social Relations. Minnesota Symposia on Child Psychology, Vol. 13. Hillsdale, N.J., Erlbaum, 1980, 304 pp.

91. Gelman, R.: Counting in the preschooler: what does and does not develop. In Siegler, R. (Ed.): Children's Thinking: What Develops? Hillsdale, N.J., Erlbaum, 1978. pp. 213-241.

92. Shatz, M.: On the development of communicative understandings: an early strategy for interpreting and responding to messages. Cognitive Psychology 10: 271-301, 1978.

93. Perlmutter, M. and Lange, G.: A developmental analysis of recall recognition distinctions. In Ornstein, P.A. (Ed.): Memory Development in Children. New York, Halsted Press, 1978.

94. Rohwer, W.D.: Prime time for education: early childhood or adolescence? Harvard Educational Review 41: 316-341, 1971.

95. Templin, M.C.: Certain Language Skills in Children. Minneapolis, University of Minnesota Press, 1957, 183 pp.

96. Sander, E.K.: When are speech sounds learned? Journal of Speech and Hearing Disorders 37: 55-63, 1972.

97. Ingram, D.: Phonological rules in young children. Journal of Child Language 1: 49-64, 1974.

98. McReynolds, L.V. and Engmann, D.L.: Distinctive Feature Analysis of Misarticulations. Baltimore, Md., University Park Press, 1975, 150 pp.

99. Eimas, P.D.: Speech perception in early infancy. In Cohen, L.B. and Salapatek, P. (Eds.): Infant Perception: From Sensation to Cognition. New York, Academic Press, 1975, pp. 193-231.

100. Jusczyk, P.W.: Infant speech perception: a critical appraisal. In Eimas, P.D. and Miller, J.L. (Eds.): Perspectives on the Study of Speech. Hillsdale, N.J., Lawrence Erlbaum Associates, 1980, 464 pp.

101. Lasky, R.E., Syrdal-Lasky, A., and Klein, R.E.: VOT discrimination by four- to six-and-a-half-month-old infants from Spanish environments. Journal of Experimental Child Psychology 20: 215-225, 1975.

102. Kuhl, P.K. and Miller, J.D.: Speech perception by the chinchilla: identification functions for synthetic VOT stimuli. Journal of the Acoustical Society of America 63: 905-917, 1978.

103. Cutting, J. and Rosner, B.S.: Categories and boundaries in speech and music. Perception and Psychophysics 16: 546-570, 1974.

104. Jusczyk, P.W., Rosner, B.S., Cutting, J.E., Poard, C.F., and Smith, L.B.: Categorical perception of nonspeech sounds by two-month-old infants. Perception and Psychophysics 21: 50-54, 1977.

105. Kuhl, P.K.: Perceptual constancy for speech-sound categories in early infancy. In Yeni-Komshian, G.H., Kavanagh, J.F., and Ferguson, C.A. (Eds.): Child Phonology: Perception and Production; Vol. 1: Production, Vol. 2: Perception. New York, Academic Press, 1980. Vol. 2, pp. 41-66.

106. Smith, N.V.: The Acquisition of Phonology. Cambridge, University Press, 1973, 228 pp.

107. Barton, D.: The role of perception in the acquisition of phonology. Doctoral dissertation, Stanford University, 1976. Reproduced by the Indiana University Linguistics Club, 1978.

108. Kornfeld, J.: Theoretical issues in child phonology. In Papers from the Seventh Regional Meeting. Chicago, Ill., Chicago Linguistic Society, 1971.

109. Garnica, O.K.: The development of phonemic speech perception. In Moore, T.E. (Ed.): Cognitive Development and the Acquisition of Language. New York, Academic Press, 1973, 308 pp.

110. Ingram, D.: Phonological Disability in Children. London, Edward Arnold, 1976, 188 pp.

111. Menyuk, P.: The Acquisition and Development of Language. Englewood Cliffs, N.J., Prentice-Hall, 1971, 285 pp.

112. Clark, E.: What's in a word? on the child's acquisition of semantics in his first language. In Moore, T.E. (Ed.): Cognitive Development and the Acquisition of Language. New York, Academic Press, 1973, 308 pp.

113. McNeill, D.: The development of language. In Mussen, P. H. (Ed.): Charmichael's Manual of Child Psychology, Vol. I, Ed. 3. New York, Wiley, 1970. pp. 1061-1161.

114. Nelson, K.: Structure and strategy in learning to talk. Monogr. Soc. Res. Child Dev. 38: No. 149, 1973.

115. Dale, P.S.: Language Development: Structure and Function. New York, Holt, Rinehart & Winston, 1976, 358 pp.

116. Andersen, E.S.: Cups and glasses: learning that boundaries are vague. Journal of Child Language 2: 79-103, 1975.

117. Bowerman, M.: The acquisition of word meaning: an investigation into some current conflicts. In Johnson-Laird, P.N. and Wason, P.C. (Eds.): Thinking: Readings in Cognitive Science. Cambridge, University Press, 1979.

118. Carey, S.: The child as word learner. In Halle, M., Bresnan, J., and Miller, G.A. (Eds.): Linguistic Theory and Psychological Reality. Cambridge, MIT Press, 1978, 321 pp.

119. Donaldson, M. and McGarrigle, J.: Some clues to the nature of semantic development. Journal of Child Language 1: 185-194, 1976.

120. Eiler, R.E., Oller, D.K., and Ellington, J.: The acquisition of word-meaning for dimensional adjectives: the long and short of it. Journal of Child Language 1: 195-204, 1974.

121. Huttenlocher, J.: Encoding spatial information in sign language. In Kavanaugh, J.F. and Cutting, J.E. (Eds.): The Role of Speech in Language. Cambridge, MIT Press, 1975, 335 pp.

122. Kuczaj, S.: Young children's overextension of object word in comprehension and/or production: support for a prototype theory of early object word meaning. Paper presented to the Society for Research in Child Development, 1979.

123. Braine, M.D.S.: Children's first word combinations. Monogr. Soc. Res. Child Dev. 41 (No. 1, Serial No. 164): 1-96, 1976.

124. Maratsos, M.P.: New models in linguistics and language acquisition. In Halle, M., Bresnan, J., and Miller, G.A. (Eds.): Linguistic Theory and Psychological Reality. Cambridge, MIT Press, 1978, 321 pp.

125. deVilliers, J.G. and deVilliers, P.A.: Language Acquisition. Cambridge, Harvard University Press, 1978, 312 pp.

126. Tolbert, M.K.: A cross-cultural study of derivational complexity in Spanish and Cachiquel. Unpublished doctoral dissertation, Harvard University, 1978.

127. Fillmore, C.J.: The case for case. In Bach, E. and Harms, R. (Eds.): Universals in Linguistic Theory. New York, Holt, Rinehart, & Winston, 1968.

128. Lakoff, G.: Irregularity in Syntax. New York, Holt,

Rinehart, & Winston, 1970, 207 pp.

129. Chomsky, N.: Remarks on nominalizat[illegible] In Jacobs, R.A. and Rosenbaum, P.S. (Eds.): Readings in English Transformational Grammar. Waltham, Mass., Ginn and Company, 1970, 277 pp.

130. Jackendoff, R.: Morphological and semantic regularities in the lexicon. Language 51: 639-671, 1975.

131. Bresnan, J.: A realistic transformational grammar. In Halle, M., Bresnan, J., and Miller, G.A. (Eds.): Linguistic Theory and Psychological Reality. Cambridge, MIT Press, 1978, 321 pp.

132. Bloom, L.: Language Development: Form and Function in Emerging Grammars. Cambridge, MIT Press, 1970, 270 pp.

133. Schlesinger, I.M.: Production of utterances and language acquisition. In Slobin, D.I. (Ed.): The Ontogenesis of Grammar. New York, Academic Press, 1971. pp. 63-101.

134. McNeill, D.: The creation of language by children. In Lyons, J. and Wales, R. (Eds.): Psycholinguistics Papers. Edinburgh, Edinburgh University Press, 1966. pp. 99-132.

135. Bates, E.: Language and Context: The Acquisition of Pragmatics. New York, Academic Press, 1976, 375 pp.

136. Bever, T.G.: The cognitive basis for linguistic structures. In Hayes, J.R. (Ed.): Cognition and Development of Language. New York, Wiley, 1970. pp. 279-362.

137. Slobin, D.I.: Cognitive prerequisites for the development of grammar. In Ferguson, C.A. and Slobin, D.I. (Eds.): Studies of Child Language Development. New York, Holt, Rinehart, & Winston, 1973. pp. 183-186.

138. Antinucci, F. and Miller, R.: How children talk about what happened. Journal of Child Language 3: 167-190, 1976.

139. Brown, R. and Hanlon, C.: Derivational complexity and order of acquisition in child speech. In Hayes, J.R. (Ed.): Cognition and the Development of Language. New York, Wiley, 1970, 370 pp.

140. Schiefflin, B.: Cross-cultural perspectives on speech

to children. Paper presented to Conference on Pragmatics in Children's Speech, Nordic Hills, Ill., April 13, 1980. To appear in Schiefelbusch, R. and Pickar, J. (Eds.): Communicative Competence: Acquisition and Intervention, in press.

141. Slobin, D.I.: Universal and particular in children's language. Paper presented to Conference on Language Development: the State of the Art, University of Pennsylvania, May 10, 1978.

142. Anderson, J.R.: An ACT approach to language acquisition. Cognitive Psychology 4: 78-126, 1978.

143. Maratsos, M.P. and Chalkley, M.A.: The internal language children's syntax: the ontogenesis and representation of syntactic categories. In Nelson, K. (Ed.): Children's Language Series, Vol. II. New York, Gardner Press, 1980.

144. deVilliers, J.: Rule learning in children: a new look. In Nelson, K. (Ed.): Children's Language Series, Vol. II. New York, Gardner Press, 1980.

145. Maratsos, M.P.: The establishment and evolution of grammatical categories in children. In Gleitman, L. and Wanner, E. (Eds.): Language Acquisition: The State of the Art. Cambridge, Harvard University Press, in press.

146. Schlesinger, I.M.: The role of cognitive development and linguistic input in language acquisition. Journal of Child Language 4: 153-169, 1977.

147. Gardner, B.T. and Gardner, R.A.: Two comparative psychologists look at language acquisitions. In Nelson, K.E. (Ed.): Children's Language Series, Vol. II. New York, Gardner Press, 1980. pp. 331-369.

148. Premack, A.J. and Premack, D.: Teaching language to an ape. Sci. Am. 227: 92-99, 1972.

149. Terrace, H.: Nim: A Chimpanzee Who Learned Sign Language. New York, Knopf, 1979.

150. Piaget, J.: The Language and Thought of the Child. New York, Harcourt Brace, 1926, 246 pp.

151. Shatz, M. and Gelman, R.: The development of communication skills: modifications in the speech of young children as a function of listener. Mono. Soc. Res. Child Dev. 38: (No. 152): 1-38, 1973.

152. Maratsos, M.P.: Nonegocentric communication abilities in preschool children. Child Dev. 44: 697-700, 1973.

153. Flavell, J.H.: Cognitive Development. Englewood Cliffs, N.J., Prentice-Hall, 1977, 286 pp.

154. Sugarman, S.: Communicative intentions in the preverbal period. Paper presented to Conference on Pragmatics in Children's Speech, Nordic Hills, Ill., April 13, 1980. To appear in Schiefelbusch, R. and Pickar, J. (Eds.): Communicative Competence: Acquisition and Intervention, in press.

155. Dore, J.: A pragmatic description of early language development. Journal of Psycholinguistic Research 3: 343-350, 1974.

156. Gibson, E.J.: Principles of Perceptual Learning and Development. New York, Appleton-Century-Crofts, 1969, 537 pp.

157. Neisser, U.: Cognitive Psychology. New York, Appleton-Century-Crofts, 1967, 351 pp.

158. Just, M. and Carpenter, P.: Reading comprehension as the eyes see it. In Just, M. and Carpenter, P. (Eds.): Cognitive Processes in Comprehension. New York, Halsted Press, 1977.

159. Morton, J. and Marshall, J. (Eds.): Psycholinguistics: Structures and Processes. Cambridge, MIT Press, 1979, 187 pp.

160. Klima, E. and Belugi, U.: The Signs of Language. Cambridge, Harvard University Press, 1979, 429 pp.

161. Goldin-Meadow, S.: The resilience of recursion: a study of a communication system developed without a conventional language model. Paper presented at Conference on Language Acquisition: The State of the Art, University of Pennsylvania, May 10, 1978.

162. Stern, D.N.: The goal and structure of mother-infant play. J. Am. Acad. Child Psychiatry 13: 402-421, 1974.

163. Ainsworth, M., Blehar, M., Waters, E., and Wall, S.: Patterns of Attachment: A Study of the Strange Situation. New York, Halsted Press, 1978, 391 pp.

164. Mason, W.A. and Kenney, M.D.: Redirection of filial

attachments in rhesus monkeys: dogs as mother surrogates. Science 183: 1209-1211, 1974.

165. Ruppenthal, G.C., Arling, G.L., Harlow, H.F., Sackett, G.P., and Suomi, S.J.: A 10-year perspective of motherless-mother monkey behavior. J. Abnorm. Psychol. 85: 341-349, 1976.

166. Super, C.: Behavioral development in infancy. In Munroe, R., Munroe, R.H., and Whiting, B. (Eds.): Handbook of Cross-Cultural Human Development. New York, Garland Press, 1980, 900 pp.

167. Bischof, N.: A systems approach toward the functional connections of attachment and fear. Child Dev. 46: 801-817, 1975.

168. Maccoby, E.E. and Feldman, S.S.: Mother-attachment and stranger reactions in the third year of life. Mono. Soc. Res. Child Dev. 37: 1-86, 1972.

169. Sroufe, L.A. and Waters, E.: Attachment as an organizational construct. Child Dev. 48: 1184-1199, 1977.

170. Carr, S.J., Dabbs, J.M., and Carr, T.S.: Mother-infant attachment. The importance of the mother's visual field. Child Dev. 46: 331-338, 1975.

171. Mueller, E.C. and Vandell, D.: Infant-infant interaction. In Osafsky, J.D. (Ed.): Handbook of Infant Development. New York, John Wiley, 1979. pp. 591-622.

172. Hartup, W.W.: Children and their friends. In McGurk, H.M. (Ed.): Issues in Childhood Social Development. London, Methuen, 1979, 256 pp.

173. Freud, S.: New Introductory Lectures in Psychoanalysis. New York, Norton, 1933, 257 pp.

174. Heckhausen, H.: Achievement motivation. In Hartup, W.W. (Ed.): Review of Child Development Research, Vol. 6. Chicago, University of Chicago Press, in press.

175. Hill, J.P.: Understanding early adolescence--a framework. Unpublished manuscript, Center for Early Adolescence, University of North Carolina, 1980.

176. Collins, W.A.: Development of cognition, affect, and social relations. Minnesota Symposia on Child Psychology, Vol. 13. Hillsdale, N.J., Erlbaum, 1980, 304 pp.

177. Levine, R.A.: Child rearing as cultural adaptation. In Leiderman, P.H., Tulkin, S., and Rosenfeld, A. (Eds.): Culture and Infancy. New York, Academic Press, 1977. pp. 15-27.

178. Hunt, J.McV.: Fiction versus fact in infant development. Invited address at the International Conference on Infant Studies, New Haven, April, 1980.

179. Kagan, J. and Moss, H.A.: Birth to Maturity: A Study in Psychological Development. New York, John Wiley, 1962, 381 pp.

180. Belsky, J. and Steinberg, L.D.: The effects of daycare: a critical review. Child Dev. 49: 929-949, 1978.

181. Hartup, W.W.: The social worlds of childhood. Am. Psychol. 34: 944-950, 1979.

182. Kagan, J., Kearsley, R.B., and Zelazo, P.R.: Infancy: Its Place in Human Development. Cambridge, Harvard University Press, 1978, 462 pp.

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