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ABSTRACT

This profile of significant research findings comprises a framework for analyzing and synthesizing information on the cognitive development of children. The variables used to systematize the literature search were: perception; motor development; language; conceptual activity; and learning, memory, and problem solving. The findings are arranged according to these variables by age group and include author citations, the classification of research as empirical or theoretical, and the identification of source as prime or a review article. A final bibliography provides complete citations. (MLF)

A PROFILE OF COGNITIVE DEVELOPMENT IN CHILDREN

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As Consultants to:

OPERATION PEP: A State-wide Project to
Prepare Educational Planners for California

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PREFACE

Many research findings have been published in the area of cognitive behavior. These findings are slowly being adopted by the educational community wherein increased attention is being devoted to the cognitive domain. One obvious reason for the slow rate of diffusion is the lack of an integrated framework that portrays cognitive development in children.

Many educational managers recognized the need for and value of this type of integrated framework, but they generally do not have sufficient resources for its development. OPERATION PEP asked the authors of this document to prepare a profile of cognitive development in children based upon significant research findings. The profile developed provides educational managers with a tool which can be used to direct the efforts of other professional educators.

The integrated framework is open ended and can be used as a baseline for analyzing and synthesizing information pertaining to the various aspects of cognitive development in children. The bibliographic information presented has been carefully selected to orient educators to themes in cognitive development and, thereby, to facilitate expansion of the profile. The variables used in presenting the profile provide a preliminary basis for future investigations and explorations of new research findings.

THE VARIABLES USED IN CHARTING COGNITIVE DEVELOPMENT IN CHILDREN

In charting the child's cognitive domain at various points in the age span it became necessary from the outset to be selective in the choice of variables to be included. The following variables were chosen and are presented with a brief explanation of their pertinent aspects and reasons why the author's felt these variables were important.

A. Perception

The basic problem is how the individual gets information from his surroundings and how his ability to register and process information changes with age. Three factors are important in this regard:

1. Relationship between the nature of the stimulus and the organism
2. Attention span of the organism
3. Selective attention and organization of stimulation by the organism

Many issues central to perception, essentially those relating to morphology or structure of the environment, have been left for other sections as have other topics such as perceptual-illusions.

B. Motor Development

Primarily this belongs to another section, but to the extent that perceptual-motor coordinations are thought by many (e.g., Piaget (1950), Hebb (1949)) to be the basis for later cognitive development, some early aspects have been included

C. Language

The development of language is assumed to have two functions, that of facilitating communication with others, and that of making internal thought possible. While the increased ability to communicate is clearly observable, the relationship between language and other forms of cognitive functioning is less obvious. Studies of verbal mediation and acquired distinctiveness of cues suggest that language may facilitate discrimination and some forms of learning. Whether the development of language triggers, parallels, or interacts with the cognitive changes which occur around ages five to seven and eleven to twelve is still unclear.

For the purposes of this review it is reasonable to include language skills, regardless of their theoretical relationship to other processes, since teaching methods presently used in our schools rely heavily on verbal presentation and verbal response. Hence, a child who fails to acquire linguistic competence is likely to be impaired in both comprehension and performance.

The evidence included in this initial review was limited by the decision to draw more heavily on theoretically-guided process research, rather than upon normative data from other studies. The reason for this choice resides in the assumption that if process variables could be specified, the data would be more useful in suggesting interrelationships with other process variables and in developing teaching methods and materials. Unfortunately, the psycholinguistic approach to language is relatively new, and little empirical data are available. The formation of early grammars has been studied in small groups of subjects, but there

are only two studies on the development of transformations; one study on the growth of morphological rules, and no empirical studies on the growth of phonemic systems. For this reason the data are often sketchy. In addition, some of the most recent reviews of completed and ongoing psycholinguistic research (i.e., McNeil's chapter in the Carmichael handbook) has not been published as of this time. The time limitation on the review may also have caused the author to overlook certain evidence.

D. Conceptual Activity

The ability to form concepts is basic to our thinking, problem solving and all forms of cognitive functioning. As a consequence, how concepts are formed and maintained is a crucial psychological question.

Vinache (1952) indicates that in concept formation there are four basic questions to be answered:

1. How can we explain and describe development of the child's ability to form and use concepts?
2. What concepts characterize various developmental stages in the child's ability to think and act?
3. How does an individual attain a particular concept and what behavioral conditions are related to concept formation?
4. What are the characteristics and content of the child's conceptual system?

A distinction should be drawn between concept formation which Bruner, Goodnow and Austen (1956) call "the inventive act by which classes are constructed" and concept attainment which refers to the search for and testing of attributes that can be used to distinguish exemplars from non-exemplars. This latter process refers to a translation process in which a concept already

in a person's repertoire is associated to a new name or symbol. Much of the research on concepts is of this type--yet we judged this aspect as considerably less important for understanding cognitive development than the processes by which concepts are initially developed.

We have tried to be concerned with processes and underlying concepts rather than merely charting the particular concepts a child has at a given time. This is partly a subjective decision. For example, is the concept of "middleness" basic to other thinking because it is a relational concept, or is it too specific a concept for our purposes, or has a body of literature been built up around it because of other reasons?

The most useful theoretical (and empirical) source in the cognitive domain is Piaget's monumental work. But it is difficult to capture the essence of this theory in outline form using age bands as organizing features in a cognitive profile. Piaget's theory has integrating theses (i.e., mathematical-logical notions of reversibility, associativity, etc.) that recur at different points in development and enter into almost all concepts. This report centers more on the child's acquisition of the most important concepts studied by Piaget, rather than the presumed processes related to concept formation.

E. Learning, Memory and Problem Solving

These topics have obvious relevance for a profile of cognitive activity and education. However, as defined in the psychological literature, these topics contain much that is irrelevant to cognitive development. For example, classical

conditioning of the eye--blink response, or operant conditioning of the smiling response of infants seem largely unrelated to the type of phenomena we are interested in, yet in the developmental literature such studies account for the greater part of research.

PROBLEMS IN CHARTING COGNITIVE DEVELOPMENT IN CHILDREN

We have been plagued by a number of persistent problems in trying to chart the child's cognitive development from infancy to adulthood. The most troublesome problems--indicated in point form--are the following:

1. What Constitutes "Having a Concept?"

(a) Consider the concept of time in relation to the problem of surface manifestation vs. underlying understanding. Various researchers have used criteria such as ability to tell the time, cope with the clock, the calendar and historical sequences. These might be considered as surface manifestations. Other researchers, notably Piaget and collaborators, have tried to get to the underlying understanding of the mathematical-logical properties inherent in the notion of time (i.e., succession of time, additivity of time units, need for fixed time unit, etc.). Thus, the measuring instrument plays a crucial role. No matter how complex the formal definition of the thinking process, in the final analysis they are defined operationally by the measuring instruments used in the research.

(b) When a concept possesses varying components (as for example time) and the component concepts develop at different ages or stages in development, then at what point can we say the child has "mastered the concept"? The decision as to which criterion to accept will naturally influence the age at which the concept may be said to be typically acquired by children.

2. Interrelations between Concepts and Processes

According to various theoretical schemata and the author's convictions, there are many interrelations between concepts and conceptual processes. Regarding products or outcomes, Piaget's theory reveals that intimate relationships are developed between certain concepts as, for example, between the concepts of time, movement and velocity or between the concepts of seriation, classification and number. Considering processes on the other hand, links are seen between: (1) motor activity and concepts [Piaget (1950), Held (1964) and Bruner (1966)] (2) perceptual learning and concepts [Hebb (1949)] and (3) language and concepts [Kendler (1963) and Brown (1964)]. In a schematic profile of cognitive and developmental skills oriented to age levels of children 1 - 19 years, it has been initially impossible to indicate the interrelationships.

3. Interrelationships between Cognitive Accomplishments and Other Developmental and Personality Achievements

The child's cognitive accomplishments influence every facet of his life and are not restricted to the intellective domain. It was the genius of Piaget and some of his followers [e.g., Kohlberg (1967) and Elkind (1967)] who have recently made this point with greatest impact. For example, Piaget (1948) has shown how the notion of "egocentrism"--a concept important in understanding children's preoperational concepts--is important in understanding the development of moral judgments in children. Kohlberg (1966) has used the Piagetian concept of "conservation" to explain the sex typing of young children. Elkind (1968) shows how the child's cognitive development influences his understanding of politics and religion. Even more important, Flavell (1969) discusses how cognitive factors influence a child's

self-concept, as well as his social and psychological concepts such as role taking and empathy with another. Bandura (1968) acknowledges the importance of the child's cognitive capacities in modeling and identification. Both processes are central to the child's personality development. Yet the links between the cognitive variables and other developmental domains do not show up in our schematic profile.

4. Cognitive Development and Environmental Influences

It is difficult to conceive of cognitive development proceeding without being influenced profoundly by the environment. Yet in our profile we were unable to indicate the most important environmental influences that are known. The child's utilization of concepts in an experimental situation is influenced by the kinds of materials with which he is dealing, the instructions he is given, and a host of other specifics. Furthermore, emotional attitudes, motivational states, states of adjustment and acquired approaches to the environment influence the attainment of concepts. On another level, variables such as socio-economic status and sex differences [Maccoby (1966)] seem to influence the child's cognitive competence at any given age. These variables do not appear in our cognitive profile.

5. Competence vs. Performance

A distinction has to be drawn between what the child can do under optimum conditions (competence) and what he does in fact do under known conditions (performance). In developing a cognitive profile of the child it seemed more important to be concerned with competence rather than performance. This attitude would encourage new hypotheses for innovation

in education. However, most of the research has yielded "typical performance" curves, and, even where research was intended to tap the cognitive competence of the child, the results are highly dependent on the experimental procedures used. One example will suffice to document this, although countless examples may be found in the psychological literature. Until relatively recently it was believed that neonates could not discriminate pitch since all known methods failed to produce results. However, it has recently been shown, using heartbeat as a response, that neonates can indeed discriminate pitch.

6. Nature and Nurture in Cognitive Development

In a perhaps redundant statement of a worrying problem that occurred throughout our compilation of cognitive changes during development, we found that research did not indicate and theory did not suggest the relative contributions of maturation and learning (environmental influences) on cognitive development. We found ourselves forced to assume the following:

(a) A "normal" child--i.e., a child who lacked gross devient patterns of development.

(b) A "normal" environment--whatever that might mean. Since most of the psychological research has been carried out in Western countries and involved middle-class children, we might well be misled in attributing importance to certain intellective operations which we considered basic. It might emerge that such an operation is a function of, for instance, schooling, an environmental variable. Cross-cultural research would be of great value in clarifying the universals of cognitive development.

7. Individual Differences

A profile of cognitive development or any other area gives the erroneous impression of uniformity of development across children, or even uniformity in sequence of development. The data show mean differences, and very few studies show patterns of development within individuals (some exceptions are found in Piaget-inspired research). Even those that investigate patterns of change fail to show that all children, at a given point in time, are at the same stage of development. The vast body of literature on individual differences indicates that we must not allow "average" age to blind us to the tremendous inter-individual variation. Thus, for any practical purposes in dealing with groups of children, several neighboring age bands must be studied in order to appreciate the variation that can be expected among "normal" children of a given age.

8. Age and Stage as Concepts in Cognitive Development

Current theorizing on intellective development is caught up in the controversy of "age" or "stage" as the best mode of conceptualizing the changes that occur throughout life. The basic issue is whether there is continuity or discontinuity in the processes which underlie the changes. Since the approach taken in preparing this profile of cognitive development is eclectic, a way had to be found to present both age changes and stage changes. In stage changes the most crucial feature is the sequential order of the emerging concepts. We found it difficult to emphasize the invariant or[illegible] the age categories that we used, although such an order is crucial in understanding Piaget's theory.

Age-related changes do not provide sufficient insight into the wide

range of individual differences that exist within a population of children. Most age norms depend for their accuracy on the sampling techniques used in the empirical work from which they were derived. In most instances the sampling has been anything but careful. Age changes are only generalizations that fifty percent or more of sample showed this behavior.

9. Interrelationships Among Variables

We conceptualized cognitive development in terms of seven variables. This facilitated our task of organizing an immense amount of material. However, we wish to stress that this subdivision was for the sake of convenience only. We do not conceive of parallel or separate development in these areas. We believe that these seven variables are completely interwoven in a way that is as yet unknown. There has been great debate among philosophers, psychologists and others as to the relationship between language and thought--whether these develop synchronously but independently, or whether they interact, or even whether they are both manifestations of a third and even more basic variable. When we add to this debate the other five variables, the problem becomes enormously complex and we have not attempted to resolve it in this report.

10. Lack of Research in Vital Areas

A limiting factor in the comprehensiveness of the cognitive profile is the paucity of developmental research on some of the crucially important variables. For example, little research has been done on attention, stimulus selection and memory in very young children. In most instances of completed research, the results merely state that there are improvements

with age, without going into the processes that may be involved, or the changes in processes with age.

By necessity, the profile presented is limited by the nature and quality of the research that has been done and, even in topics that are comparatively well researched, there are surely whole issues that have not been studied. Furthermore, our survey does little to indicate what these might be. In a profile we were not able to indicate the adequacy of the research. We looked for the existence of convergence among different studies.

Finally, our literature search has not been exhaustive, nor has it been equally thorough for the seven variables we chose to investigate. The topics of language and concepts received the most attention, but even there new lines of evidence have surely been overlooked. Other topics were researched primarily through the use of review chapters. We regard our profile as a tentative effort in charting the child's cognitive development and in no sense regard it as a finished product.

COGNITIVE DEVELOPMENT IN CHILDREN

Classification of Variables

The following seven variables were used to systematize cognitive development in children:

1. Perception
    a. discrimination
    b. attention--information extraction
2. Sensorimotor (or Perceptual-motor) Development
3. Language
    a. vocabulary
    b. syntax and grammar
    c. semantics
    d. articulation
    e. functions
4. Memory
5. Learning
6. Problem Solving
7. Conceptual
    a. classification
    b. logical concepts
    c. mathematical concepts
    d. scientific concepts
    e. others

At various ages these variables are differentially important. During infancy, perception and sensorimotor development are very important. On the other hand, language development, a key indicator of symbolic

activity, is featured as a major variable between age two and age four. During middle childhood, more obvious "cognitive" variables, such as learning, problem solving and conceptual processes, undergo development. During adolescence there is less emphasis on the "stock of concepts" and more on strategies for their use--or what might be called thinking or reasoning. These aspects of cognitive development are included in 7e of the profile.

Structure of the Profile

The profile is an ordered sequence of cognitive development that begins with birth and extends through late adolescence or early adulthood. The cognitive activities are organized using the variables outlined in the preceding section. Opposite each activity the following information is presented:

1. E or T--the research is classified as Empirical (E) or Theoretical (T)
2. Source--the author's last name and year of publication
3. P or R--the source is classified as a Prime Source (P) or Review Article (R)

Survey of Integrating Themes

There seem to be some discontinuities in cognitive function that are obscured by casting the profile against age. The authors were able to visualize five age periods.

(a) 0 - 2-1/2

Sensorimotor activity [Piaget (1950) and Werner (1948)] and perceptual

activity [Hebb (1949), Piaget (1950) and Wohlwill (1962)] are the dominant modes of functioning. Probably important neurophysiological changes especially involving memory take place during this period.

(b) 2-1/2 - 5

--Language influences discrimination [Spiker (1963)] learning [Kendler (1963) and Kuenne (1946)], classification [Inhelder and Piaget (1964) and Bruner (1966)] and most other cognitive domains.

--Symbolization (ikonic representation) becomes important [Bruner (1966)] and frees child from immediate present.

(c) 5 - 7

--A global or intuitive feel for the cognitive phenomena--but a lack of "planning and foresight" characterize this period [Inhelder and Piaget (1964)]

--An ability to inhibit the first thought or solution [White (1965)]

--Ability to string together chains of S - R

--Greater efficiency in using language for thinking and sharing information [Miller (1956)]

(d) 7 - 11

--A more "cognitive" approach, freed from the constraints of perception [Piaget (1950) and Bruner (1966)]

--Ability to maintain orientation toward invariant dimensions of stimuli in a state of flux [White (1965)]

--Building complex of concepts which are interrelated and which exhibit properties of logic [Piaget (1950)]

--Learning of strategies for collecting information

(e) 11 - 14

Move from building concepts to thinking and working with concepts at higher level of abstraction [Piaget (1950)]

A Tentative Profile of Cognitive Development
in Children

AGE 0 - 3 Months

Cognitive Activity	E or T	Source	P or R
1. Perception			
Discrimination			
- Figure--ground distinction innate	T	Hebb (1949)	P
Attention			
- Orienting reflex (to food, labyrinthine stimuli, to sound and sight stimuli)	E	Fantz (1961)	P
- Aural orienting reflex and visual orienting reflex		Russian Research	
- Neonate fixates only one small portion of stimulus field, no visual exploration			
2. Sensorimotor			
- Very early perceptual learning through eye movements to provide basis for later learning of all kinds	T	Hebb (1949)	P
- Self-stimulated repetitive actions and coordinating actions of own body, e.g., eye-hand	E	Piaget (1954)	P
3. Learning			
- Infant can be classically conditioned			
4. Language			
- Coos and chuckles	E	Lenneberg (1966)	R
- Can increase number of positive vocalizations through social reinforcement	E	Rheingold, Gewirtz and Ross (1959)	P

AGE 3 - 6 Months

1. Perception			
Discrimination			
- Discrimination of moving objects, complex objects and faces (using fixation time)	E	Fantz (1961)	P

Cognitive Activity	E or T	Source	P or R
- Prefers face to pattern, and pattern over plain stimuli (fixation time)	E	Ling (1941)	P
- Discrimination among simple geometric forms	E	Mussen (1960)	R
- Color discrimination but no consistent color preference	E	Bower (1967)	P
- Shape and size constancy			
2. Sensorimotor			
- Repetition of acts on objects	E	Piaget (1954)	P
- Coordinates vision and movements of hands and arms. Grabs for objects in visual field			

AGE 6 - 9 Months

1. Perception			
Discrimination			
- Ability to judge size of an object independent of its distance from S, and independent of the size of its projection on retina	E	Bower (1967)	P
- Depth perception (measured by visual cliff)	E	Gibson (1963)	R
- Beginnings of object permanency, child searches for object which disappears from sight	E	Piaget (1954)	P
2. Sensorimotor			
- Shows goal-directed activity and some intentionality	E	Piaget (1954)	P
- Development of prehension grasping activity, finger manipulation	E	Piaget (1954)	P
3. Language			
- Babbles, producing sounds such as "ma" or "da"	E	Fry (1966)	R & P
- Reduplication of common sounds	E	"	"
- Establishment of auditory feedback loop (link between kinesthetic and auditory sensations)	T	"	"
- Produces and experiments with the sounds required in phonemic system	T	"	"

AGE 9 - 12 Months

Cognitive Activity	E or T	Source	P or R
1. Sensorimotor			
- Elementary means-ends comprehension - Some systematic exploration of new objects (pulls string to obtain lure) - Some "insight"--using new stimuli to obtain desired effect	E	Piaget (1954)	P
2. Memory			
- Memory for simple things with delay of 20 seconds to 1 minute (delayed reaction experiment)	E	Mussen (1960)	R
3. Language			
- Jabbers in sentences, uttering them with assertive, interrogative and exclamatory inflections	E	Werner & Kaplan (1963) Fry (1966)	R

AGE 12 - 18 Months

1. Language			
- Speech characterized by monoremes (one-unit referential patterns that refer to total happenings, rather than to delimited components)	T	Werner & Kaplan (1963)	P
- Vocabulary consists of small number of such words (or monoremes) of which approximately 1/4 comprehensible	E	Lenneberg (1966)	R
		McCarthy (1954)	R

AGE 15 Months - 2 Years

1. Perception			
Discrimination			
- Recognizes shape despite 45° rotation, background changes, 90° rotation (15 mo.)	E	Carmichael (1946)	R
- Preference for "shape" over "color"	E	Brian and Goodenough (1929)	P
- Can match colors (age 2)	E	Sigel (1964)	R
- Can judge larger and smaller of two equally distant objects	E	Sigel (1964)	R

Cognitive Activity	E or T	Source	P or R
- Recognizes pictures without any training	E	Gibson (1963)	R
- "Syncretic" functioning, i.e., fusion of several processes, perceptual, sensory, motor affective	T	Werner (1948)	P
- Some representation of spatial position of one stimulus relevant to another--string and lure	E	Carmichael (1954)	R
2. Sensorimotor development			
- Coordination of physical movement and sensory impression basis for form perception	T	Hebb (1949) Piaget (1954) Werner (1945)	P P P
- Active experimentation--new variations introduced in exploring a stimulus	E	Piaget (1954)	P
- Motor representation abbreviated, partly internalized in language	E T	Piaget (1954) Vygotsky (1962)	P P
3. Language			
Vocabulary			
- Increases from about 20 to 300 words	E	Lenneberg (1966)	R
	E	McCarthy (1954)	R
Syntax			
- Mean length of sentence 1.0 - 2.1 words	E	McCarthy (1954)	R
- These 2 - 3 word sentences: A - omit articles, prepositions, auxiliary verbs B - omit inflections (such as plurals and -ing endings) C - add ungrammatical combinations	E	McNeil (1966)	R
- Emergence of grammatical classes marked by pivot class and open class words, combined to form sentences according to the rule S=(P)+O or S=N+N	E	McNeil (1966)	R
Phonology			
- Has vowel system of 8 - 10 vowels	E	Fry (1966)	R
Semantics			
- Some monoremes still present	T	Werner and Kaplan (1963)	P
- Two vocable utterances (duoremes) allow possibility of linguistic representation of different aspects of a situation			

Cognitive Activity	E or T	Source	P or R
- Development toward greater generalization or categorization in meaning			
- The two vocables overlap in reference, rather than each having distinct meaning			
Functions			
- Speech is essentially social	T	Vygotsky (1962)	P
- Children unable to carry out verbal instructions if delay between instruction and action	E	Luria (1958)	P
4. Memory			
- Can remember after 20-minute delay	E	Carmichael (1954)	R
- Some associative clustering in recall	E	Flavell (1969)	R
5. Problem Solving			
- Some insight in stick and goal problems; string and lure problems and box stacking problems, but mostly trial and error attempts	E	Carmichael (1954)	R
6. Conceptual			
Classification			
- Notion of object permanence despite invisible but inferable displacements	E	Piaget (1954)	P
- Representational behavior with the referent absent from the immediate perceptual field, i.e., search for object	E	Piaget (1954)	P
- Preconceptual naming behavior in children			
- Some beginnings of classificatory behavior in some children when objects belong to two classes and have strong perceptual attributes	E	Flavell (1969)	R
- Form more important attribute for classification than color (age 2)	E	Brian and Goodenough (1929)	P

AGE 2 - 2-1/2 Years

Cognitive Activity	E or T	Source	P or R
1. Language			
Vocabulary			
- About 400 words	E	Lenneberg	
- Uses prepositions and pronouns	E	(1966)	R
- About 2/3 comprehensible	E		
Syntax and Grammar			
- Number of grammatical categories increases, by division of original pivot class into articles, demonstrative pronouns, adjectives and possessive pronouns	E	McNeil (1966)	R
- Increased frequency of sentences generated (according to the rules having a hierarchical structure):	E T T	McNeil (1966)	R
1 - S=Pivot(P)+Noun Phrase (NP) NP=(P)+(N) or N+N			
2 - S=Predicate Phrase Predicate Phrase=Verb + NP NP=(P)+N or N+N	E	McNeil (1966)	R
- Negative sentences which occur result from base structure and do not involve transformations	E	McNeil (1966)	R
Semantics			
- Different components of 2 + 3 vocable utterances more differentiated in reference, although still some overlap	T	Werner and Kaplan (1963)	P
- No understanding of the preposition "on"	E	Sokhin (1959)	R
Functions			
- Speech essentially social	T	Vygotsky (1962)	P
- Children unable to carry out verbal instructions if delay between instruction and action	E	Luria (1958)	R

AGE 2-1/2 - 3-1/2 Years

1. Perception			
Discrimination			
- Reacts to whole "global" stimulus rather than differentiates parts	E	Murphy (1960)	R
	E	Piaget (1954)	P
	T	Werner (1948)	P

Cognitive Activity	E or T	Source	P or R
- Perception labile--or susceptible to change	T	Werner (1948)	P
- Animistic (physionomic) perception-dynamic apprehension of things	E	Werner (1948) Piaget (1954)	P
- Recognizes inverted figures	E	Gibson (1963)	R
- Better discrimination with solid objects than planometric objects: Better planometric discrimination than discriminatio s between painted objects	E	Gibson (1963)	R
- Around 3, color preference over form	E	Brian and Goodenough (1929)	P
- Preference for novel stimuli compared to familiar stimuli	E	Cantor (1963)	P
- Need for redundant information to recognize an object	E T	Wohlwill (1962)	P
Attention - information extraction			
- Use of tactile exploration over visual	E	Zaphorozhets (1965)	R
- Global and passive tactile exploration, resulting in poor identification	E	"	R
- Uses "push & pull" in haptic (tactile) perception--no systematic exploration	E	"	R
- Fixation (visual) on single portion of a stimulus; few eye movements, many fixations	E	"	R
2. Sensorimotor Development			
- Can copy a circle and a vertical line but not other geometric shapes	E	Maccoby (1967)	P
3. Language			
Vocabulary			
- Fastest increase at this time; number of words used doubles to 800	E	Lenneberg (1966)	R
	E	McCarthy(1954)	R
Syntax			
- Means sentence length--2.2 - 3.4 words	E	McCarthy(1954)	R
- 3 and 4 word sentences common	E	Lenneberg (1966)	R
- Growth of transformational rules, e.g., negative sentences that characterized earlier stages have dropped out	E	McNeil (1966)	R
Phonology			
- Whole system of about 20 vowels complete	E	Fry (1966)	R
Semantics			
- Word referents no longer overlap with frequency	T	Werner and Kaplan (1963)	P

Cognitive Activity	E or T	Source	P or R
- Comprehension of preposition "on", but unable to direct behavior in placing one block on the other	E	Sokhin (1959)	P
Function			
- Speech essentially social	T	Vygotsky (1962)	P

AGE 3 - 3-1/2 Years

1. Language			
Vocabulary			
- 1,000 words or more	E	Lenneberg (1966)	R
- 90% comprehensibility			
Syntax			
- Mean sentence length 4 - 4.8 words	E	McCarthy (1954)	R
- Grammatical mistakes less frequent	E	Lenneberg (1966)	P
- Increased use of transformation rules for negatives	E	McNeil (1966)	R
- Children using most of the syntactic rules used by adults	E	Menyuk (1963)	P
Semantics			
- Complete comprehension of preposition "on" indicated by ability to direct behavior according to instructions using the word	E	Sokhin (1959)	P
- Nouns used semantically in references to objects, rather than in reference to abstractions	E	Brown (1957)	P
- Know that some indicates a mass noun, a indicates a particular noun and the suffix -ing indicates a verb	E	Brown (1957)	P
Articulation			
- Articulation 50 - 67% of a mature adult	E	Templin (1957)	P
- Nasals, in all positions, best articulated			
- Initial consonant sounds articulated better than medials, and medials better than final			
- Substitution errors occur 10 times as often as errors of omission			
Speech-sound discrimination			
- Approximately 50% accuracy (range 25 - 75%)	E	Templin (1957)	P

Cognitive Activity	E or T	Source	P or R
Functions			
- Earlier social speech is divided into egocentric and communicative speech	T	Vygotsky (1962)	P
- Children can follow an instruction, but cannot inhibit an act unless the verbal instruction is simultaneous with the desired responses	E	Luria (1958)	P
- Child's own verbal commands capable of replacing the regulatory action of the external signal			
2. Learning			
- Some evidence of learning to learn for the first time (i.e., learning set)	E	Brackbill (1967)	R
- Learning to learn--rate of learning improves with the number of previous problems solved	E	Mussen (1960)	R
3. Problem Solving			
- No systematic approach to problem solving, trial and error used	E	Carmichael (1946)	R
4. Conceptual			
Classification			
- Undifferentiated and syncretic concepts	T	Werner (1948)	P
- Categories on basis of single characteristics of objects	E T	Piaget (1954)	P
- Conceptualization is perceptual dominant	T	Piaget (1954)	P
- "Concrete" classes emerge, but not abstract	E	Piaget (1954)	P
- Not exhaustive or consistent in applying criteria--guided by common participation in totality. Results in	T E E	Inhelder and Piaget (1964) Bruner (1964)	P R
figural collections	T	Inhelder and	
configurations	E	Piaget (1964)	P
thematic groupings	E	Bruner (1964)	P
- Concepts defined in terms of actions and functions	E	Vygotsky (1962)	P
- Child develops concepts at "middle size"	E	Bruner (1964)	R
- Child fails to differentiate between words and their referents	E	Piaget (1926)	P
- Belief that names inhere in things and objects can have only one name	E	Piaget (1926)	P

AGE 4 - 5 Years

Cognitive Activity	E or T	Source	P or R
1. Perception			
Discrimination			
- Good visual matching to standard, which was seen 5 seconds and then removed	E	Gibson (1964)	R
- Form dominance over color	E	Lee (1965) and Colby(1942)	P
- Difficulty disembedding stimulus from context	E	Witkin (1962)	P
- Global, diffusely organized perception	T	Werner (1948)	P
- Excellent tactile perception of form--can discriminate between linear and curvilinear usually and by angles. Explores one aspect	E	Zaphorzhets (1965)	R
- Plane figures on paper can be identified despite changing orientation	E	Mussen (1960)	R
- Language (naming) helps discrimination, decrease in form, word and letter reversals	E	White (1965)	R
	E T	Spiker (1960 & 1963)	P
Attention - information extraction			
- Need for redundant information for recognition	E T	Wohlwill (1962)	P
- Difficulty in breaking set (in reversible figures and embedded figures)	T E	Witken (1962)	P
- Strength of stimulus organization (Gestalt-properties) determines whether attention to "whole" or to "parts"	E	Brackbill (1967)	R
- Visual scanning along central lines of stimulus, more eye movements, particularly within the stimulus figure-tracing length and width	E	Zaphorozhets (1965)	R
2. Sensorimotor			
- Can carry out many sensorimotor tasks--copy square, complete line drawing of man, tie knot; fold paper to make triangle, etc.	E	Stanford Binet IQ Test	P
3. Language			
Vocabulary			
- 1,500 - 2,000 words	E	Lenneberg (1966)	R

Cognitive Activity	E or T	Source	P or R
Syntax and Grammar			
- Mean sentence length 4.8 - 5.3 words - Formation of plural by /-s/or/-z/ allomorphs by approximately 75% children - Formation of possessive - 50-75% - Only 1/4 or fewer could form plural by adding /-z/ - Formation of progressive verb form by adding -ing - 75% children - Approximately 2/3 form past tense by adding -t and -d allomorphs - Only 1/3 form past tense by adding -ed - Failed to form the correct irregular past tense rang - 50% could form third person singular of the verb by adding /-əz/	E	Berko (1958)	P
Semantics			
- Double function of terms such as cold, hard, deep not understood; comprehend only physical meaning	E	Asch and Nerlove (1960)	P
Articulation			
- Approximately 3/4 that of a mature adult	E	Templin (1957)	P
Functions			
- Speech both egocentric and communicative	T	Vygotsky (1962)	P
- Child capable of regulating his own behavior according to previously given rules	E	Luria (1958)	P
4. Learning			
- Large amounts of generalization in learning studies - Can carry out "near transposition" but not "far transposition"	E	White (1965)	R
5. Problem Solving			
- Exploration of problem emerges (5+ years)	E	Carmichael (1946)	R
6. Conceptual			
Classification			
- Use of mediated generalization--child categorizes on basis of common abstract label			
Logical, mathematical and scientific concepts			
- In thinking about causality confusion between psychological and mechanical factors	E	Piaget (1930)	P

Cognitive Activity	E or T	Source	P or R
- "Intuitive" thought--child concludes on basis of intuition and inadequate analysis. Gives global impressions which are influenced by perceptual factors (For more specific details see next age level)	T	Piaget (1950)	P

AGE 5-1/2 - 7 Years

1. Perception			
Discrimination			
- Color preference over form (5-6) then change to form preference (6+)	E	Brian & Descoudres (1914) Goodenough (1929)	P
- Influence of needs and wishes on perception, and influence of reward and punishment	T E	Solley & Murphy (1960)	P
- Recognize intersecting forms			
Attention and Information Extraction			
- Trace outline of stimulus figure with eyes and dwell on distinctive feature. Associated with improved recognition of figures. Systematic tactile exploration for clues to identity. Dwell on distinctive features	R R	Zaphorozhats (1965) "	P P
- Great increase in "apprehension", i.e., span of perception; e.g., faster tachistoscopic recognition			
- Difficulty in selecting a wanted stimulus out of a complex array when this cannot be accomplished by differential orientation of sense organs (selective auditory attention)	E	Maccoby & Konrad (1967)	P
- Can make use of "preparatory set" if task follows immediately	E	Maccoby (1967) (b)	R
2. Sensorimotor			
- Trace a line in a maze	E	Stanford Binet IQ Test	P
- Copy a diamond			

Cognitive Activity	E or T	Source	P or R
3. Language			
Vocabulary			
- 2,000 - 3,000 words	E	Lenneberg (1966)	R
		McCarthy (1954)	R
Syntax and Grammar			
- Transformations for dealing with negatives, questions and passives used consistently	E	Olson (1967)	R
- 100% generate rule of adding /-s/or/-z/ to form plural	E	Berko (1958)	P
- 1/3 form plural by adding /əz according to a rule			
- Nearly all generate rule for forming progressive -ing correctly	E	Berko (1958)	P
- 75-85% generate the past tense formation rule of adding -d or -t			
- Approximately 1/3 use past tense rule of adding -əd			
- 25% can generate the irregular rule			
- 50% generate rule for forming the third person singular of the verb			
- 80-100% form the possessive according to the rule: add -z, -s or əz			
- Mean sentence length 5.5-7.25 words	E	Lenneberg (1966)	R
Semantics			
- About 40% understand dual meaning of double function words	E	Asch and Nerlove (1960)	P
- 2/5 - 2/3 use terms describing the dimensions of size, weight and strength synonymously	E	Ervin and Foster (1960)	
- Approximately 2/3 used the descriptive terms--happy, good pretty--synonymously, indicating poor differentiation of denotative meaning			
Speech-sound Discrimination			
- 80% accuracy	E	Templin (19)	P
Functions			
- Egocentric speech increasingly internalized; serves function of autistic and logical thinking	T	Vygotsky (1962)	P
- About 50% of children made "reversal shifts"	E	Kendler (1964)	R

AGE 5-1/2 - 7 Years

Cognitive Activity	E or T	Source	P or R
1. Learning			
- "Transposition" in far test	E	White (1963)	R
- "Reversal shift"--implies greater mediational control (of language)	E	Kendler (1963)	P
- Onset of resistance to classical conditioning (voluntary inhibition)	E T	White (1963)	R
- Efficiency in simple discrimination learning possibly due to complex hypotheses	E T	White (1963)	R
2. Problem Solving			
- Growth of inference in a behavioral task (Learned A→B, X→Y and B→G. Then given A, told to get G)	T	Kendler (1967)	P
- Double alternation problem in temporal maze solved (i.e., handling of sequences)	E	Carmichael (1946)	R
3. Conceptual			
Classification			
- Names treated as separate from things they represent	E	Piaget (1960)	P
- Emergence of ability to think in classes			
- Understand "some" and "all" relations in exhaustive classes	E	Inhelder & Piaget (1964)	P
Logical concepts			
- Increase in use of "because","since", "but" and "then"	E	Piaget (1926)	P
- Can handle negation as a logical operation in classification task	E	Feldman (1968)	P
Mathematical concepts			
- Conservation of continuous and discontinuous quantities	E	Piaget (1952)	P
- Ability to handle provoked and unprovoked correspondence and spontaneous correspondence, understanding of topological properties of order, enclosure and continuity	E	Piaget (1952) Piaget (1960)	P
Scientific concepts			
- Genuine physical explanations and awareness of need for causal agent	E	Piaget (1960)	P

See next age grouping for continuity in development...

AGE 7-1/2 - 9 Years

Cognitive Activity	E or T	Source	P or R
1. Perception			
- Item perceived in terms of surrounding context	E	Witkin (1962)	P
- Perceived causation (as adults know it)		Piaget (1930)	
2. Language (Age 7-8)			
Semantics			
- Approximately 40% understand dual meaning of double-function words	E	Asch & Nerlove (1960)	P
Articulation			
- Attain mature articulation = to an adult	E	Templin	P
Functions			
- Increasing internalization of egocentric speech which serves as basis for logical thinking	T	Vygotsky (1962)	P
(Age 8-9-1/2 Years)			
Semantics			
- Signification (acquisition of word meaning) characterized by:	E	Werner & Kaplan (1950)	P
1 - lack of differentiation between word and sentence, indicated by word sentence fusion and word-embeddedness in all children			
2 - partial differentiation of word and sentence indicated in non-sentential holophrastic, syncretic and fluid concepts in all children			
3 - 80% exhibited concrete realism, either by homophonic symbolism (in which sound patterns are comprehended as directly conveying meaning) or by sentence realism (in which the hypothetical nature of the sentence is not understood)			
Speech-sound discrimination			
- 90% accuracy	E	Templin (1957)	P
Functions			
- About 60% made reversal shifts	E	Kendler (1964)	R
3. Problem Solving			
Some ability to solve problems which involve stringing together stimuli and response in sequence	E	Kendler (1967)	P

Cognitive Activity	E or T	Source	P or R
4. Concepts			
Classification			
- Use of conceptual categories of a more inclusive nature in free sort	E	Sigel (1963)	R
Mathematical concepts			
- Spatial concepts			
- Can draw and predict cross sections	E	Piaget & Inhelder (1956)	P
- Can take another perspective			
- In the sequence of topological, projective and Euclidean properties children at this age can handle primarily topological properties only	E	Piaget, Inhelder & Szeminska (1960)	P
- Geometric concepts			
- Concept of fractions	T	Piaget, Inhelder & Szeminska (1960)	P
- Homogeneous space			
- Measurement-use of unit measurement			
- Ability to measure in one dimension			
- Emerging ability to handle area			
- iterable measurement unit			

AGE 9-1/2 - 11

1. Perception			
- Integration of details into larger wholes	E	Mussen (1960)	R
- Decreasing influence of rewards, punishments and needs or perception	E	Solley & Murphy (1961)	P
2. Language			
Semantics			
- Approximately 50% understand dual meaning of double function words	E	Asch & Nerlove (1960)	P
- Signification characterized by:			
a. lack of sentence word differentiation in approximately 80%	E	Werner & Kaplan (1950)	P
b. immature signification in 100%--some forms higher than at age 9			
c. 68% exhibit concrete symbolism			
3. Learning			
- Incidental learning at a maximum in this age range	E	Carmichael (1949)	R

Cognitive Activity	E or T	Source	P or R
4. Concepts			
Classification			
- Can give a member which is at an intersect of two sets	E	Inhelder & Piaget (1964)	P
- Can handle additive composition of classes B=A+A', ∴ A ⟨ B	E	"	P
- Can handle quantification in relation to inclusion	E	"	P
- Can handle relationships between "all" and "some" in complex situation			
Mathematical concepts			
- Spatial concepts			
- Handle projective properties and projective space (refers to the perceptually invariant features of objects even when the point of view from which the object is viewed is changed)	E	Piaget & Inhelder (1956)	P
- Some ability to handle Euclidean space, i.e., to deal with concepts of angularity, rectangularity and parallelism		"	
- Geometric concepts			
- Better handling of area and measurement of area (2 dimensional + measurement)			
- Emerging ability to handle measurement of volume (3 dimensions)			
- Other			
- Can handle easy proportions; e.g., in verbal and numerical analogies		Bruner (1956)	
Scientific concepts			
- Handle conservation of substance and weight well. Emerging ability to handle conservation of volume (NB sequence is important here)	E	Flavell (1963)	R
	E	Bruner (1966)	R
- Chance and probability--emerging abilities: can conclude same chance for X to occur if 4/8 or 2/4			
- Can handle sampling with replacement	E	Flavell (1963)	R
Other			
- Child constructs simple hypotheses but acts as though the product is imposed by the data rather than derived from his own mental activity	E	Elkind (1967)	R

AGE 10-1/2 - 11-1/2 years

Cognitive Activity	E or T	Source	P or R
Semantics			
- Signification characterized by:	E	Werner & Kaplan (1950)	P
a. lack of sentence-word differentiation - 50%			
b. immature signification in 96% of children observed			
c. concrete symbolism - 50%			
- over 3/4 understand dual meaning of double function words	E	Asch & Nerlove (1960)	P
- 60-80% differentiate size, weight and strength terms as distinct referents	E	Ervin & Foster (1960)	P
- less than 50% used happy-pretty-good synonymously			

AGE 11 - 14 Years

1. Perception			
Least influence of background on perception of item (tested by embedded figures; rod and frame test)	E	Witkin (1962)	P
2. Language			
Semantics			
- Signification characterized by:	E	Werner & Kaplan (1950)	P
a. lack of differentiation--less than 10%			
b. immature signification--96%			
c. concrete symbolism: 20%			
3. Conceptual			
Classification			
- Can fully handle classes--in hierarchies	E	Inhelder & Piaget (1964)	P
Logical concepts			
- Can handle logical connectives on propositions including implication, conjunction, identity, disjunction, negation	E	Inhelder & Piaget (1958)	P
Mathematical concepts			
- Can handle probability and chance including probability when sampling with replacement and when sampling without replacement	E	"	

Cognitive Activity	E or T	Source	P or R
Other			
- Scientific reasoning--systematic formulating and testing of hypotheses	E	Flavell (1963)	R
- Isolation and control of variables in testing hypotheses		"	
- Think in terms of ideal and possible			
- Reasons in terms of hypothetical entities			
- Can use the hypothetical-deductive procedure in trying to determine reality		"	
- Can handle complex numbers of variables and see how to separate variables (basis of scientific method)			
- Can deal with equilibrium problems (based on law of proportions, in which one variable equals the quotient of the other two variables)		"	
- Can use propositional thinking (not limited to the "present")			
- Inferential behavior (using a behaviorist definition) accomplished	E	Kendler (1967)	P
- Change from descriptive statements to explanations	E	Peel (1965)	R

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