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RICHARD E. SNOW
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TECHNICAL REPORT NO. 13
APTITUDE RESEARCH PROJECT
SCHOOL OF EDUCATION
STANFORD UNIVERSITY

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This report surveys the literature on cognition and learning in young adults. First an outline of a theory of the cognition-learning system is presented with particular attention to differences between young adults and other age groups in information processing skills. The report then reviews the literature on cognitive abilities and achievements of young adults, focussing on changes in achievement and ability organization in the high school and post-high school years.

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College students and military trainees have been the most available and thus the most studied human subjects in cognitive psychology. Yet, the vast literature on human cognition and learning says virtually nothing about young adulthood as a significant phase of life-span cognitive development. From the developmental view, Goldberg and Deutsch (1977) observed, "...the study of cognition during early and middle adulthood is in its infancy..."

This chapter attempts to draw from what evidence and conjecture now exist to form a picture, however crude and hypothetical it must be at this stage, of cognition and learning in young adulthood, i.e., through the age range from 17 - 18 to 28 - 30 years. Both intraindividual changes and inter-individual differences are of interest, because both kinds of differences are known to be substantial in this age range and both may imply developmental effects and trends. Where possible, contrasts are made with younger and older persons and between the young adults of today and those of other eras. The chapter, however, can be only a selective, surface survey of implications from the intricate knowledge base of cognitive psychology. It offers no substantive theory of psychological-social-cultural changes in cognition and learning, nor does it take definite positions on general theoretical issues such as the relative value of continuous vs. discontinuous models of cognitive development across this and adjacent age ranges.

Many kinds of life events, including personal-developmental, family, and social experiences shape the human cognitive-learning system, just as characteristics of the system condition the products of learning from these experiences. For young adults, the years spent in formal education can be expected to have especially profound effects. Many general and special educational events influence cognitive development along the way, and cognitive characteristics interact with educational treatments to produce marked individual differences in learning and performance at the high school level. The relationship between intellectual development and education is thus reciprocal. We cannot deal here with all the particular effects that run in each direction. For a summary of some of this literature, see Cronbach and Snow (1977) and Snow and Yalow (in press). Also, since only a percentage of young men and women graduate from high school, and since high school experience is as varied as the college and/or occupational experiences that come later, any conception of "average" young adult competence will be substantially misleading. The contexts in which such competence is attained and displayed are tremendously variable across both time and place. And "...what cognition is depends upon context", to quote Labouvie-Vief and Chandler's (1978, p. 202) paraphrase of Jenkins (1974). Thus, the questions addressed in this chapter provide some general guidelines for inquiry; they can at best be given only distributional, probabilistic, and time-limited answers.

The general questions for this chapter are: What are young adults able to do cognitively? What do they know? What effects does high school education have on subsequent learning and cognitive development? What are the further effects of college attendance? Are there important differences to be noted between the present generation and other generations in this decade or between this cohort of young adults and previous cohorts? What generational or cohort differences might be expected in the future?

The Cognition-Learning System in Theory

With the rapid advance of cognitive psychology in the past decade, research on information processing in cognition and learning has produced a reasonably elaborated and coherent model of the basic human cognitive system. Discussions of this theoretical construction usually assume, implicitly or explicitly, that the system depicted is general, i.e., that it characterizes the cognitive organization and functioning of all human beings. The validity of this assumption need not be examined here. Because so much of the research supporting current information processing models has been conducted using U.S. young adults as subjects, we can take the general view as a reasonable starting description of that segment of the population with which this chapter is concerned, whether or not it proves valid as a characterization of younger or older persons, or even of all young adults. Process-oriented research on child cognitive development (e.g. Klahr & Wallace, 1976; Flavell, 1977) and on later adult cognitive development and decline (Baltes, Reese, & Lipsitt, 1980; Whitbourne & Weinstock, 1979) has now fanned out from this basic model, and will hopefully connect back at some point to synthesize an improved characterization of development across the full age range.

An overview of the young adult cognitive-learning system as it is presently understood was provided by Bower (1975) and used elsewhere by Snow (1978) to consider the possible nature of individual differences in such a system. Hunt and Lansman (1975) also discussed individual differences from this general information processing viewpoint. Those treatments can provide a framework for the present survey.

System architecture. Bower's organization of cognitive processing components begins by distinguishing the initial sensory-perceptual functions from three kinds of memory; short term memory (STM), intermediate or working memory (ITM), and long term memory (LTM). Beyond these, there must be executive planning, assembly, and decision-making functions and also control, monitoring, and evaluation functions. Of course, there must also be components concerned with behavioral response generation, whenever cognitive processing or the demands of environmental situations reach points where overt response is needed. It is important to recognize that all these components are considered distinguishable cognitive functions, not necessarily different places in the neuropsychological system. Yet, it is convenient to depict these functions schematically in a flow-chart such as that shown in Figure 1. We have dispensed with the arrows usually used to show information or control flow in such diagrams, since there would be so many of them. We have also added an extra box to the usual diagram, to keep in mind that there must be some source of conative or affective motivation that activates learning and other cognitive operations and maintains system functioning.

Figure 1 here

The system is considered to be hierarchically organized. Skilled actions are described as running motor programs, fitting output to input under the control of higher-order programs and plans running at perceptual and conceptual process levels. One can imagine the whole cognitive system as a hierarchy or nested system of computer programs. At the lowest level,

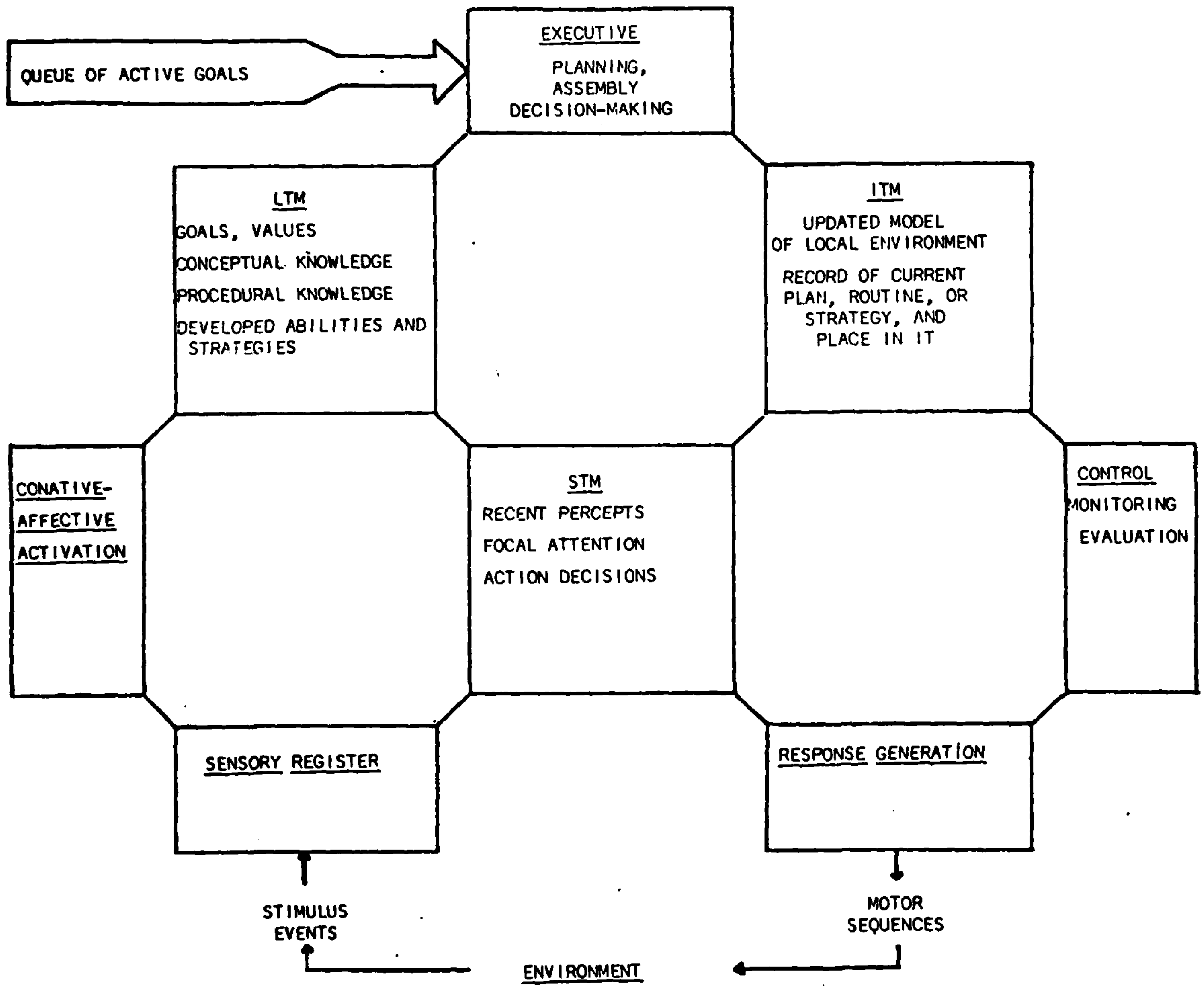

Figure 1. A schematic flow-diagram of the cognitive-learning system in theory adapted from Bower (1975) and Snow (1978a).

skilled action is rapid and automatic, without the need for conscious processing; there are direct sensory-motor connections. At higher-levels, more complex cognitive processing programs are brought into operation as necessary. Incoming information flows up the hierarchy activating higher-level processes. Control flows down the hierarchy regulating lower-order processes. At the highest level are executive plans, attached to long-term goals and values as well as short-term needs, and activated by internal as well as external sources of information.

The following sections review briefly the characteristics of each of the major components of the system. Emphasis is placed on identifying the individual skills and limitations presumably involved in the functioning of each that might relate to performance on higher cognitive and learning tasks. The main aim, given the present state of knowledge, is to promote more detailed developmental hypotheses about emerging phenomena in this area. For details on what is known about the cognitive system in general, without regard to individual or developmental differences, the reader should consult some of the many basic texts and general discussions (e.g., Bourne, Dominowski, and Loftus, 1979; Lachman, Lachman, and Butterfield, 1979; Neisser, 1967, 1976).

Sensory-perceptual-motor functions. The initial sensory register presumably consists of a buffer for each sense modality that registers and transduces patterns of stimulus energy from the environment falling onto the receptor surfaces. In this registration stage, there are pre-attentive processes that enhance contours, center stimuli, segregate figure from ground, and begin to detect significant features of the stimuli. Relationships or patterns among stimulus features are then recognized. There is also a function that provides for segmentation, analysis, and synthesis of temporally and spatially distributed collections of stimuli. The perception of wholes as well as parts is thus possible. Iconic and echoic images are readied for coding into memory.

On the motor, response generation side, there are component functions that produce, organize, and regulate behavioral sequences, once an action is decided upon. Motor functioning is usually described using the concepts of control theory: there are effector, sensor, and comparator functions, transfer functions that relate input to output, and regulator and translator functions that maintain or change overt behavioral sequences in relation to some internal or external criterion based on environmental feedback.

On average, young adults are the most able of human beings in sensory-perceptual-motor functioning. The physical, physiological, and neuropsychological supports for such functions are fully matured. The basic sensory-perceptual experience needed to tune these skills has probably reached an effective maximum. And the deteriorations of age due to disease, the wear-and-tear of work, nutritional deviations, etc., have not yet begun to dull these keen edges, at least for those who avoid misuse of drugs. So, optimum human functioning in this domain is observable among most young adults, perhaps most clearly in sports activities and in military performance. For most educational and vocational activities, the sensory-perceptual-motor capabilities of normal young adults probably exceed minimum requirements. Willerman (1979) has summarized a variety of studies showing the clear superiority of young adults in sensory and motor performance over that of older, and in some cases younger, persons. And, more analytic developmental research is ongoing. Pollack and Atkeson (1978) provided a good example for one perceptual aspect of visual sensory changes over the lifespan, suggesting that young adults are less susceptible to simultaneous illusions, and more susceptible to successive illusions, than are children or elderly adults.

Yet, there appear to be substantial individual differences in sensory-perceptual-motor functioning among young adults. Many of these may reflect developmental variations in biological and experiential history, and in turn have implications for present and future competence. Marked individual differences in sensory acuities are known to exist. For vision, these are clearly multivariate, and include differences associated with near and far acuity, depth perception, and dark adaptation. Color sensitivity varies consistently among individuals, and color blindness does not occur in females. Systematic differences in ranges and thresholds of auditory acuity are linked also to gender. (See Guilford, 1959, for details on such differences). By the time of young adulthood, most insensitivities have presumably been detected and individuals have learned how to adapt to or to compensate for any resulting deficiencies. But marked deficiencies, such as myopia, may have particularly significant consequences for young adults, in both cognitive and personal-social spheres, influencing r ading habits, educational and career choices, friendships, etc.

Beyond the purely sensory level, it is believed that individuals differ in the size of the stimulus sample they can take in at a glance. Trabasso and Bower (1968) proposed that such differences might be associated with differences in measured intelligence and in response to anxiousness. Information held for the first fleeting seconds in a sensory register is then subject to decay, which may also vary across individuals. What developmental evidence there is suggests that the capacity of the sensory register and its decay rate do not change with age. Rather, encoding speed increases through childhood so that young adults can presumably transfer more information to STM before decay than can children. Similarly, the superiority of young adults to older persons in sensory memory performance is attributed to the latters' difficulty with divided attention tasks rather than to deficits in capacity or decay rate (Baltes, Reese, & Lipsitt, 1980). Among young adults, however, there seem also to be individual differences in the stre..gth or resistence to decay of the initial image, the speed with which it is encoded into STM, and/or the sequence within which encoding and related STM processes are carried out (Snow, 1978). Hunt's research (see, e.g., Hunt, 1978; also Lunneborg, 1978) associates differences in speed of encoding from sensory register to STM with verbal ability. Day's (1973) work in the auditory domain suggests further that some persons are more bound to stimulus details while others more readily integrate stimulation to perceive meaning. It has been thought for some time, from the factor analytic studies of Thurstone (1944), Guilford (1967), and many others, that two separable human abilities in the visual system, Closure Speed, and Perceptual Speed, are associated with differences in speed of integrating spatially arrayed stimuli as meaningful wholes and of discriminating them as same vs. different, respectively. There may be comparable abilities in the auditory system (Messick & French, 1975; Guilford, 1967). Thurstone's (1944) factor analysis of perceptual abilities also identified several other individual difference factors presumably associated with the functioning of the sensory-perceptual system. Among these were: susceptibility to optical illusions, rate of alternation effects with ambiguous stimuli (e.g., the Necker cube), and simple reaction time to a visual or auditory stimulus. These abilities have been less well studied correlationally than have the closure and perceptual speed factors.

Marked intra- and inter-individual differences in eye movements can be observed as young adults solve the sorts of figural problems found in many spatial ability and reasoning tests; these suggest strategic differences in stimulus scanning (Snow, 1980a). Rothkopf (1978) has inferred different processing styles from such observations during reading and suggested their possible relation to learning differences. Eye movement differences have also been associated with preferences for words vs. pictures in associative learning tasks (Coffing, 1971) and with performance on tasks thought to reflect fluid-analytic ability and field independence (Boersma, et al., 1969. The latter construct is interpreted by Witkin (1976) as a cognitive style difference contrasting those persons able to disembed focal stimuli easily from compelling background context and those having difficulty distinguishing stimuli from background. The difference, whether interpreted as ability or style, has been shown to exist among young adults, and to be associated with motor sensitivities as well as such personality variables as the development of a sense of separate identity, the development of social skills, and even with career choice. Gender and ethnic-cultural differences in field-independence have also been postulated.

There may be other perceptual styles grounded in the parameters of the sensory-perceptual-motor system as well, and these may also relate to higher cognitive learning and problem-solving ability (Messick, 1976). Much of the modern research on style differences has been conducted with children, however (Kogan, 1976), and may not extend directly to young adults. As one example, children exhibit stable differences in reflectivity vs. impulsivity--the tendency to minimize errors through slow careful work as opposed to the tendency to work rapidly without controlling to avoid errors. Among young adults, however, variations in speed-accuracy tradeoff are easily manipulated. Most individuals are able to maximize speed or to minimize errors; they will choose a tradeoff strategy based on task and instructional conditions and will vary this tradeoff flexibly, both within and across tasks. Also, it has been shown that speed on simple tasks is quite different, psychologically, from correctness on more complex tasks (Lohman, 1979a). There may be processing speed or capacity limits, these may differ systematically among individuals (perhaps in association with the perceptual and closure speed abilities mentioned earlier), and such human limits may be important in the real world performance of young adults (as radar or sonar operators, for example). In any event, one general mark of young adult performance in a wide range of cognitive and learning tasks should be speed-accuracy tradeoff. This makes the understanding of skilled performance, and apparent changes in it over the life span, a complex problem.

Perceptual and motor reaction time and their relation to intellectual abilities has received increasing attention in current research. Hunt (1978), as noted above, and Chiang and Atkinson (1976) have studied relations between reaction times taken to represent speed of encoding and other parameters of the visual perception and memory system, and measures of verbal and quantitative ability. Jensen (1980) has shown associations between choice reation time and general intelligence differences. Research on attention in relation to intelligence has been comprehensively reviewed by Cooper (1980), however, with the conclusion that little is known for sure about such individual differences. Carroll (1980) reached a similar conclusion in another review and reanalysis of this literature. Much more work will be needed to establish adequate theories for the tasks used in this field before any such individual or developmental differences can be clearly interpreted.

A host of other perceptual-psychomotor abilities have been identified and classified by Fleishman (1967, 1975), largely using young adult samples. These represent individual differences in various reaction times, precision and coordination of movements, manual and finger dexterity, steadiness, flexibility, strength, body equilibrium, and stamina. These variables have been used in conjunction with cognitive ability measures in the analysis of complex psychomotor skill learning, particularly in military settings. Typically, it is shown that such learning involves a mixture of lower-order with higher-order cognitive functions, at least until overlearning produces a level of skill that appears to be automatic. But some complex psychomotor skills seem not to reach plateaus in young adulthood. Highly practiced psychomotor skills, such as those of the expert cigar maker or concert musician, can continue to improve at high levels throughout adult life, at least up to physiological limits (Fitts, 1964).

Short-term and intermediate memory. Stimulus information is encoded into STM symbolically so that attention can be focussed upon it and further conscious processing can take place. Information obtained from the environment, or retrieved from long-term storage is acted upon here, and recent changes in the environment are noted. STM tends to preserve the temporal order of the incoming stream of symbols but has limited capacity for storing independent symbols. Thus, information is lost if it comes too rapidly, or if some short-term retention operation is not applied. In young adults, on average, normal short term memory span has been found to be 7 ± 2 items (Miller, 1956). Through the pattern recognition, segmentation, and analysis functions of the perceptual system, and through grouping or other

mnemonic strategies applied in STM, information can be "chunked." It is the number of chunks that must be held or worked on in STM at once that is limited. Also in STM, associative mediators and elaborative codings can be applied to aid remembering (Rohwer, 1980). Mental images can be formed for this purpose (Paivio, 1971). Material to be remembered can also be rehearsed (Atkinson & Shiffrin, 1968). Young adults can be trained with practice to use such memory skills as learning aids.
In one report a young adult subject succeeded in extending his immediate memory span to over 70 digits by using an idiosyncratic hierarchical clustering mnemonic (Chase, Ericsson, and Faloon, 1980).

Again, we would expect short-term memory abilities to be at a maximum, on average, among young adults. Memory span is seen to increase during the childhood years (Case, 1978; Pasqual-Leone, 1970), to reach a peak during early adulthood, and to decline thereafter (Botwinick & Storandt, 1974; Craik, 1977). Some argue that these memory span differences reflect developmental changes in STM capacity (e.g., Pasqual-Leone, 1970), while others maintain that capacity remains relatively constant (e.g., Craik, 1977). Flavell (1977) has summarized work showing the development in children of associative, elaborative, and related "metamemory" skills that serve as aids in short-term retention. Research has also shown clearly that apparent memory deficits among the elderly, relative to young adults, can be markedly reduced by strategy training. Older adults and children appear normally to use simpler, more concrete approaches than do young adults. The training effects imply that a strategy difference rather than a deficit interpretation accounts for the superiority of young adults over other age groups. This view is supported also by the fact that recall tasks typically show more substantial age differences than do recognition tasks, and recall seems more likely to be aided by deliberate use of strategies. The dominant view at present seems to be that differences in perception, familiarity of the stimuli, and such mnemonic strategies account for the larger portion of the observed differences in memory span across the life span (Baltes, Reese, & Lipsitt, 1980).

Still, there are marked individual differences in memory span among young adults, and in associative and elaborative memory abilities. These kinds of differences have occasionally been shown to be relevant to real world tasks. For example, note-taking skill in learning from formal lectures may depend in part on memory span, according to studies by Berliner (1971) and DiVesta and Gray (1972). Associative memory ability was found by Dunham and Bunderson (1969) to play a role in concept learning, particularly when students do not have organizational rules or other instructional structures to rely upon. Jensen (1969) distinguished these rote memory abilities, which he called Level I, from the Level II abilities commonly thought of as comprising general scholastic ability or intelligence. A substantial amount of research now suggests that the two are relatively uncorrelated in older children and young adults, and that only Level II abilities seem associated with various racial, ethnic, and socio-economic contrasts (Vernon, in press). The implication is that training and instruction geared to capitalize on Level I abilities would serve the vocational and educational goals of a wider segment of the U.S. young adult population. Of course, such instruction ought not to be designed to the detriment of the development of Level II abilities.

Information that is not in focus but that is relevant to immediate performance is presumed to be stored in an intermediate or working memory. Here, a model of the task, setting, or environment is constructed and updated as changes are noted in STM. Keeping track of one's location in a physical environment, or in a conversation, or in a plan being implemented, are functions of ITM. So too may be some memory functions related to evaluations or predictions in planning and problem-solving. Individuals can even change their models of the environment in "experimental" ways, to imagine alternative consequences of actions or decisions they may take in the future. Much less is known about ITM relative to STM, and there are not comparative statements to be made about young adults or individual differences among them regarding ITM specifically. Some kind of ITM function is clearly needed in theory, however (Bower, 1975), and we can hypothesize that effective use of ITM is particularly characteristic of young adulthood. At least impressionistically, children and elderly persons often seem less aware of surroundings and more likely to lose track of their place or direction in ongoing activities than young adults.

Factor analytic studies of memory abilities have routinely used short duration tasks that do not contrast STM and ITM functions systematically. As with the sensory-perceptual-motor category, a long list of distinguishable memory factors can be constructed. Beyond the memory span and associative-elaborative abilities mentioned above, one can posit separate individual differences representing memory for colors of objects, their forms and positions in space, for verbal vs. figural or auditory vs. visual materials, etc. (see Kelley, 1964; Christal, 1958; Guilford, 1967). It appears that many of these distinctions derive mainly from differences in the kinds of content to be remembered, rather than in the kinds of memory processes involved. Most content distinctions are fairly obvious on the surface and few are likely to have particular connection to young adulthood or to important age differences in general; we need not list all such distinctions here. But there are also implied process differences, in research on both short and long term memory, that may be hypothesized to relate to age and other individual differences in potentially important ways.

Studies using the Sternberg (1969) STM search paradigm, for example, have sought to distinguish serial vs. parallel and exhaustive vs. self terminating processes. When a person searches a list of items stored in memory to find a match with a newly presented item, is the stimulus item compared with each stored item in turn (serial) or with several stored items simultaneously (parallel)? Is the stimulus item compared with all stored items (exhaustive) or is the search process stopped when a match is found (self terminating)? Most evidence supports a serial exhaustive model (S. Sternberg, 1975), but this conclusion is based primarily on young adult performance. One can hypothesize that younger children or older adults might employ a self-terminating search process, perhaps because such individuals would be less concerned with thoroughness. It is even conceivable that older or younger subjects would adopt a parallel processing scheme. The developmental research to date is not sufficient to judge such issues.

Long-term memory and knowledge structure. In LTM, there are other such distinctions, between incidental and intentional learning, episodic and semantic memory, and visual and verbal representation. Each imply processing differences that may to some degree be age- or experience-related. Intentional learning, where the individual is set by instructions or personal choice to use deliberate strategies such as rehearsal or elaboration, is typically superior to a more passive, incidental form of learning (Postman, 1964; Bower, 1975). It may be that incidental learning involves a different, perhaps more iconic or echoic, representation system in LTM (Deese, 1964). It is known that visual and verbal memory representation systems have different qualities (Paivio, 1971; Kosslyn, 1980). Episodic memory is the repository of time-related personal life experiences, while semantic memory is an organization of knowledge about words, meanings, concepts and their interrelations, as well as rules for manipulating such symbols (Tulving, 1972).

It is presumed that information processed through STM is represented in LTM, that this representation is organized to create a web or network of interconnections among related bits of information, and that the organization is maintained to promote appropriate retrieval upon personal or situational demand. Current research seeks to explicate the cognitive functions involved in this process, but there are not yet definitive conclusions.

It can be shown that young adults are, on average, more proficient than other age groups in learning and memory performances that rely on LTM. Among young adults, the evidence might be overwhelming that LTM is organized primarily for storage and retrieval of intentionally learned, semantic, verbal information. Yet the evidence is at present insufficient to judge the importance of incidental learning, episodic memory, or visual representation in young adult performance, or to distinguish age groups in these respects. One can speculate that the primacy of intentional semantic verbal memory is a product of formal schooling, and that young children and older adults routinely make more use of incidental, episodic and/or visual memory in their everyday lives. It may be that young adults use more deliberate memory strategies, as noted earlier. They may exhibit more elaborative propensity in learning than younger persons and, presumably, they also have much larger event-repertoires already stored in LTM on which to draw for elaborations (Rohwer, 1980). Learning for them is very much a constructive, generative process (Wittrock, 1977), relative to learning for children. It may also be that the semantic memory of young adults is geared more to complete and literal recall than that of older persons. There is evidence, for example, that younger adults tend to give verbatim responses while older adults tend to paraphrase in semantic recall tasks (Labouvie-Vief, 1980).

Another potentially important distinction, within the semantic memory category, that has emerged from research with young adults is that between conceptual and procedural knowledge. Both kinds of knowledge are stored and retrieved in an organized way, and the organization is provided by schemata. In Greeno's (1980, p. 718-719) words: "...schemata are data structures or procedures that are used to organize the components of specific experience and to expand the representation of an experience or message to include components that were not specifically contained in the experience, but that are needed to make the representation coherent and complete in some important sense." In the case of conceptual knowledge, the dominant schemata are thought to be semantic networks of interrelated facts and concepts. The individual builds such networks by associative processes and elaborates and reorganizes the structure as experience accumulates (J. Anderson & Bower, 1973; Norman & Rumelhart, 1975). Procedural knowledge, on the other hand, is represented schematically as a structure of production systems -- if-then statements that specify sequences of steps to be taken if and whenever certain environmental conditions hold. Production systems are built up through exercise in performing a series of related tasks or solving example problems that form a class; the productions are generalized to apply to a larger class of tasks or problems, or specialized to a narrower class, based on feedback. (J. Anderson, Kline, & Beasley, 1980).

The distinction is important theoretically because it provides a formal and coordinated way to characterize the difference between "knowing that" and "knowing how", generally. It is important practically because it appears that formal instruction often concentrates on conceptual knowledge while ignoring the development of procedural knowledge (Greeno, 1978). Thus, young adults might be expected to have more elaborate and more similar conceptual structures connected to areas of formal education; they might have had to induce procedural knowledge largely on their own, and may thus show much more idiosyncracy here. In any case, understanding the organization of knowledge in LTM is a key problem for cognitive psychology today. Basic research, as well as the analysis of school learning in these terms, is now proceeding in depth (see, e.g., R. Anderson, Spiro, and Montague, 1978; Greeno, 1980). Most of this work is based on the performance of adolescents and young adults, but without a developmental perspective.

Human beings build up vast structures of particularized knowledge, both conceptual and procedural, during their lifetimes. These include the meanings of thousands of words and phrases, cognitive maps of places and events, knowledge of the properties of the physical and social world, beliefs, values, goals, and plans regarding self and others, and a host of skills and strategies for various kinds of problem-solving. Such knowledge is often partial and incomplete in idiosyncratic ways. And different bodies of partial knowledge can be brought to bear on the same stimuli by different persons or by the same person under different frames of reference (R. Anderson & Freebody, 1979). Thus, individual differences in particularized and partial knowledge extend virtually to infinity. It would be pointless to try to list all the possible categories of these in detail, though later sections of this chapter will summarize evidence bearing on a few of the major categories of such knowledge and skill.

It might be expected also that the period of young adulthood would be marked by a major transition in this acquisition process. Formal schooling has completed its attempt to aculturate the young population. Knowledge thought generally important for all members of society has presumably been imparted, while opportunities for specialization have begun to be explored. There is thus a turning point. Individuals in young adulthood turn increasingly to achievement in particularized domains. The diversification of particularized knowledge in this period is thus tremendous, and probably becomes more so with each passing generation. Schaie (1979), among others, has discussed the developmental implications of increasing environmental complexity from cohort to cohort within young adulthood.

<u>Executive assembly, control, and motivation</u>. Superordinate in the cognitive-learning system are vaguely understood functions that one or another theorist has called the "executive" (Reitman, 1965), or "hidden observer" (Hilgard, 1977), or "metacognition" (Brown, 1978), or "control processes" (Shiffrin & Schneider, 1977), or some such. While little is yet known about these processes, they must be present. Human beings plan and make decisions. They assemble and reassemble performance programs to meet task demands and monitor their functioning. Checking and related self-evaluative activities during ongoing information processing often cause recyclings of performance programs or shifts in strategy. The hallmark of

mature intelligence would appear to be flexible adaptation of such cognitive processing to fit the characteristics of the problem at hand (Snow, 1980a).

Similarly, humans display volition and purposeful striving. They can be playful and creative intellectually. And, they are subject to affective responses that may be produced by and may in turn influence the details of cognitive processing. Motivation is not simply a push at the start. Yet little is known about how motivational events alter the details of ongoing functioning in cognition and learning (Snow, 1980b).

Assessments of cognitive performance on some test or task are never pure measures of primary ability, or primary process. Executive, control, and motivational functions always exert some influence, and comparisons among individuals or age groups will always include these sources of variance. Differences in meta memory strategies, for example, were noted above as one interpretation of observed age variations on STM tasks. It is thus impossible at the present time to disentangle these various sources of individual and group differences in observed data.

Yet, it is possible to extrapolate from current theory, at least in broad strokes, to hypothesize that measures of general intelligence should reflect an increased proportion of variance due to executive-control-motivational sources among young adults, in comparison to children, and that young adulthood particularly should be a time of substantial development in this area. According to Piagetian theory, at the capstone of cognitive development should be the capability for formal, logical reasoning, reached at approximately age 17. But there is evidence that many high school graduates do not display the quality of reasoning on Piagetian tasks that would demonstrate the attainment of formal operational thought (Flavell, 1977). Furthermore, there is reason to believe that young adult intelligence does not stop developing at Piaget's last plateau. Riegel (1976) has hypothesized a dialetical process whereby the young adult continues to change cognitively by facing the continuous disequilibria of everyday life. Arlin (1975) regards this fifth Piagetian stage as the development of "problem-finding," in contrast to "problem-solving," ability. Flavell (1970) also noted that young adult development is driven more by experiential changes, as opposed to the maturational changes more obvious through childhood. These involve primarily changes in judgments, attitudes, and beliefs, the individual's implicit theories of self, others, and the world as a whole. Presumably also, as noted above, the tremendous increase and diversification of semantic conceptual knowledge up to young adulthood has its counterpart in the growth of executive, procedural knowledge that is also heavily particularized by these experiential variations.

Schaie (1977/78, 1979) has gone on to posit several broad stages of cognitive development through adulthood. These are thought to arise as a result of changes in environmental demands during different stages of adult life, rather than of changes in the physiological substructure that is assumed in theories of child development. He regards childhood and adolescence as a stage of <u>acquisition</u> of skills and abilities, and considers most traditional work on intellectual development to be confined to this period. Young adulthood brings on a stage of <u>achieving</u>, in which continued development occurs in those intellectual skills and abilities that now must be creatively applied to real world problems. In the age range from

30 to 60 come two parallel stages; a responsible stage, where integration of skills is required to meet the demands of increasingly complex environments, and, at least for some, an executive stage, in which complex problem solving is extended beyond the responsibilities of primary job and family. A reintegrative stage then reflects the character of old age, for Schaie.

The combination of all these views, then, suggests that young adulthood is characterized by at least two broad cognitive-learning phenomena: 1) the application, specilization, and continued development of previously acquired abilities in real world decision-making, problem-finding, and problem-solving; 2) the integration and extension of this ability organization to meet larger personal responsibilities and goals, and their related complexities, in later adulthood. Both trends imply the central involvement of executive-control-motivation functions.

Perspective: learning, development, and the construction of cognitive competence. Reference to learning in the above discussion has been infrequent and indirect, because little needs to be said here about learning traditionally defined. Where traditional learning theory and research concentrated on performance in simple, short, and largely meaningless laboratory tasks, it engaged rather little of the cognitive-learning system as depicted here. Modern cognitive theory has concentrated instead on the characteristics of human information processing in problem-solving, both fast and slow and both simple and complex. As a result, theory construction has now progressed to the point where complex learning and developmental phenomena can be addressed anew in a substantially more powerful way. The theories of knowledge organization in LTM, noted earlier, are theories of complex learning and development, and they apply rather directly to the analysis of the kinds of cognitive-learning phenomena found in real life situations, such as formal learning tasks (J. Anderson, 1980; Greeno, 1980). Ability development, also, can be understood in these terms. The formative hypotheses of Ferguson (1954, 1956), that abilities develop as transfer relations connecting learning experience on similar tasks, and of Hunt (1961), that intelligence improves through the formation and mobilization of information processing strategies, can now be expressed in operational computer analogies. And, potentially, the traditional taxonomy of human learning (e.g. Gagne, 1970) can be integrated with the new taxonomy of information processing (Gagne & White, 1978; Snow, 1978).

A related trend in this section is apparent in the fact that many sources of individual differences can be distinguished as special dimensions or skills in the sensory-perceptual-motor and STM categories, while discussion of LTM and executive-control-motivation functions refer increasingly to the more molar constructs of ability and intelligence. Although the details of individual differences in these latter categories are acknowledged to be vast, coherent organizations of these appear to justify defining a few more general constructs. It is as if coherent higher-order cognitive organizations are constructed in the developing system from components separable at a lower level. The ability constructs discussed in the next section of this chapter can be viewed in this way, as products of a process of cognitive construction shaped by the nature of schooling and related learning experience in western industrialized culture.

Simon (1976, p. 96) conjectured that intelligence may be "...the efficacy of the learning programs that assemble the performance programs", and such an assembly function was noted earlier as part of the executive in the cognitive system. Learning, in this sense is cognitive system adaptation. Certainly, "learning ability" and "adaptation of performance to circumstances" have been central defining characteristics of intelligence throughout the history of research on that construct (see Snow, 1978, for a compilation of definitions). New work on intelligence and learning is elaborating this theme; intelligence is taken to mean both the ability to use knowledge and skill components already developed in the cognitive system (that is, already learned) and the ability to learn new knowledge and skill from incomplete experience, including new experience in any environment, not just in formal training or instructional settings. Crystallized intelligence refers to the organization and specialized application of familiar prior constructions. Fluid intelligence would appear to be the flexible, adaptive facility to construct new component organizations to meet those demands of adult life that have not been formally or fully anticipated in prior constructions provided by schooling and acculturation (Snow, in press).

There are thus clearly reciprocal relations between cognitive and learning aspects of the system. In Piagetian terms, individual cognitive development involves both "assimilation" and "accomodation." In information processing psychology, the terms of choice are "accretion", "restructuring," and "fine tuning" (Rumelhart & Norman, 1976). The acquisitions of intelligence through the years of childhood and adolescence, in any event, may further be seen as a preparation for coping with the general or special, familiar or novel, problems of later years. Executive-control-motivation functions may be, to a significant extent, emergent properties of such organization for young adulthood. This is not to say that there are not such functions evident in the cognitive performance of children. It is rather to hypothesize that, in late adolescence and young adulthood, a major expansion in this realm, or perhaps an extension of it to plans, goals, and values covering larger life segments, takes place. Young adulthood seems to involve both the generalization and specialization of the acquisitions of youth and preparation of the cognitive-learning system for something like Schaie's (1979) "executive" and "responsibility" stages of later adulthood.

Cognitive abilities and achievements

With a theoretical framework of the sort proposed, we can now examine several other sources of empirical evidence that add further description of the cognitive-learning characteristics of young adults.

Many kinds of individual differences in mental abilities and skills among young adults were noted above. Some of these differences appear to be more general abilities involved in many kinds of cognitive performance. Others appear to be special skills developed and applicable in more narowly defined situations. Also, some appear to be directly produced by learning in school; others are not the focus of formal instruction. At any rate, by high school age and beyond, most of the major known dimensions of ability and achievement are clearly separable.

Ability organization. The major ability constructs can be identified in the correlational patterns obtained when large collections of mental ability tests are administered to samples of young adults. Both general and special ability components can also be found in any test matrix. Factor analyses of such matrices, from the early studies of Spearman (1927) through Thurstone (1938), Vernon (1950), Guilford (1967), to the current work of Horn (1976, 1978), can be shown to support a hierarchical model of ability organization. Figure 2 gives a schematic view of this sort of organizational model, showing the major distinctions among cognitive abilities as well as several levels of generality. General mental ability or intelligence appears at the top, most general, level. This construct can be broken down to distinguish crystallized ability, fluid-analytic ability, and visualization ability. These in turn divide into more specialized verbal, quantitative, and spatial, perceptual and memory abilities. At the lowest level, many kinds of specific skills and concepts can be identified. The question marks and dashed boxes in the figure are intended to suggest that less is known about the fluid-analytic and spatial visualization side of intellect. Current research (e.g. Lohman, 1979ab)

Figure 2 Here

suggests that there may be several specific spatial abilities, that these do not tie neatly into a gross picture such as Figure 2, and that there may be subtle connections, including strategic tradeoffs within individuals, between verbal, analytic, and spatial information processing abilities. As Humphreys (1962) once suggested, the simple hierarchy may be a useful taxonomy, even though it is too simple a view of ability organization. It appears consistent with the results of most large correlational studies conducted with young adults and is thus a fitting starting point from which to ask questions about prior and continuing developmental trends. Provisionally, young adult abilities can be thought of as performance programs, developed through prior learning and exercise, and stored in LTM or assembled therefrom under the control of executive adaptation to situational demand.

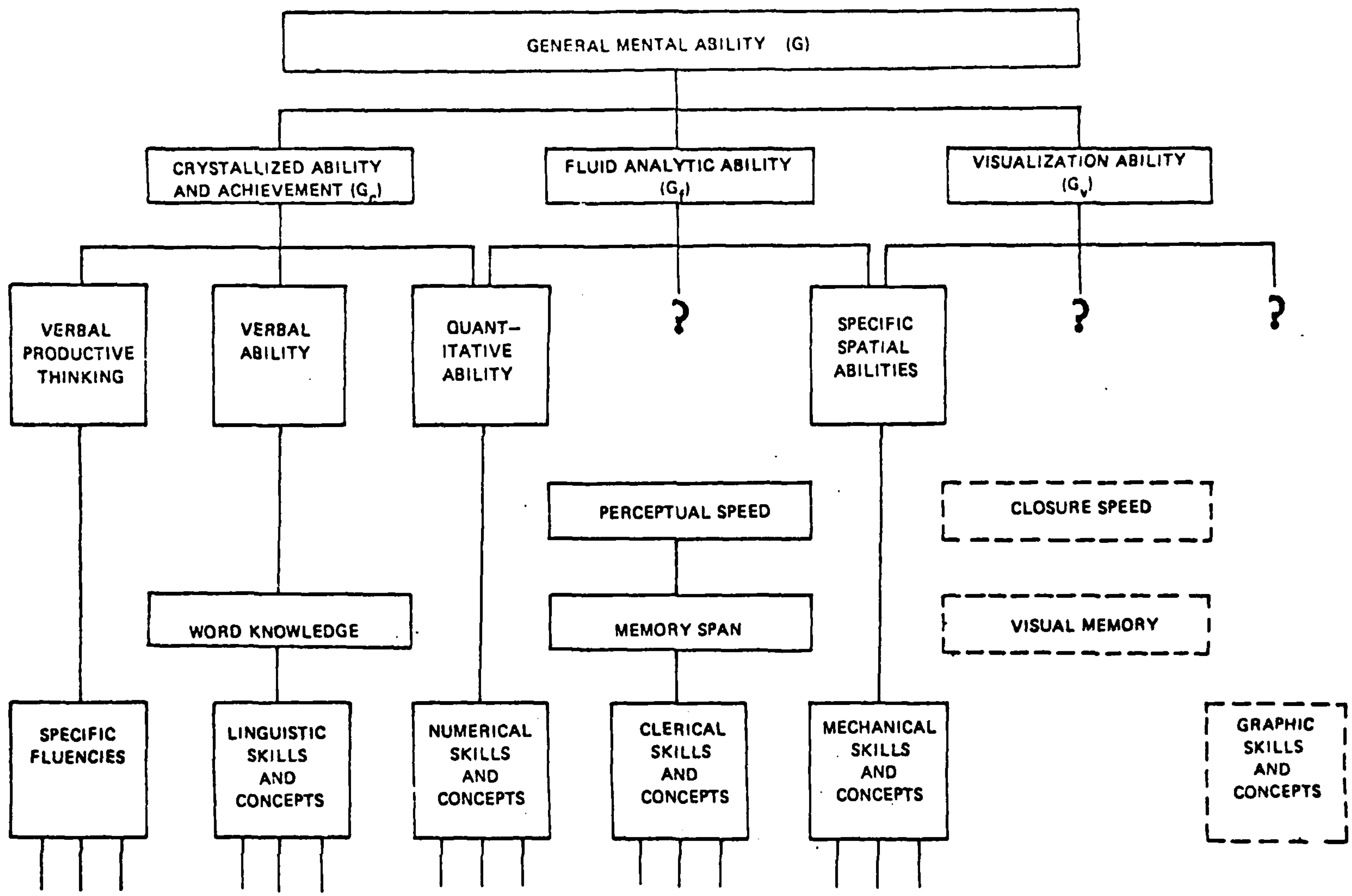

Figure 2. A hierarchy of mental abilities (after Snow, 1978a).

Achievement through the school years. The area of crystallized ability and achievement in Figure 2 is usually assumed to be most centrally involved in and developed by formal education. While there is continuing debate about the distinction between "aptitude" and "achievement" in this connection (Green, 1974), no sharp separation is assumed here. Standardized achievement tests and verbal and quantitative ability tests correlate rather highly, and it seems useful to try to distinguish "ability" from conceptual and procedural knowledge only at very specific levels of the hierarchical model.

Before examining the cognitive achievements of young adults at high school graduation and beyond, it is important to trace briefly some of the features of such characteristics as they emerge through the primary and secondary school years. Education is a cumulative process. Cognitive attainments build on prior attainments, and individual differences noted among students of a given age appear not only to be perpetuated in later years but to expand. That is, while some students master the skills or achievements that others have attained earlier, the latter have gone on to elaborate and extend these accomplishments, and to integrate them into higher-order cognitive skills. Unfortunately, some students never fully acquire some of the skills prerequisite to advanced development.

Thus, individual differences in achievement within grades overshadow differences between grades throughout the school years, but particularly through high school. Standardized achievement tests consistently reveal this pattern. The variance of such scores increases at each age level from kindergarten through high school. Item characteristic curves flatten as grade in school becomes an increasingly poorer predictor of achievement with advancing age. Those who do not master the basic skills in an area fall further behind, while those who do achieve well get compound interest.

As an example, Figure 3 shows the percent of students at each grade who correctly answered four items selected from each of the four difficulty levels of the 1970 California Achievement Test (Tiegs and Clark, 1974).

Figure 3 here

Items from other achievement tests would yield similar results. The plots are seen to be steepest at the lower grades, indicating substantial age-grade differences, relative to individual differences within grade. Shallower slopes for the higher grades reveal that items become poorer discriminators between grade levels, as grade level advances. Further, the percent passing some items actually decreases between grade at the high school level, even though most items that would show this decline are ordinarily eliminated from the tests during the standardization procedure. Items that show such declines usually require the application of basic skills taught in the lower grades that are not taught or reviewed at the high school level (Tiegs and Clark, 1974). Items that depend on basic skills taught at the grade school level generally fail to discriminate among different grades of high school students, even though the percent passing remains well below the ceiling. Instead, items that discriminate between high school grades involve increased complexity or specialized knowledge not introduced at earlier grades. In short, basic skills do not show much improvement after junior high school; some even show decline over the high school years.

The Project Talent study provides another example of these trends at the high school level. Although means increased consistently for almost all of the 81 Project Talent ability and achievement variables from grade 9 through grade 12,

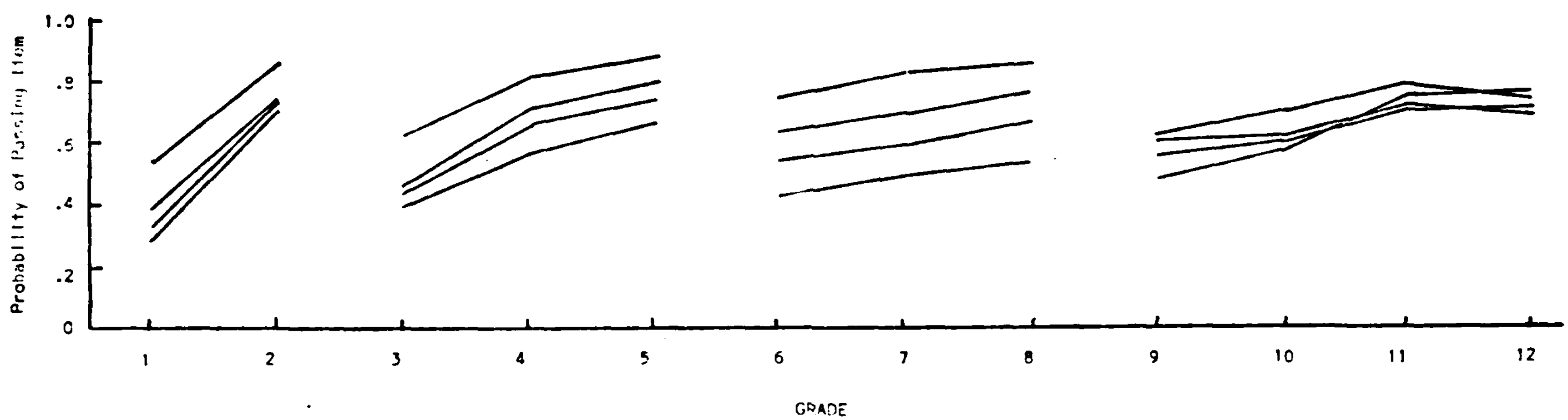

Figure 3. Probability of passing four representative reading subtest items from each of four levels of the 1970 California Achievement Tests for students in grades 1 through 12 (after Tiegs & Clark, 1974)

differences between grades were "...all slight in comparison with differences in ability within a grade." (Flanagan, et al., 1964, p. 3-2). Similarly, Learned and Wood (1938) in a massive study of academic achievement of Pennsylvania high school seniors and college students found that ten percent of the college seniors scored below the mean of high school seniors on a broad test of academic achievement, despite the fact that less than one in ten high school students went on to college in 1928 when the testing was conducted (Pace, 1979). To our knowledge there is not a comparable modern study of young adults.

Thus, differences between individuals both at entry to high school and at graduation overwhelm differences between grades within a high school, and also differences between high schools. Some educational researchers have been puzzled by the consistent failure to find significant school effects on student achievement. When student differences in scholastic aptitude and socioeconomic status are controlled, differences between schools in average achievement are found to be miniscule (Coleman, et al., 1966; Jencks, et al., 1972; Bachman & O'Malley, 1980; Averch, et al., 1974). Bachman and O'Malley (1980) summarize the results of their ten year longitudinal study of a representative sample of over 2000 U.S. public high school males in the following way:

> What sets the present study apart from earlier work is that this failure to find differential high school effects is not limited to the more typical dimensions of test scores, or educational and occupational aspirations and attainment. On the contrary, our inability to find important differential school effects extends across a broad array of criterion dimensions--especially those noncognitive dimensions which have sometimes been seen as the more promising

domains for discovering school effects. Moreover, our search for school effects involved a relatively exhaustive set of school measures. Some 1600 descriptors of schools--many of them aggregated from data provided by 20 or 30 teachers and/or students within each school--were explored, refined, and consolidated in an effort to find those sets of school characteristics which would show a differential impact on students.

Among the statistical complexities and substantive hypotheses advanced to explain this failure to find effects for school quality are the possibility that schools do not vary systematically in achievement production (Bachman & O'Malley, 1980), or that classes within schools vary more than do schools (Coleman, et al., 1966), or that "nonschool" factors are overwhelmingly important (Averch et al., 1974). Of the so-called "non school" factors, student ability and prior achievement are by far the best predictors of achievement at graduation. It has also been shown that such student aptitudes interact with alternative instructional methods, and may interact with class, teacher, and school variables as well (see Cronbach & Snow, 1977; Cronbach, 1976). Unfortunately, student aptitudes have not yet been analyzed sufficiently from the perspective of cognitive-developmental psychology to produce a useful theory of aptitude development in relation to schooling. We can at best, at present, use the cognitive aptitude constructs that have been produced to date to describe at least a portion of the cognitive variations that exist between and within age cohorts.

Ability development and differentiation. General intelligence, interpreted here loosely as reflecting the efficiency of the cognition-learning system *in toto*, has been the cognitive characteristic most studied by developmental psychologists, and an average curve showing the growth of general intelligence through young adulthood can be traced from both longitudinal and cross-sectional studies. Most intelligence test data show continued increases in average score in the age range from age 17 to the early 20's, a more or less steady state to age 30, and the beginnings of decline after age 40. (Anastasi, 1968, p. 277; Doppelt and Wallace, 1955). But such changes parallel differences in education, over this age range or, cross-sectionally, among cohorts born in different eras. This makes as strong a case for the effects of education as it does for the effects of age. Results from cross-cultural studies argue strongly that developmental studies of such curves reflect the effects of culture-bound education rather than the operation of culture-free developmental laws (Sharp, Cole, & Lave, 1979). Also, the methodological problems involved in assessing alleged intellectual growth and decline are substantial (Baltes & Willis, 1979).

As noted in the first section of this chapter, the educational experiences of young adults become more diversified, idisyncratic, and self-controlled, after the massive formally controlled educational treatment of the public school years. Whether significant restructurings occur in the young adult cognitive system, as perhaps in consort with newly emerging executive or motivational functions, or whether such changes mainly involve the specialization and fine tuning of conceptual and procedural structures already present, probably depends on the individual's unique experiences as well as those common to an era. At any rate, the decreased importance of chronological age as an organizer of developmental change becomes most apparent during the young adult years. Age and years of education become uncoupled as compulsory school attendance ends. The physical and maturational bases that may underly intellectual growth have reached a plateau. Personal choices and other non-normative life events have become more important than chronological age in determining the subsequent course of development.

The apparent life-span curve for general intelligence is also undone when different kinds of cognitive ability are distinguished. Cattell and Horn (see, e.g., Cattell, 1971; Horn, 1976, 1978) developed the distinction between fluid-analytic intelligence (Gf) and crystallized intelligence (Gc), noted earlier in Figure 2, and have studied it across the age range. Gf is regarded as the more native, earlier developing intelligence represented by abstract and often nonverbal reasoning tasks that require flexible, adaptive problem solving. This kind of ability is thought to peak at about age 17 and to decline thereafter, particularly as advanced ages are reached. According to the Cattell-Horn theory, Gf is invested in learning through the school years to produce Gc, which is the kind of ability required by most verbal, knowledge, and school achievement tests. After reaching a somewhat later peak, at age 20 or thereafter, Gc is thought not to decline appreciably with age. During the young adult years, one might hypothesize some slight changes in Gf -- continued development, if Gf is thought of as including the ability to find novel problems to solve, or the beginnings of decline, if Gf reflects the biological integrity of the cognitive-learning system as the Cattell-Horn theory argues.

But the most dramatic changes over the young adult years would seem to be found in the continued development and elaboration of Gc skills and achievements. Those who continue their education or training after high school show continued improvements. Those who do not enroll in further academic studies or vocational training in the post high school years fall slightly behind high school seniors in academic problem solving. These persons may, however, show advantages relative to high school seniors on the kinds of problems more likely to be encountered in everyday life, such as calculating finance charges (National Assessment of Educational Progress, 1976). Except for those who continue their education through college, the Gc skills that improve most during the post high school years appear to be largely job related. However, existing surveys have tended to emphasize academic achievements, slighting other kinds of special skills and knowledge. Hence, we have little data on the continued elaboration of crystallized intelligence through young adulthood. Yet it is precisely in this age range where the talent specilizations to be used throughout later life are most likely to be crystallized. Those who will be successful in business, the sciences, arts, professions, the military, etc. probably lay their most important cognitive foundations in this period; many may do some of their most industrious and creative cognitive work here as well. Again, advances in the executive-control-motivation functions may loom large in this picture.

If one moves still further down in the hierarchical organization of abilities, beneath the Gf-Gc-Gv distinction to constructs representing Thurstone's primary mental abilities, other developmental trends emerge. Schaie (1979) and his coworkers have used such dimensions in studies of adult decline to suggest that reliable decrement cannot be demonstrated for many abilities and many individuals until very old age; those abilities that do show earlier decrements seem to reflect speed of responding, and those decrements that appear more general occur in individuals with more significant health impairments. Schaie's data suggest that cohort differences account for most cross-sectional age differences reported in earlier research, and emphasize again the tremendous individual differences observable within age-groups at almost any age. For another view of these data, see Horn and Donaldson (1976).

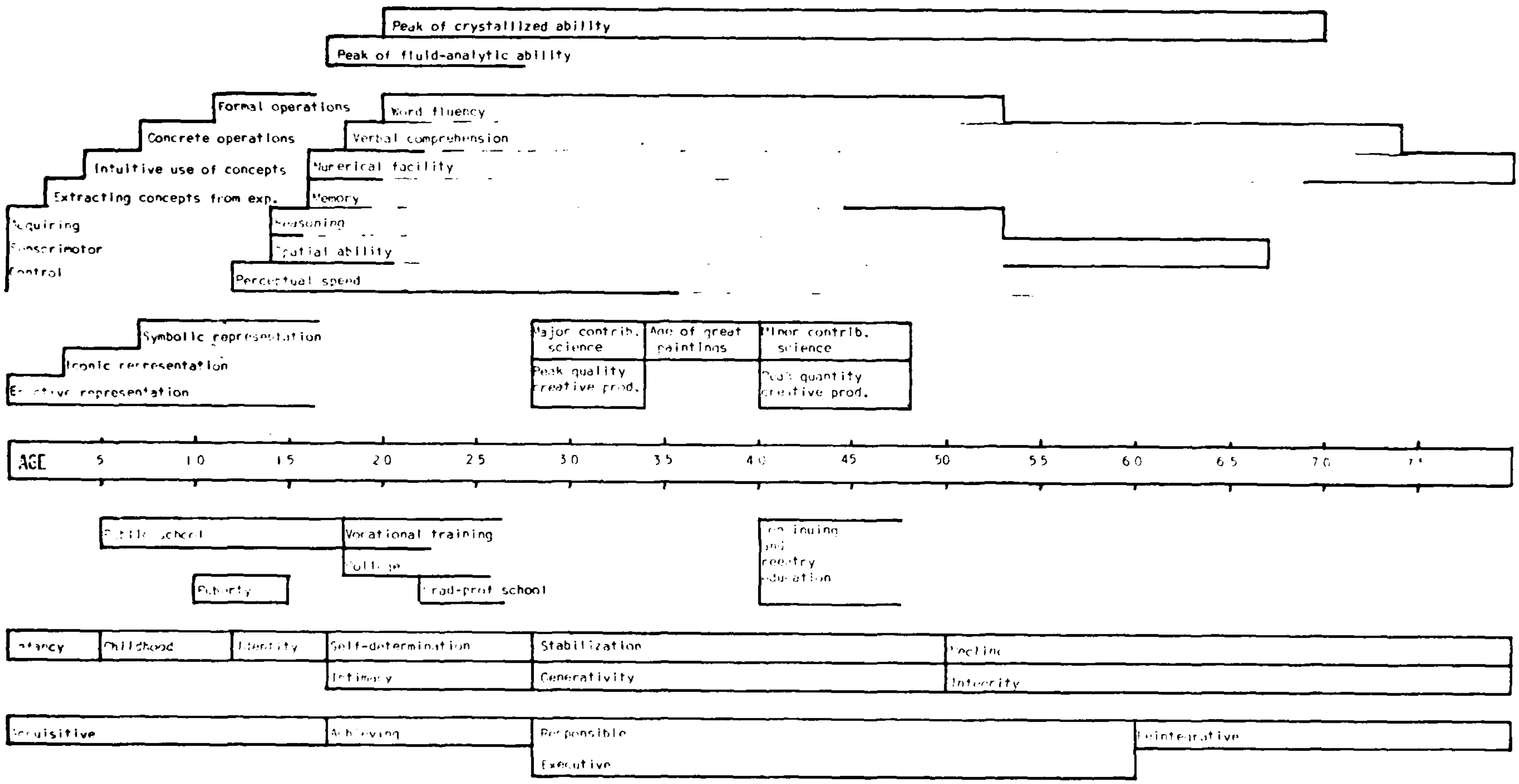

Figure 4. Selected points and stages of significance in life-span cognitive development.

and adolescence. This has been viewed by some as due to maturational unfolding and differentiation of the nervous system (Garrett, 1946) and by others as the result of learning and transfer relations among cognitive tasks (Ferguson, 1954; 1956). The latter hypothesis comes closer to current views. But research has not progressed to the point where the sources and forms of this ability differentiation have been clearly established, and there are contrary views (see, e.g., Guilford, 1967).

As one breaks down the general ability constructs to examine more specialized kinds of ability, then, different patterns of growth and decline are seen for different ability dimensions. Those appearing and declining earlier in life seem closer to fluid analytic and speeded performance abilities; those appearing and declining later seem more associated with crystallized verbal-educational abilities.

One can think of the causal and/or developmental flow as running either up or down in the hierarchical model, though it is typically thought of as flowing down. Thus from top to bottom, in Figure 2 or from left to right in Figure 4, the hypothesized differentiation and development of multiple, increasingly specialized abilities from childhood through young adulthood is depicted. As the environments in which young adults learn and perform become increasingly differentiated after high school, more specialized levels of ability continue to differentiate. And, as chosen occupational activities come to the center of attention for particular individuals, the special abilities involved in these activities probably continue to develop while those not exercised on the job, or in hobbies, or other leisure activities, may reach plateaus or decline. It is not surprising that verbal ability does not decline, and may even continue to rise in adulthood; people continue to read, learn, and use words in meaningful sentences throughout their lives, whatever other abilities they may or may not exercise, and higher education and professional jobs for an increasing proportion of the population assures this; the exercise of higher-order cognitive functions should be expected to maintain and extend such functions.

On the other hand, one can think of some more general abilities being formed as a kind of coagulation of positive transfer relations among specific skills as they are learned and exercised together. Crystallized ability is regarded as the generalized product of combined achievement in formal school learning. It is developed ability to profit from continued instruction in the formal educational medium, i.e., scholastic aptitude, and becomes thus the best predictor of success in college. At any rate, by high school and college age it is evident that the full spectrum of adult mental abilities has appeared. Special abilities show some continued increases in the early young adult years (Cronbach, 1970, p. 230). And, apparent losses in some special abilities during later life may well be due to changes in quickness, or motivation, or speed-accuracy tradeoff, since the tests that show decline are typically speeded. Again, speed performance is not psychologically equivalent to power performance (Lohman, 1979b), so it is not clear that "ability" declines in any substantive sense.

As a speculation on developmental trends through the history of cognitive differential psychology, note the generational specificity that appears to be correlated with the results of different investigators. Spearman's (1923) data were collected on school children during the early 1900's and showed a strong general intelligence factor, Thurstone's (1938; 1941) data were collected in the 1930's on high school and college students to demonstrate from seven to ten primary ability factors, while Guilford's

(1967) data came initially from college students and military personnel during and following World War II to justify his Structure of Intellect model, positing 120 separate special abilities. While many methodological as well as substantive differences confound this contrast, it is intriguing to think that part of the difference in results among these research programs is due to the differentiation of mental abilities over both age and era.

The special case of scholastic aptitude. It was noted above that verbal and quantitative abilities and generalized school achievement can be taken together to form what is usually called scholastic aptitude, or crystallized intelligence. Regardless of one's view of the degree to which general or fluid intelligence is influenced by school experience, these crystallized abilities are usually regarded as rather directly influenced by schooling; they represent the development and generalization of aptitude for further, higher scholastic work (Snow, 1980c).

Measures of scholastic aptitude taken in high school, such as SAT and ACT, show substantial correlation with college freshman achievement (Lennings, 1975; Lavin, 1965) and are thus used as selection devices for college entrance. The predictive validity of these instruments has not changed much over the decades and does not vary appreciably by gender, ethnic group, or other such breakdowns of the young adult population.

On average, however, there has been a marked decline in scholastic aptitude scores over the past decade. Figure 5 shows the decline of average SAT scores by year as one example. Military studies also show substantially lower scholastic aptitude scores, on average, for entering recruits today as compared to a decade ago. Thus, relative to older generations and to earlier eras, today's young adult population displays a distinctly lower level of scholastic aptitude at high school graduation.

As noted in Figure 5, young adults who were age 17-18 in 1980 scored lower on average (then) than did those of age 27-28 in 1980 when they took the SAT at age 17-18. Thus, in the one decade or so age span of the current generation of young adults, the youngest are on average more than .4 standard deviation units lower in verbal aptitude, and almost .3 standard deviation units lower in quantitative aptitude, than the oldest. And the entire generation averaged lower scores than the previous generation of young adults, because the decline actually began in the early 1960's.

Figure 5 here

Public and academic concern about the implications of this trend has been considerable in recent years. The decline has been interpreted as reflecting reduced verbal and quantitative ability of young adults today, resulting from the failure of the U.S. educational system through the 1960's and 70's. An independent national commission studying the trend and associated data (Wirtz & Howe, 1977) has attributed the decline to two major kinds of influences. First, with the expansion of college opportunities in the past two decades, particularly for members of ethnic minorities, many more high school students have considered college and thus elected to try college entrance examinations. With an increasingly heterogeneous population of examinees, the average scores were likely to show decline. This is a shift in test population over years, rather than a decline across comparable generations. On top of this trend, however, a second influence has been exerted by a combination of social and educational factors, including the effects of television, diversification of elective high school course

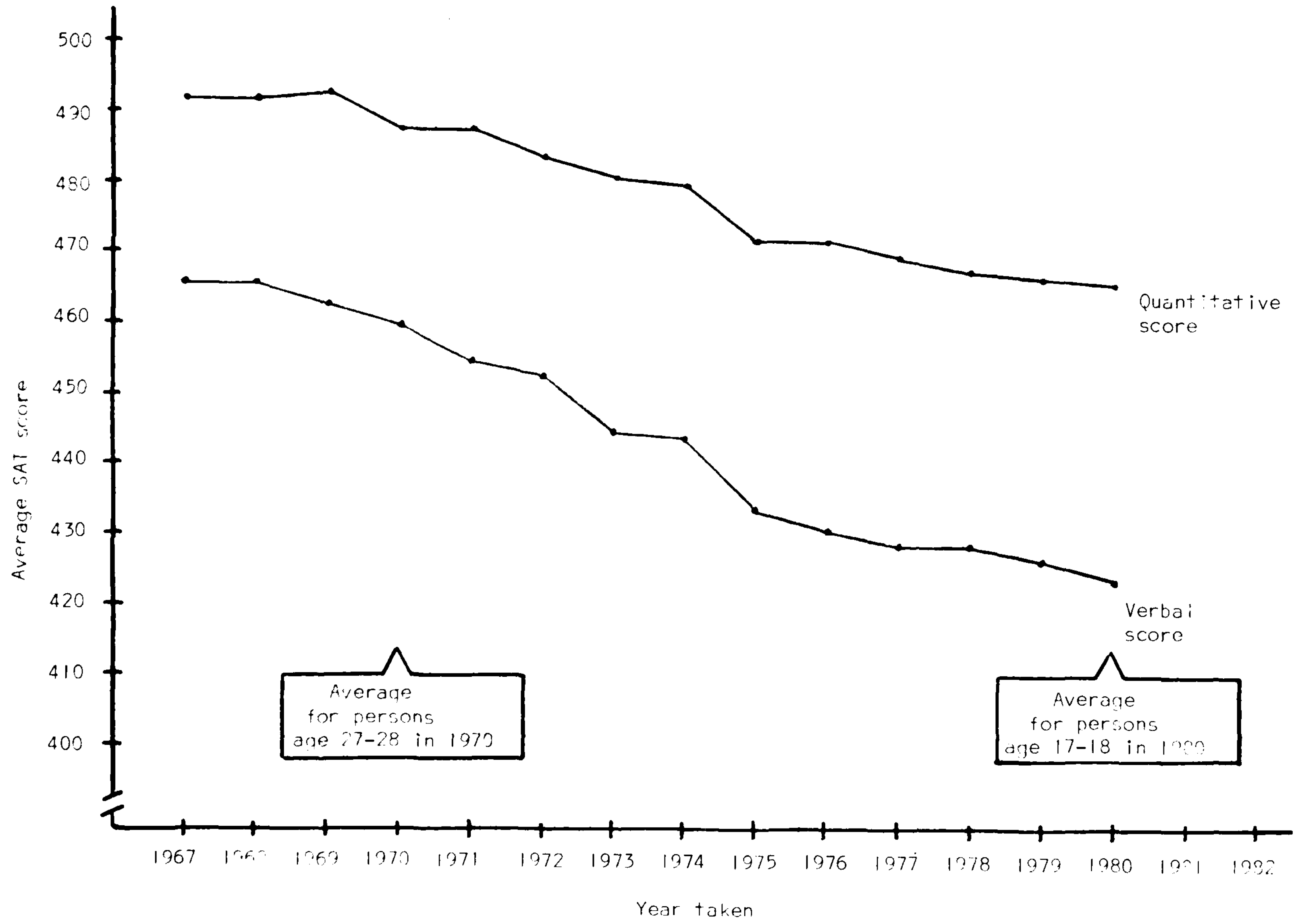

Fig 5. Average SAT score declines by year test taken

work coupled with a reduction in required courses, decline in the perceived value of education in the malais of the Vietnam-Watergate era, etc. In 1970, for example, it was estimated that children then watched an average of 5,000 to 8,000 hours of television before reaching kindergarten (Winn, 1977). One can guess that television viewing has remained substantial in this and younger cohorts in the vening years, competing for time and attention with home study, leisure reading, and other educational activities.

Componential analysis of abilities. In recent years, a marked increase in research aimed at analyzing the components of cognitive abilities has appeared. The hope is that all of the major ability constructs, and the hierarchical relations between them, can be represented by a configuration of information processing models of cognitive performance tasks. Such models would show how component functions of the cognitive-learning system, such as stimulus encoding into STM, retrieval from LTM, matching of stimulus features, checking, etc., are assembled and controlled in ongoing cognitive performance. A process theory of young adult cognitive ability, to supplement the factor theory of Figure 2, would then be in hand. This work cannot be reviewed here (see Sternberg & Detterman, 1979; Snow, Federico, & Montague, 1980). But some studies have included developmental contrasts involving young adults. As with much other developmental research, young adult samples seem to be included mainly to provide a standard against which to interpret the performance of younger or older age groups; the findings do not integrate neatly to yield a substantive picture of young adult ability. Still, a representative sample from this literature can be noted here to indicate the direction of current work.

Sternberg's (1977, 1979a) componential theory of reasoning ability has been studied across subject groups ranging in age up to 19. The theory distinguishes such components as stimulus encoding, inference, mapping, application, and response in various inductive and deductive reasoning tasks. In general, all components are found in performance at all ages, component latencies decrease, overall correctness increases, and strategies appear to become more consistent with age. But there are some inversions and special effects that imply characteristics of young adult performance that differ from those of childhood. Sternberg and Rifkin (1978), for example, found that latency for stimulus encoding decreased with age in childhood but then increased again between ages 12 and 19. The authors suggested that older, more able reasoners come to adopt a strategy wherein more time is invested in thorough stimulus encoding of the problem, so that less time is needed in subsequent cognitive operations involved in reasoning and problem solving. Studies of mathematical problem solving point to a similar conclusion: good problem solvers spend much more time than poor problem solvers comprehending the problem, constructing the "problem space", and planning their solution strategy (Heller & Greeno, 1979).

With verbal analogies, Sternberg and Nigro (1979) have identified an extra process component, word association, in young children's performance that was not identifiable in young adult reasoning. Also, the tendency to process analogies exhaustively increased with age. In linear syllogistic reasoning, there seem not to be strategy changes with age (Sternberg, 1979b).

Sternberg (1978) has also applied a componential approach to study developmental trends in the comprehension of logical connectives, a requirement for adult formal reasoning. Comprehension of most kinds of connectives increased with age, but at quite different rates. Thus, understanding of the connective "or", for example, was found to be still developing through high school and college, and the connective "if and only if" was wrongly interpreted by many college students; the proportion using one form of incorrect interpretation (the conditional rather than the biconditional) actually appeared to increase with age. A study of conditional reasoning by Wildman and Fletcher (1977) gave related results. Though performance was seen to increase on some forms of formal reasoning from grade-school age to college age, performance of college sophomores was still mediocre. Error analyses revealed that many young adults confuse conditional "if-then" reasoning with biconditional "if and only if" reasoning.

Performance on tasks reflecting perceptual speed ability have also been analyzed componentially (see, e.g. Royer, 1971), but without concerted efforts to trace developmental trends. In one study that attempted this, Storandt (1976) was able to distinguish speed and coding components in performance on the Wechsler digit-symbol test, a measure of perceptual speed ability. Both components were shown to decline between young adulthood and old age.

In studies that may also relate to the developmental identification of sensory-perceptual-motor components, Mackworth and Bruner (1970) have shown that young adults are more consistent than children in visual scanning of photographic stimuli. Eye fixation patterns showed more adequate coverage of stimuli and long leaping movements to relate important but separated areas of displays for young adults in contrast to children. Also, Goldstein (1975) has compared subjects ranging in age from 3 to 20 on a task requiring inverted photographic recognition of friends' familiar faces. Performance improved with age up to about age 14 but deteriorated thereafter, up to young adulthood.

The relatively poor performance after adolescence is attributed to perceptual rigidity due to overlearning of the noninverted facial configuration.

A study of mental rotation as a component of spatial ability was contributed by Gaylord and Marsh (1975). They compared young adult and elderly males on a spatial rotation task. Processing time for mental rotation increased with age as did time for other components such as stimulus encoding.

In the domain of STM, developmental research that includes young adults has concentrated on aspects of recognition memory, paired-associate learning, and memory span. Blake and Vingilis (1977) used a successive tachistoscopic recognition task to suggest that improvement in performance with age up to young adulthood is due primarily to age differences in encoding processes and possibly also in STM storage, but not to reported interference or retrieval strategies. Bisanz, Pellegrino, Kail, and Siegel (1978) compared 8, 11, and 20 year olds to examine an acoustic-to-semantic encoding shift hypothesis in recognition memory. Recognition accuracy correlated with age when encoding was biased toward semantic encoding, and not when encoding was biased toward acoustic encoding. Kausler and Kleim (1978) used a recognition learning task to show that young adults paid less attention to irrelevant features of stimulus during learning but also recognized more wrong words on a memory test, than did elderly adults. Witte (1975) has reviewed the literature on paired associate learning among young and elderly adults to show that young adult superiority is especially marked with relatively short anticipation intervals.

Regarding memory span, Taub (1973, 1977) has compared young adult and elderly females on digit and letter sequence memory span tasks. Subjects of all ages appear to improve with practice, but with older subjects, level of performance seems especially dependent on initial memory span ability. Results also suggest that young adults are better able to maintain sequential ordering information in memory than are older persons when the number of items to be remembered equals or exceeds maximum memory span.

Aspects of long-term memory are also now being studied. Saltz, Dunin-Markiewicz and Rourke (1976) demonstrated that the semantic structure of natural language concepts differentiates with age up to young adulthood, using a semantic differential instrument. Factor analysis showed only one general factor in young children's responses but up to five separable dimensions among college students. Stones (1978) also compared young adult and middle-aged subjects to suggest differences in the structure of semantic memory associated with age. Young adults showed less intraindividual variability and higher relations among vocabulary and word fluency tasks, relative to older subjects. Hultsch, Nesselroade, and Clemons (1976) studied young adult women and four older age groups on free recall learning and its relation to other cognitive abilities. It was found that learning performance was better predicted by verbal fluency ability for younger women but by memory ability among older women. In the same age groups, Hultsch (1974) has also studied learning-to-learn and transfer phenomena in free recall. He suggests that as chronological age increases beyond young adulthood a shift from positive transfer among tasks at all stages of learning to negative transfer in early and positive transfer in late stages of learning takes place. His data also support the possibility that cognitive organization of information to be learned underlies learning-to-learn and is more pronounced among young adults than among older groups.

In other isolated studies in the LTM category, Nolan, Havemeyer and Vic (1978) compared young adult women with older women on immediate or delayed free recall of historical prose passages. Young adults were better on immediate recall but not on delayed recall. No facilitation of learning or recall resulted from the older women having lived through the historical period described in the passages. And Yussen and Paquette (1978) have demonstrated that adolescents and young adults of age 15-22 possess an awareness of constructive interference in their own memory for sentences, while younger subjects do not. They know, in other words, that distinguishing old and new sentences will be more difficult in a list of related sentences to be rembered than in a list of unrelated sentences.

Finally, imagery has been studied as a strategic aspect of memory. Kosslyn (1976) examined the use of imagery in retrieval from LTM among children and young adults in a task involving speed at judging the possession of different characteristics by various animals. When instructed to use imagery in making such judgments children and adults did not differ appreciably. When not asked to use imagery, however, adult judgments were much faster than childrens', and some children reported preferential use of imagery in this condition. The implication is that young adults have largely shifted to a non-imagery retrieval scheme. Whitbourne and Slevin (1978) also found young adults recalling more words than elderly adults from sentences varying in imagery potential. In this study, elderly subjects seemed to use less imagery than young adults but did vary verbal mediational strategies between concrete and abstract sentences.

Specific Products of High School

Several large-scale studies can be combined to yield some further specification of what young adults know and can do. However, virtually all of the relevant studies are surveys employing cross sectional designs. Comparisons of the 1960 Project Talent data (Flanagan, Davis, Dailey, Shaycoft, Orr, Goldberg, & Neyman, 1964) and the 1969 National Assessment of Educational Progress (e.g., National Assessment of Educational Progress, 1970) or the 1969 Assessment with the 1973 Assessment reveal some apparently significant changes across these years, particularly concerning contrasts between males and females, and blacks and whites (Johnson, 1975). But inferences about the growth or decline of cognitive knowledge and skills across generations from these data remain highly speculative.

Knowledge and skill at graduation. The National Assessment of Educational Progress has provided the most comprehensive sampling of basic academic knowledge and skills among individuals at the threshold of young adulthood. The samples typically included approximately 2,500 persons at each age group and were chosen to be representative of the national population in geographic region, size and type of community, ethnicity, and sex. Table 1 summarizes some for the results of the 1973-74 National Assessment for 17 year olds. Data are reported for four areas: reading and writing, mathematics, science, and social studies. Following Mullis, Oldefendt, and Phillips (1977), statements are divided into three categories: what most (more than 67%), some (33% to 67%), and few (less than 33%) of the 17 year olds sample knew and could do at the time of testing.

Table 1 here

Table 1

Exemplary Reading-Writing, Mathematics, Science, and Social Studies Skills Represented in the 1973-1974 National Assessment of Educational Progress Passed by Most, Some, and Few 17 Year Olds

(After Mullis, Oldefendt, & Phillips, 1977)

Percent Passing	Reading-Writing	Mathematics	Science	Social Studies
More than 67%	Are familiar with well known literary works and characters. Are familiar with the elements of literary language. Read novels outside of school. Can give a general description of their qualifications in a job application letter. Know letter writing conventions. Can write a note explaining a problem. Have mastered the mechanics of writing.	Add, subtract, multiply, and divide whole numbers and decimals. Add negative whole numbers. Multiply fractions and reduce them to lowest terms. Calculate a simple average. Name geometric figures. Know that the diameter of a circle is twice the length of the radius. Evaluate simple expressions and solve first-degree equations and inequalities.	Know the names of the particles that make up an atom. Understand some basic facts about nutrition, illness, and disease. Know basic facts about plants and animals. Know that the color white reflects more sunlight than other colors. Can use a thermometer.	Understand and support the rights guaranteed by the U. S. Constitution. Believe that people should not be denied jobs because of race, sex, religion, or political opinions. Know reasons for societal rules and regulations. Know that the unfair laws can be changed. Know that there can legally be more than two political parties. Undersand some functions and limitations of the executive and judicial branches of government.
33-67%	Can read and understand detailed instructions and regulations. Can select an appropriate title for a three paragraph story. Can make inferences after reading a long paragraph. Can read a college-level article and identify the main idea of the article. Can express feelings in writing. Can organize and elaborate ideas in writing. Can argue persuasively in writing. Can improve their own writing by revising it. Include an address or telephone number at which they could be contacted in a job application letter.	Convert decimals to common fractions. Add fractions. Multiply two negative integers. Convert measures for volumes, weights, and lengths. Bisect an angle using a straightedge and compass. Recognize the graph for y=x. Determine the probability of randomly drawing a given ball from a jar. Solve word problems involving subtraction with negative integers or division with decimal answers.	Know that electrons are involved in forming chemical bonds. Know that cancer is uncontrolled cell division. Know about human reproduction. Know that wood burning is an example of oxidation. Know that pendulum length controls the time required for a swing. Can use an apparatus to demonstrate the daily and yearly cycles of the earth.	Know that each state has two senators and that the number of representatives varies with state population. Know that congress passes tax laws. Know that political parties are not mentioned in the constitution. Know that people can refuse to testify on the grounds that they might incriminate themselves.
Less than 33%	Can thoughtfully evaluate poetry or prose. Write excellent essays. Read poems or plays outside of school.	Calculate the area of a square given its perimeter. Simplify algebraic expressions. Understand probability or statistics. Convert Fahrenheit to centigrade given the conversion formula.	Know how long it takes light to reach the earth from the stars. Know that oxygen and silicone make up most of the earth's mass. Understand quantitative relations in chemistry and physics. Know why a large amount of mineral fertilizer placed around a plant will cause it to wilt and die. Know that water vapor is produced when a candle burns.	Know the functions of the legislative branch of government. Know that farm prices seek their own level in a free market system. Know geographic relationships.

In mathematics, most 17 year olds could perform basic arithmetic operations, and solve simple word problems that required addition, subtraction and multiplication of whole numbers. More individuals knew how to multiply fractions than how to add them. Few could solve problems that required more than one step for solution. In science, most 17 year olds were unfamiliar with concepts from chemistry or physics but did know basic facts about disease, nutrition, and the human body. In reading, most were able to read and understand the literal meaning of short sentences. But questions on longer passages or those that required some inference from what was read were correctly answered by fewer students. Measures of writing skills showed a similar pattern, while 80% of the sample could write a simple note, only half were able to choose a side to the proposition "A woman's place is in the home," and defend their position with written arguments. The average word length used by 17 year olds in the writing exercise was only four letters. While some could write sophisticated essays, about ten percent did not display even the most basic writing skills.

Comparisons within young adulthood. The 1976 National Assessment of Adult Work Skills and Knowledge provided an overview of the basic educational skills of a representative national sample of approximately 5,000 young adults aged 17 or 26-35. Four areas were assessed: computation and measurement skills (e.g., converting pounds to ounces, calculating area), graphic and reference-materials skills (e.g., reading bar graphs, using a telephone book), written-communication skills (e.g., writing a letter of application), manual-spatial-perceptual skill (e.g., measuring the length of a line,

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Percent Passing	Reading-Writing	Mathematics	Science	Social Studies
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33-67%	Can read and understand detailed instructions and regulations. Can select an appropriate title for a three paragraph story. Can make inferences after reading a long paragraph. Can read a college-level article and identify the main idea of the article. Can express feelings in writing. Can organize and elaborate ideas in writing. Can argue persuasively in writing. Can improve their own writing by revising it. Include an address or telephone number at which they could be contacted in a job application letter.	Convert decimals to common fractions. Add fractions. Multiply two negative integers. Convert measures for volumes, weights, and lengths. Bisect an angle using a straight edge and compass. Recognize the graph for y=x. Determine the probability of randomly drawing a given ball from a jar. Solve word problems involving subtraction with negative integers or division with decimal answers.	Know that electrons are involved in forming chemical bonds. Know that cancer is uncontrolled cell division. Know about human reproduction. Know that wood burning is an example of oxidation. Know that pendulum length controls the time required for a swing. Can use an apparatus to demonstrate the daily and yearly cycles of the earth.	Know that each state has two senators and that the number of representatives varies with state population. Know that congress passes tax laws. Know that political parties are not mentioned in the constitution. Know that people can refuse to testify on the grounds that they might incriminate themselves.
Less than 33%	Can thoughtfully evaluate poetry or prose. Write excellent essays. Read poems or plays outside of school.	Calculate the area of a square given its perimeter. Simplify algebraic expressions. Understand probability or statistics. Convert Fahrenheit to centigrade given the conversion formula.	Know how long it takes light to reach the earth from the stars. Know that oxygen and silicone make up most of the earth's mass. Understand quantitative relations in chemistry and physics. Know why a large amount of mineral fertilizer placed around a plant will cause it to wilt and die. Know that water vapor is produced when a candle burns.	Know the functions of the legislative branch of government. Know that farm prices seek their own level in a free market system. Know geographic relationships.

drawing three dimensional objects). Most items were quite simple, since the purpose of the study was to assess basic educational skills deemed necessary to survive in this society. Therefore, less than perfect performance indicates a lack of even the most rudimentary academic skills. The results of the assessment are summarized in Table 2.

Table 2 here

In general, adults performed less well than 17 year olds in skills typically taught in school, but better in skills that people are most likely to practice in everyday life (Johnson, 1975). For example, in computation and measurement skills, the largest difference favoring adults over 17 year olds occurred on an item requiring computation of simple finance charges on a time purchase. Only 49% of the 17 year olds, but 66% of the adults answered the item correctly.

Table 2 reveals that differences between 17 year old and adult males were larger than differences between 17 year old and adult females, possibly reflecting average gender differences in occupation following high school. Only the perceptual-spatial skill area showed no differences between the two age groups. This is consistent with the hypothesis that Gf remains relatively stable over the young adult years. The male advantage here probably reflects the figural-spatial nature of most of the tasks used to represent this skill area.

Differences between the two groups reflect both cohort effects and changes over the young adult years. Thus, the slight superiority of the adult groups may result from differences in educational systems. However, in contrast with inferences about more complex cognitive skills drawn from the SAT score decline discussed earlier, these data do not suggest that the 1976 educational system was much better or worse at imparting basic skills than the system of 10 to 20 years ago.

Table 2

Mean Percent Correct for 17 Year Olds and Adults in Four Skill Areas Represented in the 1976 National Assessment

Skill Area and Examples	17 Year Old			Adult		
	Male	Female	All	Male	Female	All
Computation and Measurement	72	68	70	76	69	72
Basic conversions:						
45 seconds = ___ minutes						
30 inches = ___ feet						
Compute simple finance charge						
Writing	60	66	63	62	68	65
Write a letter of application for a job						
Address a postcard						
Graphic and Reference	80	80	80	84	82	83
Look up telephone number for "Snack Shack" given a card with the words						
Find sock size for size 10 shoes from table with six pairs of numbers						
Perceptual and Spatial	68	64	66	68	63	65
Measure a line 3 3/8 inches long with a ruler						
Sketch three dimensional geometric shapes placed on table						

The most important finding drawn from this assessment was that a substantial number of American young adults lack even the most basic work skills. For example, 88% of the 17 year olds could correctly look up a telephone number. Although more adults (93%) found the correct number, this still indicates that a substantial number in both groups who could not perform this elementary task. Less than 75% of either group could correctly complete the item "45 seconds =__minutes."

The effects of education within cohorts also appeared. In all areas, those with more education out-performed those with less education. Although this undoubtedly reflects differences in ability, SES, and other factors correlated with years of education, it also reflects skill development through education. This connects also with the Project Talent finding that high achieving students spend more time studying than do middle or low ability students. Differences were particularly large at the lower end of the education scale. Thus, differences between the performance of those with some high school experience and those who completed nine or fewer grades were much larger than differences between those who graduated from college and those who attended graduate school. Differences among the more educated groups tended to be content specific. Knowledge of particular subject matters became more important than general educational level, as measured by years of formal schooling, in distinguishing such groups.

Comparisons between those who enrolled in some form of continuing education in the post high school years and those who did not are also possible, where continuing education is defined to include on-the-job training, correspondence courses, or adult education classes. Fully 55 percent of the adults reported participation in some form of continuing education. Among those who had graduated from high school and attended vocational school, 71% were also likely to have enrolled in some continuing education after completing vocational school. Those who had never been enrolled in continuing education performed below the national average in all areas of the assessment, while those who had participated in any form of continuing education were above the national average. Further, those who reported that their continuing education courses had been useful in their work outperformed those who had participated in courses that were either unrelated to, or judged not helpful in, their work.

Although these data do not separate educational from motivational, socioeconomic, and other factors, they do reveal two important facts about young adult educational development. First, many young adults who do not enroll in formal education during the post high school years continue their education through on-the-job training, correspondence courses, and adult education classes. Further, much of this educational experience is job related, and would not be reflected in performance on typical ability and achievement tests. Second, many adults who attend vocational school, college, or even graduate school also enroll in these other forms of continuing education. Among graduate school attendees, 58% also reported enrolling in some other form of continuing education. Clearly, "years of education" is inadequate as a measure of educational experience. Adults continue to acquire new skills and knowledge, but much of this knowledge is job related. The diversity of occupations and interests, as well as educational activities, among young adults severely limits attempts to assess cognitive development through a common sample of cognitive tasks, however diverse. A more profitable avenue for research would focus on skill development within specified occupations, such as the transition from novice to master mechanic, or apprentice to physician or scientist, or sales person to sales manager. We suspect that cognitive development within such categories produces not only quantitative changes in the total store of factual, conceptual, and procedural knowledge, but qualitative changes in the way such knowledge is organized and used in continuing or new problem solving (see, e.g., Chase, and Simon, 1973; DeGroot, 1966; Glaser, 1976).

The area of foreign-language proficiency has also been studied (Starr, 1979). In 1979, only 15% of U.S. high school students were enrolled in modern foreign language courses, as opposed to 20% in the mid 1950s and 36% prior to World War II. Of the present 15% enrolled, moreover, less than 2% study the chosen language for more than two years. Among the languages studied; Spanish is the most common choice, followed by French and German. Only 1% study Latin. Examination of enrollments beyond the second year course showed only 3500 U.S. high school students studying Russian, about 400 studying either Chinese or Japanese, and only 81 studying a language such as Polish. Hechinger (N.Y. Times Jan. 10, 1979), in reviewing these data noted the severe limitations implied for young adult careers in such growing fields as international commerce.

<u>Perceived Usefulness of High School</u>. In 1975, a representative sample of 1000 individuals who were 15 year olds in 1960 and had participated in Project Talent were located and interviewed. Interview questions ranged from amount and type of schooling, number of children, skills learned in school that were useful or never used again, to rankings of

material well-being and financial security (see Flanagan, 1978).

One of the major findings was that academic skills taught in high school were rarely seen as useful in most occupational pursuits, leisure activity, marriage and family life, or civic activity. Most individuals reported that occupationally useful skills were learned on the job. Only those who went on to college reported that subjects such as English, mathematics, foreign languages, and history were useful in their jobs (Gagne, 1978; Scriven, 1978).

Predictions of educational and occupational attainment. As noted earlier, measures of general ability predict later educational attainments. For example, estimates of general ability from the Project Talent battery obtained in ninth grade were highly predictive of high school graduation, college entrance, and college graduation. Differences in general ability between those individuals who dropped out of school and those who continued at each of these points were approximately one standard deviation (Wise & Steel, 1980). Ability assessed in ninth grade even differentiated those who later earned Ph.D.'s from those who earned other advanced graduate degrees.

After ability, parenting is one of the most powerful predictors of the educational attainment of young adults. Card (1977) and Card and Wise (1978) examined the effects of parenting on educational and occupational attainment. They selected samples of men and women from the Project Talent files who had had their first child at different ages. Samples were then matched on ninth grade educational aspirations, academic abilities, socio-economic status, race, and age. Figure 6 shows the percent of men and women who had received a bachelors degree by age 29 in each of three parenting

Figure 6 here

groups. Although more males received the bachelors degree than females, the trend was about the same in both groups. Young parents of both sexes were far less likely to obtain higher education than those who had children later or not at all. It is noteworthy also that, in the Project Talent data, over half the females who dropped out of high school gave marriage as the reason (Flanagan & Cooley, 1969).

Socioeconomic status (SES) is another important predictor of college attendance. High ability, high SES students are more likely to aspire to college education and are more likely to attend college. Although ability and SES are correlated, each makes an independent contribution to the prediction of asipirations, attendance, and achievement.

Figure 7 here

Figure 7 shows the relationship between SES and ability in grade 12, and the probability of entering college within five years after high school, separately for males and females. Both SES and ability are collapsed into quartiles in these figures. SES is a more powerful predictor of college entrance for females than for males. Further, for females, only the high SES group shows the expected linear increase in college enrollment across ability levels. For some reason, females in the third quarter of both SES and ability are more likely to attend college than would be predicted on the basis of their SES and ability levels. For males, the largest SES effects are between the 3rd and 4th (highest) quartiles. This may reflect a greater probability of attending junior college in the high SES, low ability groups. In fact, there is a tendency for junior college students to be similar to noncollege students in ability, but to college students in SES (Flanagan & Cooley, 1965).

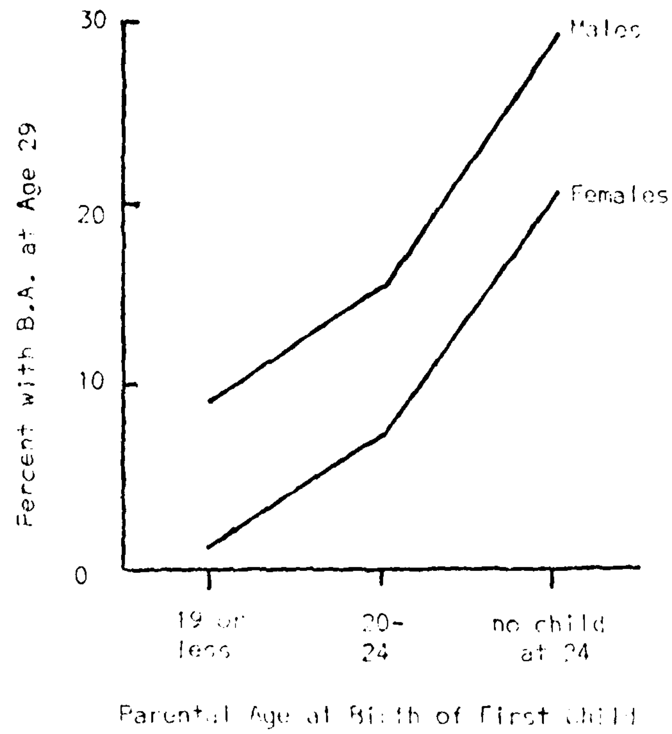

Figure 6. Percent of men and women in the Project Talent sample who had received a bachelors degree by age 29 by parental age at birth of first child (after Card & Wise, 1978).

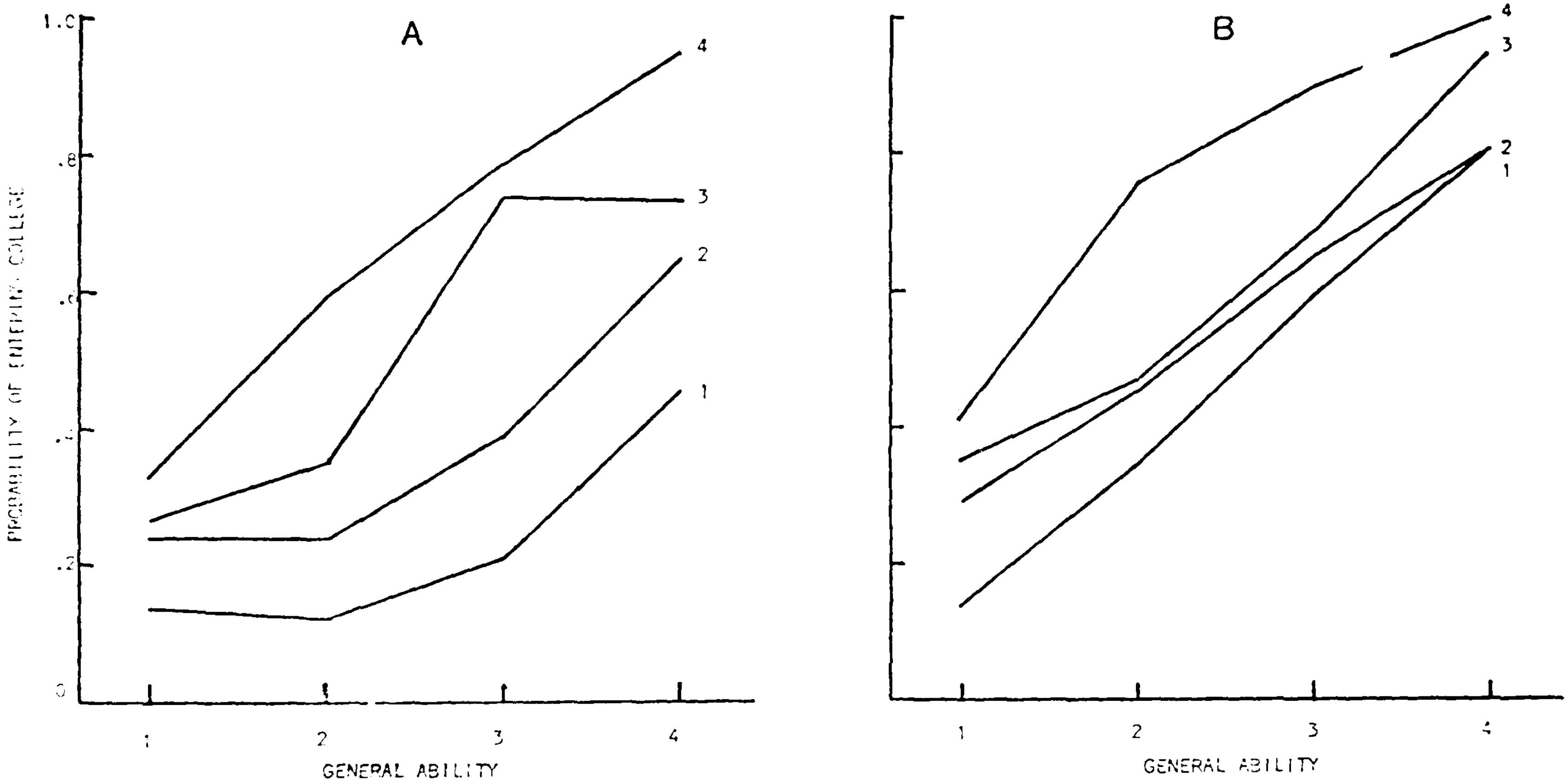

Figure 7. Probability of entering college within five years after high school versus twelfth grade general ability quartile plotted separately for SES quartiles for a) females, and b) males (after Wise & Steel, 1980).

Thus, the vast individual differences in cognitive ability and achievement observed among young adults at high school graduation are accentuated as proportions of these individuals fan out into different kinds and levels of post secondary education and occupation. Assessment of the life span development of particular cognitive ability and achievement constructs would have to take these educational and occupational classifications into account, as well as the attendant measurement problems, to reach meaningful average pictures of adult competence.

Cognitive ability and achievement measures predict occupational criteria less well than educational criteria. In one review, Matarazzo (1972) estimated that general ability correlates about .50 with level of occupational attainment but only about .20 with success within an occupation. Other studies have also shown that abilities may predict job training success, but not success on the job (Ghiselli, 1966). While the importance of cognitive ability differences in job success once a job is secured may be reduced by selection factors and the increased role of other personal characterisitics in determining success, it is nonetheless apparent that occupational prestige is strongly associated with ability. Matarazzo (1972) reported a correlation of .95 between ability and the independently judged prestige of occupations. The massive career study of Thorndike and Hagen (1959) also made this point, and showed further that ability profile differences are associated with different occupations. Following men who were tested during World War II into their occupations over a decade later, substantial relative ability differences were found. For example, accountants were relatively high in quantitative ability but low in mechanical and psychomotor abilities, while airplane pilots showed the opposite pattern. Architects were particularly high in visual-perceptual abilities, as were miners and drillers. College professors and writers scored relatively higher on general verbal intelligence than they did in other abilities. Clearly, cognitive ability patterns established up to young adulthood appear predictive of occupational prestige and in some cases also of occupational choice.

Further effects of college

In 1977, 27 percent of U.S. males in the 18 to 24 year age range, and 20 percent U.S. females in that range, were enrolled in college. This was nearly double the number of women who were enrolled in 1960 (11 percent), and about one third more men than were enrolled in 1960 (Suter, 1980). Enrollment of blacks increased dramatically during this period, from 6 percent of all college students in 1967 to 11 percent in 1977.

The costs of higher education have also increased substantially over the past 20 years. In 1977, the estimated total expenditure for institutional and student costs in American higher education was $85 billion, an amount equal to 5 percent of the GNP and nearly equal to annual defense expenditures (Bowen, 1977). The costs prompt questions: Is college worth the financial burden? Is it more than simply a selection system? What are the effects of particular colleges, or of college education in general on students?

Most research on the effects of college has focused on attitudinal and personality changes (see, e.g., Feldman and Newcomb, 1969). Studies of student learning and cognitive development are few, but their results are also less conflicting and ambiguous than those of the personality and attitudinal studies. The general conclusion is simple : students learn, and they learn most about subjects they study. Pace (1979) summarized the literature on changes in achievement over the college years in the following way: "Students learn what they study, and the more they study, the more they learn" (p. 18).

Both aptitude and achievement test scores improve over the college years (Powers, 1976). The largest gains are usually observed over the freshman year, although this may be an artifact of the heterogeneity of most achievement tests. Achievement during the junior and senior years tends to be greatest in the student's field, and thus would not be reflected in the usual achievement test. In spite of the increasing specificity of achievement, verbal skills tend to increase over the college years for all college students while improvement in quantitative skills depends more heavily on work in mathematics courses specifically. (Hartson, 1936; Louise, 1947; Rogers, 1930).

Studies by Humphreys (1968; Humphreys and Taber, 1973) have examined the correlational structure of college grade point averages and their relation to general ability and achievement measures taken before and after the four years of undergraduate college work. It was found that intercorrelations among semester grade-point-averages formed a simplex pattern and, also, that predictive validities of precollege measures dropped substantially as successively later semester averages served as criterion. Such a pattern of results would support the view that college young adults' abilities are changing through the college experience, except that it is also possible that the nature of the grading criterion is changing in successively later years and courses. Postdictive validities, from graduate level aptitude tests back to undergraduate performance show the same pattern as do the predictive validities; highest relations with freshman grades and lowest with senior grades. Thus, it appears that the academic criterion is changing in factorial composition. Major cognitive abilities may continue to develop across the college years, but they become less predictive of academic performance. It is also possible, however, as Humphreys and Taber point out, that the progression through college to increasingly advanced work involves the development of narrower or unique abilities not reflected in conventional general tests.

Different colleges might also be expected to differ in their impact on students, but there is no easy way to disentangle the effects of self selection from the effects of particular institutions (see Stanley, 1967). Colleges differ markedly in size, prestige, curricular emphasis, selectivity, religious affiliation, and in inumerable other ways (see Bowen, 1977). Yet, there is little empirical evidence that such characteristics of colleges relate in important ways to cognitive changes in students. Most of the variance in student achievement in college can be accounted for by student input differences as reflected in prior aptitude and achievement scores. Rock, Centra, and Linn (1970) provided one example of this general finding, in one of the few reports in which college characteristics did predict some of the variation in achievement not explained by prior ability differences. Multiple correlations of SAT-V and SAT-M with GRE area achievement tests four years later exceeded .90 in a sample of 95 small colleges. Then, residualized criterion scores were shown to relate to two of several college characteristic variables. These were college income per student and proportion of faculty with a doctorate. Institutional size moderated the relationship for mean income, such that among colleges with high mean income, smaller colleges had higher mean student achievement than larger colleges. Higher achievement occurred in colleges with more doctoral-level faculty. Thus it is possible that the range of college experience associated with these college variables acts to increase the cognitive achievement range among college-educated young adults.

However, most of this sort of research has ignored the possibility of aptitude-treatment interactions between students and college characteristics. Presumably some kinds of young adults might be particularly well served cognitively by one kind of college, and others by another. A later analysis of the above study data, for example, suggested that different clusters of colleges with identifiable characteristics might produce much steeper relations between verbal or quantitative aptitude and outcome than others, at least in some areas of study (Rock, Baird, and Linn, 1971). In another study related to this program, aptitude-outcome slopes were quite heterogeneous in a sample of

14 colleges, suggesting that some institutions were better for low ability students and some were better for high ability students. The few other studies of cognitive and affective aptitudes among young adults that might bear on this issue have been summarized by Cronbach and Snow (1977). One might expect, in the far distant future, that college selection could be based in part on matching the cognitive characteristics of students and colleges. Although college choice is not random, tne process by which students select a college is clearly not a rational decision based on clear knowledge of personal and institutional characteristics. In fact, entering college freshman typically have only vague and frequently inaccurate ideas about the particular college they have chosen to attend (Holland, 1959).

Research on college instructional effectiveness also suggests aptitude treatment interaction, as well as the general effectiveness of some instructional methods (Snow & Peterson, 1980). To the extent that these can be capitalized upon, young adult achievement in college can be improved. College policies and practices have been changing in the direction of increased individualization with the recognition of the increasingly individual needs of the young adult population (Willingham, 1974).

Summary and Concluding Remarks

The foregoing pages have demonstrated that research on cognition and learning in young adults is a patchwork at present, and not yet a continuing programmatic effort. But there are many parts of the patchwork that deserve intensive further work. There is a general information processing model, and also a model of the structural organization of individual differences in ability, with which to start. A collection of specific facts, trends and hypotheses also exist to provide starting points.

There is also a central developmental hypothesis. Briefly stated, it is that young adulthood marks a region of life where the basic cognitive abilities and learning skills reach, or should have reached, full development, and where therefore the focus of mental effort or attentional resource allocation should be on the development of the longer-range executive-control-motivational functions needed to meet the demand for responsible, successful, contributing adult performance. To the extent that recent and future generations of young adults have not reached or cannot reach such a stage, for whatever educational or social reasons, grim projections might be made concerning the availability of higher-order cognitive talent in the future U.S. society.

Fortunately, the average declines that have been documented in relent generations of young adults are accompanied by overwhelmingly large individual difference variations, within generations, around these averages. Also, new concerns for educational effects on these trends and the improvement of educational quality may generate new research and development designed to reverse such trends. There are new attempts to adapt instruction to fit individual differences in cognitive and learning ability, and also to train such ability directly, all along the educational age scale (see, e.g., Glaser, 1977; Snow & Yalow, in press). A more concentrated and analytic assessment of young adult cognition and learning in the coming years should inform these efforts significantly.

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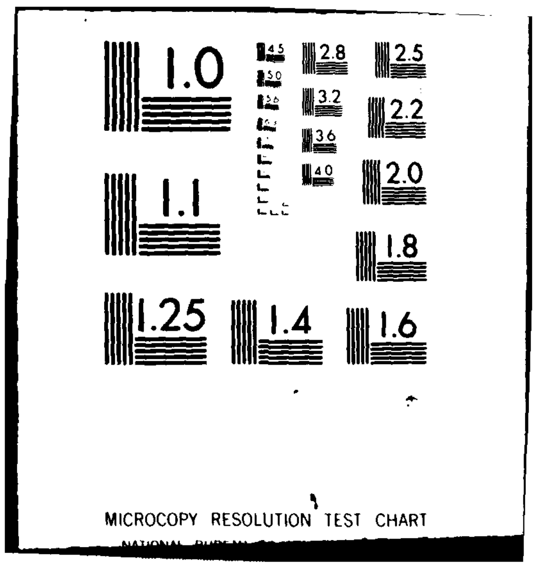
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