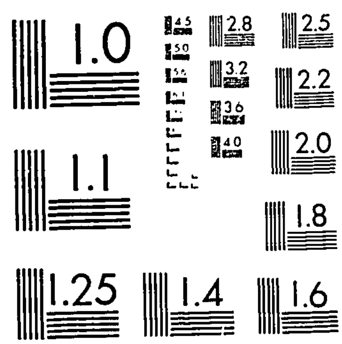
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ABSTRACT

The primary goal of this review is to acquaint developmental psychologists who have had little experience in the study of individual differences in cognition with some of the basic rules that govern this type of research. A second goal is to stimulate researchers to consider the potential benefits of studying differences among individuals whose cognitive abilities range from average to superior rather than to limit their research to studies of contrasts between functional and dysfunctional groups. Programs of research which combine the correlational-psychometric and the normative-theoretical approaches to the study of cognitive development can contribute both to better understanding of general principles of development and to the description and ultimate explanation of individual differences. A review of the literature indicates that such research is most likely to succeed when techniques that have been developed in differential, educational, and cognitive psychology, and in comparative developmental research are applied to the study of individual differences in cognitive development. (Author/SS)

Passing the Individual Differences Test:
A Cram Course for Developmental Psychologists

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Title Footnote

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Abstract

Programs of research which combine the correlational-psychometric and the normative-theoretical approaches to the study of cognitive development can contribute both to better understanding of general principles of development and to the description and ultimate explanation of individual differences. A review of the literature indicates that such research is most likely to succeed when techniques that have been developed in differential, educational, and cognitive psychology and in comparative developmental research are applied to the study of individual differences in cognitive development. Little is known about the cognitive characteristics of intellectually superior children, but studies involving this group provide an excellent context for studying individual differences in cognitive development.

Passing the Individual Differences Test: A Cram Course For Developmental Psychologists

The title and underlying theme of this review are taken from Underwood's (1975) argument that theories of cognition should routinely be tested for their power to explain individual differences in cognitive performance. Every theory should be tested against a reference point outside the theory itself and outside the paradigm that generated the theory. Any theory that cannot account for individual differences with reference to an external criterion should be set aside and not inflicted upon the professional community.

The first goal of the paper is to acquaint developmental psychologists who have had little experience in the study of individual differences in cognition with some of the basic rules that govern this type of research. A second goal is to stimulate researchers to consider the potential benefits of studying differences among individuals whose cognitive abilities range from average to superior and not to limit their research to studies of contrasts between functional and dysfunctional groups.

Applications of individual differences tests to cognitive theories typically involve variables such as age, IQ, or social status which are not, in themselves, theoretically meaningful. Underwood has questioned the validity of this approach, noting that the individual differences of interest in the study of cognitive performance are process differences. However, variables such as age and IQ can and should be used as markers identifying groups likely to differ in their cognitive processes. Variables marking individual differences that have broad implications for cognitive performance play a legitimate, if preliminary, role in the study of individual differences in cognition. In particular, programs of research which combine the correlational-psychometric and the normative-theoretical approaches to the study of cognitive development can contribute both to better understanding of general principles of development and to the description and ultimate explanation of individual differences (Carroll, 1976).

In the past few years, applications of individual differences tests to theories in adult cognition or educational psychology have become very popular. A number of different sets of boxes and arrows have been tested for their power to explain cognitive differences associated with differences in psychometric performance (see Carroll, 1978; Sternberg 1978 for reviews). Developmental psychologists, however, have been a bit backward in adopting this paradigm. Although the program for the 1979 biennial meeting of the Society for Research in Child Development, compared with that for the 1977 meeting, suggests that interest in the study of individual differences in cognitive development has been growing, most developmental psychologists still have a bit of catching up to do if they are going to work within this paradigm.

Alternate Approaches to the Study of Individual Differences

Ours has always been a largely descriptive science. Normative theories of development are essentially summaries of the ways in which behavior changes over time. When individual differences are considered, this also happens at the descriptive level. Some children are said to develop faster than others and to reach more advanced terminal points in their development (Zigler, 1969). This differential rate model is consistent with much of the data (e.g., Brown, 1974; Zigler, 1969). Nonetheless, it hardly qualifies as an explanation of individual differences. Saying that one child develops intellectually at a different rate than another contributes nothing to our understanding of why the two children are developing at different rates (Ellis, 1969).

Individual differences research, as it is presently practiced by many developmental psychologists, is hardly likely to improve this state of affairs. A distressingly large proportion of individual differences research still seems to be governed by what could be called the "One from Column A, One from Column B" approach. Column A consists of all possible intellectual or cognitive style trait measures. Column B contains cognitive performance variables of potential theoretical interest. The investigator need only select one trait variable from Column A and one cognitive performance variable from Column B, and correlate the two. Almost any variable in Column A is likely to explain at least some of the variance in any variable in Column B. Furthermore, the level and statistical significance of the relationship between the two is likely to be at least as much a function of the reliability of each measure, the ranges of performance, and the sample size as it is a meaningful function of a hypothesized process relationship between the two variables.

The psychological literature does, however, provide many resources for the investigator who wishes to become familiar with more sophisticated individual differences methodology. Recent papers in the adult cognitive literature present disucssions of both the potential and the problems inherent in any attempt to reconcile the psychometric and the experimental approaches to the study of cognition (Carroll, 1978; Cronbach, 1975; Hunt & MacLeod, 1978; Sternberg, 1978). The mental retardation and comparative psychology literatures include helpful analyses of the procedures necessary to support a conceptual leap from description of a performance difference between two groups to explanation of that difference in terms of a particular cognitive process (e.g. Butterfield & Dickerson, 1976). The psychometric and educational psychology literatures offer the developmental psychologist a necessary introduction to the issues involved in the selection and interpretation of psychometric indices (e.g. Horn, 1976).

In the next section of this paper, I will draw from the literature in all of these fields to suggest some methodological guidelines applicable to individual differences research in cognitive development.

The Nature of Psychometric Variables

Developmental psychologists are accustomed to using chronological age (CA) as an individual differences variable in cognitive research. Regardless of its limitations as an estimate of more theoretically interesting constructs such as physical or intellectually maturity or life experience, CA has the advantage of being the only measure of the construct "age," and a perfectly reliable and valid one, at that. Mental age (MA), IQ, and other psychometric indices do not share these advantages but are sometimes treated as if they did. In many studies, for example, groups of children have been matched for MA on the basis of scores from different instruments. Scores for a retarded group may be taken from a comprehensive individual test, such as the WISC, while those for a group of normal children will be from a group intelligence test or a quick estimator of intelligence, such as the PPVT (e.g., Spitz & Nadler, 1974; Winters & Goettler, 1973). The assumption necessary to justify this matching procedure is that any IQ or MA, regardless of its source, is equivalent to any other MA. This is an absurd assumption, and one that is potentially very misleading when intelligence test scores are being used as markers for potential cognitive process differences. Estimates of cross-test comparability based on norming samples are not necessarily applicable to the groups used in a particular study. The PPVT, for example, has been found to be more comparable to the Stanford-Binet in estimating the ability of middle-class children than in estimating the ability of culturally different or economically disadvantaged groups (Sattler, 1974). Furthermore, even when two different intelligence scales are known to yield scores that are strongly correlated with one another and comparable in absolute level, the tests cannot be assumed to reflect the same constellations of basic cognitive processes. It might well be that two tests that yield highly correlated scores differ substantially in the extent to which they tap a particular process that is related to the cognitive performance variable of interest.

A widely cited study by Webb (1974) illustrates how misleading the treatment of intelligence test scores as absolutes can be. Webb assessed the performance of 25 children, aged 6 to 11 years, on three tests of concrete operations and two tests of formal operations. All of the children in the sample had earned Slosson Intelligence Test IQs above 160. Since none of the children below the age of 10 years clearly passed both formal operations problems, Webb concluded that "bright children use the tools of their developmental stage very well compared to their peers. If bright children develop new tools any sooner, however, the precocity is not striking." (1974, p. 299) In stating this conclusion, Webb has clearly equated performance on the Slosson Intelligence Test with brightness. That is, he has assumed that the Slosson is a perfectly valid measure of the construct "brightness." He does not consider the possibility that children defined as bright according to their performance on some other measure of general intellectual ability, such as the WISC or the Raven Progressive Matrices, might be more likely to display extreme precocity in the attainment of formal operations. Indeed, the Slosson, which is heavily weighted with vocabulary and verbal reasoning items, might be a particularly poor marker for precocity in formal operational reasoning. In contrast, a strong relationship has been demonstrated between performance on the Raven Progressive Matrices and formal operational reasoning ability in 11- and 13-year-old boys preselected for arithmetic achievement (Keating, 1975).

Intelligence, spatial ability, and other constructs are only imperfectly measured by any particular instrument. The difference between the construct and the measure is particularly important to keep in mind in discussing the results of studies that fail to demonstrate an expected relationship between a psychometric measure and performance on some cognitive task. This is a circumstance in which the basic distinction between failure to reject the null hypothesis and acceptance of the null hypothesis must be rigorously honored.

Reliability

The probability of rejecting the hypothesis of no relationship between a psychometric and a theoretical cognitive measure is often seriously constrained by the unreliability of one or both measures. In order to interpret correlational relationships among different measures, one must first evaluate these relationships relative to the limits of interpretable variance set by the reliability of each. If a measure is not reliable, it cannot be used to predict other measures. As Campbell and Fiske argued in a 1959 paper, the reliability of each measure in a matrix should at least be greater than the correlations between different measures.

Individual differences research often involves comparisons across measures administered at different times. Therefore, the reliability of a measure as defined by internal consistency may not be the only criterion of importance. As Jensen (Note 1), Carroll (1978) and others have pointed out, the day-to-day, test-retest reliability of both psychometric and cognitive process measures limits the maximum possible relationship one could expect to demonstrate between the two types of measure. Time-based cognitive process measures have been found to be quite unreliable from day to day in adult samples, and one might expect the performance of children to be even less stable than that of adults. The progress of a psychology of individual differences in cognitive development may be determined in large part by the ingenuity that developmental psychologists can exercise in translating theoretically relevant measures into procedures which are consistently effective in eliciting and maintaining children's best performance.

Convergent and Discriminant Validity

One serious limitation of the One from Column A, One from Column B approach to individual differences research is its susceptibility to passing psychological fads. As new theories of cognition and new approaches to the description and assessment of individual differences come into vogue, newly named variables will be tested for their relationships with one another, and the possibility that the results might simply be replications of previously established findings involving comparable variables is likely to be ignored.

The literature includes many examples of studies in which supposedly new and predictively useful measures of individual differences might better be interpreted as new manifestations of old constructs. Keating's (1978) paper, "A Search for Social Intelligence," provides a chastening illustration of this problem. Keating was unable to define a separate social competence factor in the test performance of college students. Moreover, intellectual measures surpassed social measures as predictors of a social competence criterion.

As Campbell and Fiske (1959), Butterfield and Dickerson (1976) and others have pointed out, a full pattern of convergent and discriminant relationships is much more heuristically valuable than a single correlation or group difference. For example, consider the contrast between studies of skilled and unskilled readers conducted by McFarland and Rhodes (1978) and by Cohen and Netley (1978).

McFarland and Rhodes found that 9-, 11-, and 13-year-old skilled readers surpassed unskilled readers in recall of auditorially presented word lists when both ability groups were instructed to attend to the meaning of the words. There were no ability-related differences in other recall conditions. Skilled readers also showed more evidence than unskilled readers of clustering items in their recall. Because the differences between the two groups of readers were specific to certain measures and task conditions, McFarland and Rhodes concluded that skilled and unskilled readers do not differ in general memory ability but do differ in their processing of the semantic features of individual words. The investigators have indeed provided evidence for the discriminant validity of the memory-performance half of this argument, but their conclusion is suspect because the two groups were differentiated only in terms of their performance on a standard test of reading. It is likely that the groups also differed substantially in general intellectual ability and a host of more specific intellectual attributes (Guthrie, 1978). Thus McFarland and Rhodes' conclusion could probably be rephrased as a statement of the way in which high-IQ and low-IQ, or linguistically competent and linguistically incompetent, children differ. The theoretical implications of the data are, therefore, unclear.

Cohen and Netley's study of normal and learning-disabled children's performance on a battery of discrimination, learning and memory tasks provides a model of research in which the issue of discriminant validity for both experimental tasks and cognitive ability measures has been considered. Learning-disabled children were matched with normal readers for total and subscale performance on the WISC. The matched groups were then compared on a wide range of information-processing tasks. The investigators were able to identify large differences between the normal and disabled groups on some memory tasks and minimal or nonexistent group differences on other tasks. Because the groups were comparable in their performance on an intelligence scale tapping a broad range of abilities, the investigators were able to conclude that a performance deficit of the learning-disabled groups in short-term memory for supraspan auditory messages was specifically related to reading disability, even though no causal relationship could be established with this design. The attention to discriminant validity in Cohen and Netley's design facilitates the use of their data in the development of a theory of reading disability.

Ideal examples of individual differences research, in which both discriminant and convergent validation of measures are established within a single set of studies, are very far from the reality of most research in cognition or cognitive development (Butterfield & Dickerson, 1976; Campbell & Fiske, 1959; Ray & Heeler, 1975). The need for convergent validation of measures is likely to be especially problematical in research within cognitive paradigms involving measures that are very narrowly defined and closely tied to a particular model. In many cases, the question of a measure's validity outside the context of that model is not addressed. This issue is often raised in criticism of the information-processing approach to cognitive psychology (Carroll, 1978; Guthrie, 1978).

Exceptions to this generalization are, however, beginning to appear in the literature. Keating and Bobbitt's (1978) study of individual and developmental differences in performance on several measures of information-processing efficiency provides an excellent example of attention to the convergent validity of such measures. By comparing the performance of average and intellectually superior children on measures of simple and choice reaction time, speed of accessing physical and semantic information (an adaptation of the Posner letter identification task), and rate of short-term memory search (S. Sternberg's recognition task), Keating and Bobbitt obtained results suggesting both convergent and discriminant validity for a construct of processing efficiency involving similar steps in processing sequences for different tasks. Similarly, Spiegel and Bryant (1978) found that measures of information-processing response time taken from three different tasks were moderately related to one another; furthermore mean response time for each task was related to intelligence and academic achievement.

Interpreting Groups x Tasks Interactions

Attempts to isolate cognitive performance characteristics differentiating particular groups frequently rest on the interpretation of a groups x tasks interaction. The typical experimental hypothesis is in the form of a prediction that a dysfunctional group, such as poor readers or mentally retarded children, will be more seriously deficient, relative to a normal group, in their performance on one task than they are on another task. Thus this approach is often described as the "differential deficit" paradigm. A common variant of the paradigm involves matching an able and a disabled group on some psychometric index, such as MA, and comparing the groups' scores on a task designed to measure performance in the area of expected deficiency. Data consistent with the experimental hypothesis may be incorporated in a cognitive process explanation of the dysfunctional group's deficiencies. For example, Spitz and Nadler (1974) found that retarded children were inferior to normal children of equal MA in generation of information-seeking behaviors necessary to solve simple logical problems. They concluded, therefore, that retarded children are deficient in anticipatory thinking ability.

In many cases, however, studies of individual differences in cognitive development utilizing the differential deficit paradigm have failed to demonstrate the groups x tasks interaction required for identification of a supposed process difference. These null findings constitute much of the data bolstering the developmental rate model of individual differences (e.g., Weisz, 1977). Children often seem to be rather evenly slow, or evenly advanced, in their cognitive development. However, both the null findings and studies in which differential deficits have been isolated (e.g., Brown, 1974; Spitz & Nadler, 1974) are difficult to interpret because of methodological difficulties inherent in this paradigm.

Several reviewers have pointed out that one of two groups may appear to have a performance deficit in one area if the set of cognitive tasks used differ in their variance and reliability for the two populations (Chapman & Chapman, 1977; Traupmann, 1976). Bogartz (1976) has demonstrated that a given groups x tasks interaction can be interpreted as evidence <u>either</u> for or against the existence of a differential deficit unless the data are interpreted in the context of a precise mathematical prediction.

Brown's (1973) study of conservation of number and continuous quantity by average, intellectually superior, and mentally retarded children illustrates one facet of this complex problem. Brown compared the conservation task performance of three groups of children matched for Stanford-Binet MA. All groups had a mean MA of 6 years, which Brown expected to be a critical threshold level for the acquisition of conservation ability. The retarded children had a mean CA of 8 years, the average children were 6 years old, and the intellectually superior children were 4 years old. As would be predicted from the developmental rate model, the conservation performance of the retarded and average groups was equivalent. The intellectually superior 4 year olds, however, performed much more poorly than the other groups. Although several of the intellectually superior 4 year olds performed very well, the mean conservation score for this group was not significantly above that attained by 4 year olds with average IQs. Brown concluded that "the young child with a high IQ is held back by sheer lack of experience that the additional CA provides" (1973, p. 378). In other words, Brown interpreted her data as evidence for a deficit in the conservation ability of intellectually superior 4 year olds, relative to their general intellectual maturity, as defined by Binet MA. There are several reasons one might question this conclusion. As in the Webb study mentioned above, it would not be appropriate to extend a statement based on a finding of no relationship between precocity in Stanford-Binet performance and precocity in conservation performance to conclude that bright 4 year olds are generally incapable of conservation. Given another instrument of selection, more precocious conservers might have been found. More relevant to the present point of discussion is the question of differential reliability of the Stanford-Binet and conservation measures for intellectually superior 4 year olds, average 6 year olds, and mentally retarded 8 year olds. Since Brown did not give reliability estimates for the conservation measures, my comments will be confined to the Stanford-Binet, for which reliability estimates are available in other sources (McNemar, 1972; Sattler, 1974).

Stanford-Binet IQs tend to be more reliable and stable for older as opposed to younger children and for lower- as opposed to higher-scoring children. Thus the scores of the intellectually superior 4 year olds in Brown's study would be expected to be less reliable than those of the other two groups. Because of this unreliability, the Stanford-Binet MAs of the bright 4 year olds might well have regressed downward below the 6-year matching level if the children had been retested. While the "true" MAs of the average 6 year olds were probably at 6 years and the true MAs of the retarded 8 year olds might have been a bit above 6, those of the intellectually superior children were probably well below 6 years. Thus the failure of this group to match the conservation performance of the other groups might have been more a result of the procedures used than a manifestation of a theoretically meaningful performance deficit.

Permissable Inference and the Training Paradigm

One of the major methodological contributions of mental retardation researchers to the basic study of individual differences has been specification of the importance of training paradigms for proving that a hypothesized process is indeed related to a particular individual difference in performance. This approach provides the best available technique for overcoming some of the problems inherent in interpretation of a groups x tasks interaction. Briefly, the argument goes like this. Two groups differ initially in their performance on, say, a memory task. The investigator attributes this performance difference to a particular process deficiency, such as a verbal rehearsal deficit. In order to prove that a verbal rehearsal deficit is actually responsible for the group difference in performance, one should train both the proficient and the deficient group in verbal rehearsal. Ideally, the proficient group, who are supposedly already using verbal rehearsal, will not improve after this training. The deficient group will, however, have its specific process deficit eliminated by training and achieve a performance level equal to that of the proficient group. Variants of this basic paradigm involve providing some sort of aid or prop to the deficient group and interfering with the performance of the proficient group in a manner designed to disrupt the process hypothesized to account for their advantage. A comprehensive and elegant discussion of how the training paradigm can be used to validate a process explanation of deficient performance is provided by Butterfield (1977).

Success with this approach is not earned readily. It is often impossible to find training procedures and other manipulations that will result in equal performance by normal individuals and broadly deficient groups, such as mentally retarded persons (Brown & Campione, 1979) or severely disabled readers (Fleisher, Jenkins, & Pany, Note 3; Jenkins, Pany, & Schreck, Note 2). There is likely to be some improvement when the deficient group is trained but not quite enough to erase the performance difference. Gains will also occur in the proficient group. Furthermore, gains shown by the deficient group will be transient and situation specific. A likely reason for this failure is that retarded children and other cognitively dysfunctional groups are seriously deficient in metacognitive ability, or the ability to learn how to learn (Campione & Brown, 1978). The training paradigm is more likely to yield interpretable data when the individuals compared do not suffer from the broad strategic deficits associated with mental retardation. Normal individuals who differ in performance on a particular task would be expected to have relatively circumscribed and task-specific processing deficits.

The power of the training paradigm to contribute to understanding of differences among normal individuals is nicely illustrated by studies of individual differences in college students' performance on a sentence-picture verification task that have been conducted by E. Hunt and his colleagues. The verification task involves presentation of a sentence, such as STAR IS ABOVE PLUS, and then a picture, such as $\overset{*}{+}$, which is either true or false relative to the sentence. MacLeod, Hunt, and Mathews (1978) found that reaction times to solve particular types of verification problems differed for some subjects in accordance with a verbal processing model and for other subjects in accordance with a spatial processing model. Furthermore, the type of strategy subjects were likely to use was related to their performance on standard tests of verbal and spatial ability. In a followup of the original study reported by Hunt and MacLeod (1978), subjects who preferred one or the other strategy were found to be able to switch to the alternate strategy after brief instruction. Hunt and MacLeod lament this last finding as evidence against the stability and importance of individual differences in modes of information processing. The fact that college students were readily able to switch strategies when instructed to do so does not, however, invalidate the original observation of differences in preferred strategy. Moreover, these data provide an example of how use of a training paradigm can confirm that a hypothesized strategy difference did indeed account for observed performance differences.

The Other End of the Cognitive Ability Continuum

Hunt and MacLeod's data provide an appropriate point of transition from a discussion of how to study individual differences to consideration of whom should be studied. While we can learn a great deal from the individual differences methodology of researchers working with retarded or otherwise dysfunctional populations, the study of abnormal groups does not necessarily contribute to our understanding of individual differences within the normal range. Interpretation of normal-abnormal differences is too often clouded by incidence of pathology, differences in education history and general background, motivation, and so on (Guthrie, 1978; Harter & Zigler, 1974; Zigler, 1969). Just as we cannot extrapolate from studies of cognitive performance differences between

4 and 7 year olds to predict how 10 and 14 year olds will differ, we cannot extrapolate from comparisons of individuals with IQs of 70 and 100 to predict how the performance of individuals with IQs of 100 and 130, or 130 and 160, will differ. Nonetheless, surprisingly few developmental psychologists have undertaken individual differences research involving children performing in the middle to upper range of the cognitive ability continuum. Even fewer have published studies involving groups of children who could be described as intellectually superior.

Table 1 summarizes all studies involving groups of intellectually superior (high IQ) children that were located in a comprehensive, though not exhaustive, review of the cognitive literature. When one compares Table 1 with the reference list for any article reviewing the literature on cognitive performance in mentally retarded children (e.g., Odom-Brooks& Arnold, 1976), the difference in number of reports is of many orders of magnitude.

Table 1 about here

One reason the study of intellectually superior children has been ignored may be that there is no theory that specifically sets forth a model of cognitive processing or cognitive development in intellectually superior as compared with average children.

Another, related, reason might be that there is no readily available body of expertise suggesting how to go about studying such children. For example, what procedures would one use for generating a sample of intellectually superior 4 year olds? Of intellectually superior 10 year olds? How reliable would standard test scores be for these groups? What experimental techniques would be appropriate for working with a 3 year old who has a mental age of 6 years?

Basic ignorance of the intellectual and other characteristics of intellectually superior children may also limit psychologists' interest in this group. Any extreme group is only minimally represented in cross-sectional samples such as the standardization populations for intelligence tests or the supposedly average children on whom the normative developmental literature is based. The special characteristics of dysfunctional groups become known, however, because the group itself is the focus of intensive study. Because retardation is a major problem for our society, we have supported research with retarded populations and have learned what retarded individuals are like. Intellectually superior children have not received this intensive study. Therefore, we know surprisingly little about what to expect from intellectually superior children in terms of such issues as differentiation of specific cognitive abilities, relationships between cognitive and social characteristics, and so on.

In the absence of a theoretical why, a methodological how, and a descriptive what, it is not surprising that the study of intellectually superior children has been ignored.

Undoubtedly, a final reason why intellectually superior children have received little attention from psychologists is that there has been no federal money available for research with this group. Federal funds for "gifted" children are entirely program development and dissemination funds. Although these funds have increased since 1972, (U.S. Office of Education, 1972), there has been no concomitant increase in funds for basic research. Thus we find ourselves in the situation of supporting the development of special education programs for a group whose cognitive characteristics are described more by myth than by empirical evidence (Roedell, Jackson, & Robinson, in press).

Practical implications aside, the study of intellectually superior children provides a unique opportunity for applying individual differences tests to basic cognitive theories. Whatever theory of cognition and cognitive development one favors, cognitive developmental processes are likely to be characterized as constituting a highly complex system. In any complex system, opportunities for failure are numerous, and the varieties of failure may be almost infinite. There can be many different reasons for a child being mentally retarded or for a child failing to learn to read. In such a complex system, however, the varieties of success are likely to be quite limited. Success is, after all, constrained by whatever processes or structural features are essential for the successful operation of the system. If our primary goal is to learn about the system itself, we are likely to learn more, and to learn more quickly, by studying varieties of success than by studying varieties of failure. Intellectually superior children represent the system of cognitive development at its best, and their performance on cognitive tasks should tell us a great deal about the nature of the system and the degree of flexibility that can be associated with success.

Another advantage of research studying individual differences among intellectually superior children or between groups which perform in the generally above-average range on cognitive measures is that these children are likely to have been raised in relatively optimal, nurturant environments. To the extent that children come from uniform environments, genetic differences within a sample should be highlighted (Scarr, 1978). Differences in cognitive performance related primarily to genetic factors are not necessarily any more interesting than differences attributable mainly to environmental factors, but it is useful to have some sense of what one is working with. For example, one might wish to explore the extent to which individual differences in such cognitive characteristics as strategy use or processing efficiency were differentially salient in groups whose psychometric performance differences were relatively more or less associated with either genetic or environmental variation.

Comparisons between groups of children in the upper half of the cognitive ability continuum might also have the advantage of being especially amenable to application of the training paradigm. One would predict that these children, like Hunt and MacLeod's college students, would have relatively circumscribed process deficits that would respond quickly and dramatically to training designed to affect that process. Intellectually superior young children, whose performance on many cognitive tasks is similar to that of older children, would be expected to have better meta-cognitive capabilities than other children their age.

Although relatively few studies of individual differences in cognitive processes have been done with samples of children whose psychometric performance ranges from average to superior, recent research in this field has yielded consistent and heuristically provocative results. Two generalizations from the data are particularly striking:

--From the age of 9 or 10 years through the college years, individual differences in a variety of information processing and reasoning parameters may be more salient than developmental differences in these same parameters (Cohen & Nealon, 1979; Keating, 1975; Keating & Bobbitt, 1978; Keating & Caramazza; 1975)

--Individual differences within this age range tend to be characterized in terms of processing efficiency differences rather than differences in kinds of strategies used or cognitive organization (Cohen & Nealon, 1979;Cohen & Sandberg, 1977; Keating & Bobbitt, 1978; McCauley, et al., 1976; Robinson & Kingsley, 1977; Ford & Keating, note 4).

The first generalization should be considered by anyone doing cognitive research with older children and adolescents. Within this age range, chronological age may be a relatively poor marker for a number of different parameters of cognitive capability. Furthermore, the data suggest that it may be inappropriate to describe individual differences in the cognitive performance of intellectually above-average children aged 10 years or older in terms of differential maturity.

The second point is particularly interesting in contrast with the perspective on individual differences that one gets from comparisons of normal and retarded individuals. In that literature, the emphasis has been on strategic differences rather than on processing efficiency differences, although the existence of both kinds of difficulties is generally acknowledged (Campione & Brown, 1978; Cohen & Nealon, 1979). A model of individual differences in cognition that accounted for the full range of individual differences might have to be a discontinuous model. Perhaps there are threshold levels of processing efficiency which are necessary for the spontaneous adoption of particular cognitive strategies. Within samples functioning above these threshold levels, one would observe individual and developmental differences in processing efficiency or capacity but not in strategies or organization.

Methodological Issues in the Study of Intellectually Superior Children

To some extent, the problems one faces in cognitive developmental research with intellectually superior children are analogous to the problems encountered in work with the retarded or other extreme groups. There are, however, some issues involved in the study of intellectually superior children that might not be obvious to an investigator beginning to work in this field.

Just as retarded children may differ from children of average intellectual ability in educational experience and motivation, so may intellectually superior children. Consider once again Brown's finding that 4 year olds with Stanford-Binet MAs of 6 years did not match the conservation performance of average 6 year olds. In addition to the methodological issues raised earlier, this group difference in performance might be attributable to group differences in specific educational experiences. As Gelman (Gelman & Gallistel, 1977) and others (Gruen, 1975; Winer, 1968; Wohlwill & Lowe, 1972) have demonstrated, success in the traditional conservation task appears after children have mastered many counting and computational skills. The 6 year olds in Brown's study would have been more likely than the 4 year olds to have received extensive instruction and practice in number skills. One wonders whether these bright 4 year olds would have performed better if they had received an accelerated education and had been exposed to kindergarten and first grade mathematics lessons. In interpreting the capabilities of intellectually superior children, it is important to consider the possibility that a particular performance deficit may be attributable not to some sort of global and irremediable deficiency but to the lack of a specific cultural or educational experience.

Similarly, intellectually superior children are likely to differ from older, average children in a number of noncognitive attributes, such as willingness to persist on boring or difficult tasks, fine motor skill, and so on. The attribution of spurious cognitive "deficits" to young, intellectually superior children should be minimized by careful selection of experimental procedures that are equally appropriate for all age groups involved in a study.

Whenever a deficit in the performance of young, intellectually superior children relative to older, average children is found, the question of interpreting that deficit remains. As noted above, inter-age and ability group differences are not, in themselves, interpretable in terms of cognitive process differences.

Process deficits can be defined only if performance differences can be eliminated by manipulations such as training. For example, if several weeks' practice in counting and arithmetical computation were found to raise the number conservation performance of intellectually superior 4 year olds to the level attained by average 6 year olds, we could conclude that lack of such experience explained the initial failures. Subsequent research might isolate more specific experiences and cognitive process gains essential for intellectually superior 4 year olds' success on this task.

Other issues encountered in the study of intellectually superior children are more mundane. There is, for example, the problem of locating groups of subjects who are relatively rare in the population as a whole. Groups of intellectually superior school-age children can often be identified through access to the schools' records of standard intelligence and achievement test performance (e.g., Keating & Bobbitt, 1975; Keating & Caramazza, 1975).

Many districts offer special programs for children who have earned very high scores on tests of intellectual ability or academic achievement, and access to these special classes may be arranged even if the test records are not available. Although samples of very young, intellectually superior children cannot be located through the schools, parents of such children are very willing to respond to announcements requesting their participation in research. Samples of children identified by reliance on parent response to publicity about a study of intellectually superior children are, moreover, likely to yield a high proportion of appropriately able children (Jackson, Note 5).

While the generation of samples of intellectually superior children is not likely to be a problem in any urban academic community, description of the children in terms of standard test performance may present some difficulties. Standard tests normed for the children's age group may not provide enough challenging items to establish the limits of the children's abilities or to permit differentiation within the group. Even when raw score ceiling is sufficient, as is the case with most individually administered tests designed for a wide age range, standard scores may not exist for the raw score range within which many of the intellectually superior children will be performing. Imagine trying to establish a correlation between general intellectual ability and some cognitive measure when half the children in a sample have earned the maximum IQ possible for the test given.

Faced with such a ceiling problem, researchers may find themselves reduced to employing such inelegant procedures as extrapolation of standard scores above the published norms or administration of tests normed for older children. The latter procedure is the only way to cope with insufficient raw score ceiling in the age-appropriate measure, and it has worked well in a variety of practical and research settings (Roedell, Jackson, & Robinson, in press; Stanley, 1979) However, the adoption of a standard test normed for older children involves sacrificing some of the advantages of using standard measures. Reliability and validity data for the norming sample cannot be assumed to be applicable to younger groups. Age-appropriate standard scores are not available and computations must be based on raw scores, "test age" scores, scores standardized within the research sample, or standard scores for an older group. Each of these procedures has serious limitations. If interest in the study of intellectual superiority becomes more widespread, one worthwhile project would be the standardization of a set of general and specific cognitive ability measures for highly able populations at all age levels.

In general, there is a great need for development of a technology of cognitive research with intellectually superior children and for establishment of a readily accessible data base summarizing the characteristics of this population.

Conclusion

During the heyday of Piagetian theory, there was little need for mainstream developmental psychologists to concern themselves with the study of individual differences. Tests for individual differences ran counter to the spirit of the classic Piagetian approach, and the theory and measures could not readily be adapted to precise studies of individual differences. That era has passed, however, and more contemporary approaches to cognitive development are more amenable to applications of individual differences tests (e.g., Bereiter & Scardamalia, 1979). It is even possible that there will soon be substantial progress toward a process explanation of both developmental and individual differences in cognitive performance. This breakthrough will most likely come from the work of investigators and theorists who have applied rigorous individual differences methodology to the study of differences among groups of normal children whose cognitive performance ranges from average to superior.

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Table 1

Cognitive Performance Differences Between Intellectually Superior Children and Other Groups

Age or Grade Levels of Ss	Differences Related to Intellectual Status
	Learning
4, 6, & 8 years	high-IQ 4 year olds faster than average 4 year olds in solution of oddity learning problems (Brown, 1970)
K & 2nd grade	high-IQ kindergarteners more stable than average kindergarteners in use of reversal shift strategy in discrimination learning (Brier & Jacobs, 1972)
7-10 years	high-IQ group more likely to demonstrate incidental learning without prior "readiness" condition (Williams, 1970)
5th grade	When arithmetic problems matched to achievement level, high-IQ group not significantly different from average or low-IQ groups on short-or long-term relearning and transfer (Klausmeier & Check, 1962)

Table 1, cont'd.

Age or Grade Levels of Ss	Differences Related to Intellectual Status
11 years	high-IQ group more efficient in behavior during solution of arithmetic problems (Klausmeier & Laughlin, 1961)
14 years	high-IQ group more likely to make correct responses on discrimination learning tasks (Jensen, 1963)
	Memory and Speed of Information Processing
2nd & 4th grade	high-IQ groups more efficient in retrieval in a multi-trial free recall task (Robinson & Kingsley, 1977)
5th & 6th grade	high-IQ group faster in reaction time and rate of memory search in a visual recognition task (McCauley, Kellas, Dugas, & DeVellis, 1976)
10-13 years	high-IQ group better in short-term recall of digits, with group differences most pronounced on "recency" items (Cohen & Sandberg, 1977)

Table 1 cont'd.

Age or Grade Levels of Ss	Differences Related to Intellectual Status
9, 13 & 17 years	high-IQ groups faster in rate of memory search in a visual recognition task and faster in retrieval of semantic information in a letter identification task (Keating & Bobbitt, 1978)
	Reasoning
4, 6, & 8 years	high-IQ 4 year olds not significantly better than average 4 year olds in performance on two conservation tasks; high-IQ 4 year olds' performance inferior to that of average 6 year olds and retarded 8 year olds (Brown, 1973)
6-11 years	high-IQ children passed all concrete reasoning tasks but no child less than age 10 years 7 months passed all formal reasoning problems (Webb, 1974)
8 & 11 years	high-IQ 8 year olds equal to low-IQ 11 year olds, and high-IQ 11 year olds superior to agemates, in performance on conservation and combinatorial logic tasks (Goodnow & Bethon, 1966)

Table 1, cont'd.

Age or Grade Levels of Ss	Differences Related to Intellectual Status
11 & 13 years	mathematically able, high-IQ 11-year-old boys surpassed average 13 year olds in performance on concrete and formal reasoning tasks (Keating, 1975)
11 & 13 years	mathematically able, high-IQ boys at both ages more accurate than agemates in solution of verbal syllogisms; high-IQ groups' performance also superior to that of college students in another study (Keating & Caramazza, 1975)