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ABSTRACT

This report is on one aspect of a study that is trying to provide a reference basis for different researchers in their combined efforts to conceptualize and develop a theory and structure of human abilities and temperament. Specifically, the study is directed toward the identification of tests and other instruments that can serve as markers for well established factors. The present report is based on a review of analytical studies in the cognitive domain published in the decade 1963-1973. The first section of this review gives a brief description of different theories and models of cognitive factors. It is followed by a short summary of some of the major issues raised by the research on cognitive factors. Then the current status is described of each of the 24 factors in the 1963 edition of the Kit of Reference Tests for Cognitive Factors. The need to reconceptualize many of the factors in light of research findings is discussed. The final section of the report describes new factors which have appeared in the literature. Recommendations are made for the possible coverage in a revised Kit of Reference Tests such factors as chunking memory, concept formation, figural fluency, integration, memory for order, visual memory, and verbal closure. (Author)

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COGNITIVE FACTORS: SOME RECENT LITERATURE

by
Ruth B. Ekstrom

July 1973

Technical Report No. 2

Research Sponsored by the
Office of Naval Research

under

Contract N00014-71-C-0117
NR 150 329

Harry H. Harman
Principal Investigator

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Educational Testing Service
Princeton, New Jersey

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This report is on one aspect of a study that is trying to provide a reference basis for different researchers in their combined efforts to conceptualize and develop a theory and structure of human abilities and temperament. Specifically, the study is directed toward the identification of tests and other instruments that can serve as markers for well established factors.

The present report is based on a review of analytical studies in the cognitive domain published in the decade 1963-1973. The first section of this review gives a brief description of different theories and models of cognitive factors. It is followed by a short summary of some of the major issues raised by the research on cognitive factors. Then the current status is described of each of the 24 factors in the 1963 edition of the Kit of Reference Tests for Cognitive Factors. The need to reconceptualize many of the factors in light of research findings is discussed.

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Technical Report

Cognitive Factors: Some Recent Literature

Ruth B. Ekstrom

Abstract

This report is based on a review of analytic studies in the cognitive domain published in the decade 1963-1973. The main purposes of the review were to consider the status of the factors included in the Kit of Reference Tests for Cognitive Factors and to consider what additional factors might be added to a revised Kit.

The first section of this review gives a brief description of different theories and models of cognitive factors. It is followed by a short summary of some of the major issues raised by the research on cognitive factors.

The third section of the review describes the current status of each of the 24 factors included in the 1963 edition of the Kit. The need to reconceptualize many of the factors in light of research findings is discussed. Major recommendations include the removal of the length estimation and mechanical knowledge factors from the revised Kit, the development of new marker tests for speed of closure and for adaptive flexibility, the development of better scoring procedures for originality and spontaneous flexibility, and further study of the expressional fluency, semantic redefinition, and sensitivity to problems factors which have not been as clearly demonstrated as is desirable for inclusion in the Kit.

The final section of the report describes new factors which have appeared in the literature. Recommendations are made to include factors of concept formation, figural fluency, integration, visual memory, and verbal closure in the new revision of the Factor Kit since each has been fairly clearly demonstrated in several studies.

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Technical Report

Cognitive Factors: Some Recent Literature[1]

Ruth B. Ekstrom[2]

This report is on one aspect of a study that is trying to provide a reference basis for different researchers in their combined efforts to conceptualize and develop a theory and structure of human abilities and temperament. Specifically, the study is directed toward the identification of tests that can serve as markers for well established factors. The results of such research should go a long way in providing a structure for the cognitive domain of human abilities and a beginning for a comparable structure for the temperament domain of personality. Such theoretical structures are founded on empirical evidence and are amenable to continued challenge and verification. Researchers would be expected to use the resulting factor Kits by selecting a small number of tests as markers for testing conjectures about factors in their studies.

To help set general guidelines for procedures to be used in the study a conference was convened which included 20 prominent persons in the area of factor analysis and human assessment. Three guidelines that emerged are as follows: (1) A factor will be considered as "established" and markers for it will be included in the Kit if it is possible to identify it in at least three analyses performed in at least two different laboratories. (2) At least three tests will be provided as markers for each established cognitive factor; at

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[1]This study was supported by Office of Naval Research Contract N00014-71-C-0117. Opinions stated do not necessarily represent ONR position or policy.

[2]The author wishes to thank John W. French for his many helpful suggestions and comments on an earlier draft of this review.

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least four measures will be provided as markers for an established noncognitive factor, two for each of the opposite poles. (3) Newly developed tests and other measures for both the cognitive and noncognitive domains will be field tested in order to determine some of their basic statistical properties and to check their factorial content.

This technical report is aimed at the identification of "established" factors in the cognitive domain from a search of the literature. Such factors serve as the basis for the development of marker tests in the study. The literature search for the establishment of noncognitive factors is in a parallel report by John French. Psychomotor factors are not included. Analyses restricted to second-order and other higher order factor analyses are generally omitted.

Earlier work (French, Ekstrom, & Price, 1963) concluded that 24 cognitive factors had been sufficiently well established to be included in the Kit of Reference Tests for Cognitive Factors. This review will consider the status of these factors as well as considering what additional factors might be added to a revised Kit.

As in earlier studies, the criterion for deciding that a factor is "established" is that it is reported in at least three separate studies and that these studies be done by at least two different researchers or laboratories. Thus, no one researcher's factors are considered established unless they have been replicated by others.

The matching of factors across studies is dependent, not only upon the researcher's interpretation, but also upon the reviewer's analysis of the tests or tasks which load on these factors. The search here is for the psychological meaning of the factors not a mere matching of semantic terms used to name the factors. It has been necessary to omit a number of studies from this review because either too few or too many factors were extracted, because of inadequate rotations, or because there were too few tests to allow adequate factor determination.

The number of factor analytic studies attempting to isolate new factors has diminished substantially since the period of the last review (1952-1963). A major source of research into new cognitive factors has been the laboratory of J. P. Guilford. Additionally, the Structure of Intellect model developed by Guilford appears to have been the stimulus for alternative models developed by other researchers (Cattell, Guttman, Royce, etc.) as well as extensive testing of the SI model. There has also been some reanalysis of Guilford's work (Harris, Eindhoven, etc.). The other research emphases during this period have included the confirmation of the already established factors in other cultures, the determination of the degree to which factors are affected by culture and environment, and the relationship of established factors to different kinds and stages of learning.

Relation of Established Factors to Existing Models

In the 1963 Kit, an attempt was made to show how the 24 Kit factors compare with the cognitive structures described in the work of Thurstone, Cattell, and Guilford. Since additions and revisions have been made in some of these models and other models have been developed, these comparisons are reviewed in Table 1.

Thurstone. Table 1 shows the relation of the Thurstone factors to those in the 1963 Kit:

Table 1

Hypothesized Matching of Thurstone and Kit Factors

Thurstone	1963 Kit	ETS Symbol
Closure 1	Speed of Closure	Cs
Closure 2	Flexibility of Closure	Cf
Deductive	Syllogistic Reasoning	Rs
Inductive	Induction	I
Memory	Associative (Rote) Memory	Ma
Number	Number Facility	N
Perceptual	Perceptual Speed	P
Space 1	Spatial Orientation	S
Space 2	Visualization	Vz
Verbal Comprehension	Verbal Comprehension	V
Word Fluency	Word Fluency	Fw

As can be seen from the above table, there is a close correspondence between the factors found by Thurstone and those in the 1963 Kit.

Cattell. There is also a close correspondence between Cattell's cognitive factors and those in the Kit, as can be seen from Table 2. Cattell's model with factors organized in a hierarchical manner implies, of course, oblique factors. However, studies from Cattell's laboratory suggest that he accepts several of Guilford's factors not included in this list.

Cattell (1971) has presented an Ability Dimension Analysis Chart which provides a theoretical schema by which cognitive abilities can be organized. This chart has three major dimensions: (A) Action Phases, (C) Content, and (P) Process Parameters.

The three action phases are: (1) involvement of input, (2) involvement of internal processing and storage, and (3) involvement of output. The

Table 2

Hypothesized Relationship between Cattell and Kit Factors

Cattell	Universal Index	1963 Kit	ETS Symbol
Verbal Ability	U. I. (1)	Verbal Comprehension	V
Numerical Ability (Basic Manipulation Facility)	U. I. (2)	Number Facility	N
Spatial Ability	U. I. (3)	Spatial Orientation	S
Perceptual Speed (Figural Identification)	U. I. (4)	Perceptual Speed	P
Speed of Closure (Visual Cognition, Gestalt Perception)	U. I. (5)	Speed of Closure	Cs
Inductive Reasoning (General Reasoning)	U. I. (6)	Induction	I
		General Reasoning	R
Deductive Reasoning (Logical Evaluation)	U. I. (7)	Syllogistic Reasoning	s
Rote Memory (Associative Memory)	U. I. (5)	Associative (Rote) Memory	[illegible]
Mechanical Knowledge and Skill	U. I. (8)	Mechanical Knowledge	Mk
Word Fluency	U. I. (9)	Word Fluency	Fw
Ideational Fluency	U. I. (10)	Ideational Fluency	Fi

(Table 2 Cont

Cattell	Universal Index	1963 Kit	ETS Symbol
Restructuring Closure (Flexibility of Closure)	U. I. (11)	Flexibility of Closure	Cf
Flexibility vs. Firmness (Originality)	U. I. (6)	Originality	O
General Motor Coordination (Psychomotor Coordination)	U. I. (12)	-----	--
Manual Dexterity (and Aiming)	U. I. (13)	-----	--
Musical Pitch and Tonal Sensitivity	U. I. (14)	-----	--
Representational Drawing Skill	U. I. (15)	-----	--
Expressional Fluency	U. I. (70)	Expressional Fluency	Fe
Motor Speed	U. I. (71)	-----	--
Speed of Symbol Discrimination	U. I. (72)	-----	--
Musical Rhythm and Timing	U. I. (73)	-----	--
Judgment	U. I. (74)	-----	--

involvement of input is "the extent to which the ability score rests upon sensory input activity relative to the stimulus." It is largest in perceptual activities. The involvement of internal processing is "the extent to which processing of resources of shortage determine the score." It is largest in memory measures. The involvement of output, largest in performance measures, is "the extent to which qualities of output determine the score."

The two content dimensions are (1) experiental-cultural, including verbal, numerical, social, spatial, mechanical, artistic, and scientific subdimensions, and (2) neural-organizational, including visual, auditory, kinesthetic, tactile and motor subdimensions. These correspond to the distinctions made by Horn and Cattell (1966) between fluid and crystallized intelligence.

The seven process dimensions are: (1) demand in terms of complexity level of relation education, (2) demand in terms of multiplexity of sets, (3) amount of committing to memory, (4) amount of retentive activity involved, (5) amount of retrieval activity, (6) flexibility vs. firmness, and (7) speed demand.

Cattell considers these to be 12 distinct dimensions each of which can vary along a scale ranging from high to low. "If one considers only above average or high and below average or low on each of these dimensions, there would in fact be $2^{12} = 4096$ types of abilities." However, Cattell does <u>not</u> assume that there must be as many factors as types; he stated (in 1971) that he hypothesized there are between 12 and 30 factors.

<u>Guilford</u>. The Guilford model of the Structure of Intellect is, as was mentioned earlier, widely known and has been a source of stimulation for many

researchers during the past decade. The relationship of the Guilford model to the 1963 Kit is shown in Table 3.

The Guilford model contains 120 factors, only 18 of which have a one-to-one correspondence with factors in the 1963 Kit; four other Kit factors are composed of a combination of two or three Guilford factors.

The Guilford model is based on orthogonal factors and can be represented by a three-dimensional box with each dimension representing one of the three major facets: (1) operations, (2) contents, and (3) products. The five operations are: (1) cognition, (2) memory, (3) divergent production, (4) convergent production, and (5) evaluation. The contents are figural, symbolic, semantic, or behavioral. The six products are: (1) units, (2) classes, (3) relations, (4) systems, (5) transformations, and (6) implications. At present Guilford (1971) claims to have found 98 of these 120 factors. However, a tabulation of the data from Guilford studies indicates that only 50 of the 120 factors had one or more tests hypothesized for that factor actually loading on it in three or more studies. Only one of the memory factors, MSI, had the hypothesized tests loading on it in three or more studies. Only two of the behavior factors, CBS, and CBR, appeared in three or more studies.

Guttman. The Guttman model is based on a faceted definition of intelligence. There are two major facets: (1) the language of communication (verbal, numerical, or figural) and (2) the type of task imposed on the subject (rule-inferring or rule-applying). A later addition to the theory has included school-achievement as a third facet.

Figure 1, reproduced from the Proceedings of the 1969 Invitational Conference on Testing Problems, shows the Guttman circumplex and the location of some cognitive tasks on this model.

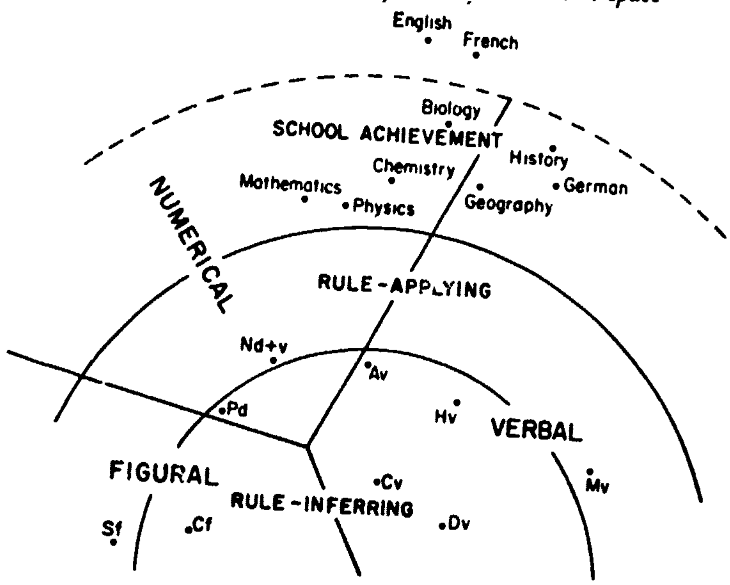
Table 3

Hypothesized Matching of 1963 Kit and Guilford Factors

1963 Kit	ETS Symbol	Guilford Factor Trigram
Flexibility of closure	Cf	NFT
Speed of Closure	Cs	CFU
Associational fluency	Fa	DMR
Expressional fluency	Fe	DMS
Ideational fluency	Fi	DMU
Word fluency	Fw	DSU
Induction	I	CFC, CSC, CSS
Length estimation	Le	---
Associative (Rote) Memory	Ma	MSI
Mechanical knowledge	Mk	---
Memory Span	Ms	MSU, MSS
Number facility	N	NSI, MSI
Originality	O	DMT
Perceptual speed	P	EFU, ESU
General reasoning	R	CMS
Semantic redefinition	Re	NMT
Syllogistic reasoning	Rs	EMR
Spatial orientation	S	CFS
Sensitivity to problems	Sep	CMI
Spatial scanning	Ss	EFI
Verbal comprehension	V	CMU
Visualization	Vz	CFT
Figural adaptive flexibility	Xa	DFT
Semantic spontaneous flexibility	Xs	DMC

Figure 1

The 18 Variables of Höger's Study Portrayed in a Two-space



Variables Included in Höger's Study

Code	*Description of variables*		
Rule-inferring			
Cv	Complete one missing word in sentence		
Dv	Find which word is different from given set of words		
Av	Word analogies		
Hv	Give subordinates of two words (e.g., rose-tulip)		
Pd	Numerical progressions		
Cf	Find which of five geometric figures (circles, squares, etc) can be put together from given parts of figure		
Rule-applying			
Mv	Subject memorizes 25 words, each belonging to one of the following categories: flowers, tools, artifacts, birds, animals; then he is asked questions of the following form: The word beginning with the letter a was: . . . (a flower, a tool, a bird . . .)		
Nd + v	Verbally formulated arithmetic problems		
Sf	Match cubes presented in different orientations in space		
School-achievement			
	German	French	Biology
	History	Mathematics	Arts
	Geography	Physics	Music
	English	Chemistry	

Royce. In an attempt to build a framework for a multi-factor theory of individuality, Royce has reviewed both the cognitive and affective literature (Royce, 1973). He considers all of the 1963 Kit factors to be adequately established with flexibility of closure, speed of closure, word fluency, induction, associative memory, number, perceptual speed, spatial relations, and verbal comprehension as the best established of these factors and memory span, originality, semantic redefinition, syllogistic reasoning, (deduction), spatial scanning, sensitivity to problems, figural adaptive flexibility, and spontaneous flexibility as the weakest.

He hypothesizes a hierarchial structure of intelligence factors consisting of six second-order factors and 21 first-order factors. The model is illustrated in Figure 2. He then goes on to a tentative synthesis of cognition based on five hypothesized third-order factors: sensory integration, verbal, nonverbal, speed, and psychomotor integration. A later step in this model postulates relationships between selected cognitive and affective factors as illustrated in Figure 3. This is one of the few attempts that has been made to relate cognitive style factors to cognitive structure.

Harris. A reanalysis of nine of Guilford's studies (involving creative thinking; evaluative abilities; planning; general reasoning; reasoning, creativity, and evaluation; problem solving abilities; and cognition and convergent production) by the use of a strategy for determining comparable common factors in a set of data was reported by the Harrises (1971). They found that while a few of the comparable common factors agreed with those obtained by Guilford, in many instances two or more of his factors combined into one comparable common factor. While the Harrises have made no attempt to interpret these factors, inspection of the data suggests that they correspond more closely with those

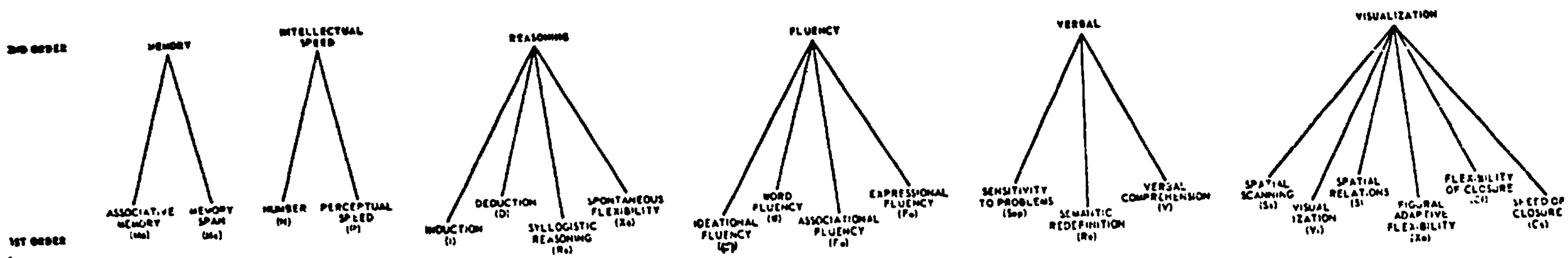


FIGURE 2. HIERARCHICAL STRUCTURE OF INTELLIGENCE FACTORS

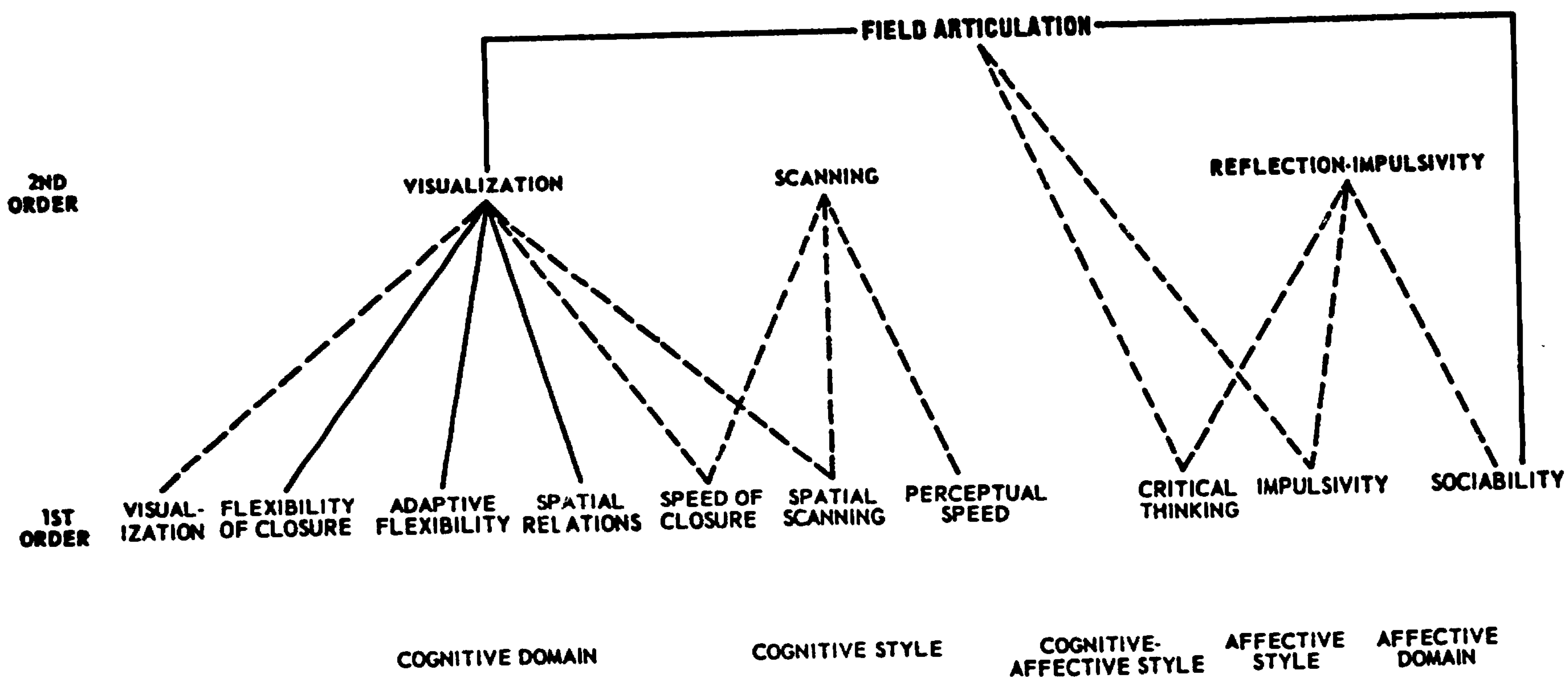


FIGURE 3. POSTULATED LINKAGES OF STYLE FACTORS TO COGNITIVE AND AFFECTIVE STRUCTURE (SOLID LINES INDICATE EMPIRICALLY BASED LINKAGES).

of Thurstone and of the 1963 Kit than with Guilford's model. This technique offers a promising means to clarify much of the existing confusion about the nature of many factors. Unfortunately, such a reanalysis of the studies discussed in this review is outside of the scope of this project.

Some Unresolved Issues

Several researchers have suggested that the speed vs. power or difficulty dimensions may be important in differentiating among factors.

Eysenck (1967) has proposed a model which incorporates speed and power in one dimension which he calls quality; reasoning, memory, and perception in a second dimension which he calls mental processes; and verbal, nonverbal, and spatial content in the test material dimension.

Werdelin and Stjernberg (1971) found that, for visual and perceptual tests, "the more difficult the test the higher its loadings on the S and R factors, and the easier the test the higher its loadings on the N and particularly the P factor." Royce (1973), as was noted earlier, had suggested speed as a second-order factor including number and perceptual speed. He has also suggested that the cognitive style called scanning may has a second-order factor relationship to speed of closure, perceptual speed, and spatial scanning.

Increasing factor differentiation and other changes in factor structure related to age and/or experience are another important issue.

Radcliffe (1966) and Silverstein (1969) have replicated earlier studies (Cohen, 1957; Maxwell, 1960) of the factor structure of the Wechsler Adult Intelligence Scale. Radcliffe found that the structure of the WAIS becomes more complex with age. Silverstein points out that, if Kaiser's criterion for retaining as many factors as there are latent roots greater than one is employed, only two factors are needed for nine of the 13 age groups and only one factor for the remaining four groups. Other studies (Mukherjee, 1962; Osborne and Lindsev, 1967; Quereshi, 1967) have all supported the differentiation hypothesis. However, Hollenbeck and Kaufman (1973) found no increase in the number of factors in the WPPSI at three different age levels. Weiner (1964) rejected the differentiation hypothesis in his study of the General Aptitude Test Battery with subjects from age 14 to 54 and Meyer and Bendig (1961) found no evidence for increasing differentiation of abilities on the Primary Mental Abilities Test from grade 8 to 11. Burt (1960) pointed out in commenting on earlier analyses of the Wechsler that "it is quite unjustifiable to assume that one and the same factor patterns will appear at all levels and with all types of children."

Aftanas and Royce (1969) administered a battery of tests for brain damage to 100 normal subjects age 16-70. After factor analyzing the battery, they analyzed the factor scores as a function of age. Two factors, identified as perceptual-motor speed and temporal perception resolution, showed significant differences related to age.

Khan (1970) conducted a study "to determine the extent to which verbal, numerical, spatial, and perceptual speed will be differentiated as a function of differing amounts of classroom learning." He administered 12 tests from the 1963 Kit to students in grades 7, 9, and 11. He found the verbal and numerical abilities at grade 7, spatial scanning emerged at grade 9, and all four factors were distinct at grade 11. Khan concludes that "the results provide support for the hypothesis that mental abilities become differentiated as a function of increased learning experience." A second study (Khan, 1972) shows that learning experiences can be designed to lead to increased factor specificity and differentiation.

One question is whether the difficulty level of tests is responsible for the lack of factor differentiation in young children. It may well be that the nature of the abilities changes with age (so that an addition task might load on a reasoning factor with very young children but on a speed factor with older children for whom it is more likely to be an over-learned, near-mechanical response). Possibly the nature of the tests used must be changed in order to make the mental process or ability required by the test be the same at different age levels. Smart (1965) has discussed the changing nature of intelligence test factors at different ages.

One hypothesis for factor differentiation with age is that new factors appear as the child reaches different developmental stages. An interesting test of this hypothesis could be made by taking children at certain "critical" ages, determining whether or not they had attained a new developmental level (such as Piaget's stage of concrete or formal operations), and comparing factor structures by developmental stage.

Although the tests in the 1963 Kit and in the revision now under preparation are not designed for use with young children (below age 12), such uses have been reported in the literature (for example, Getts, 1971). The differences in factors at various age levels help to clarify the nature of the process. Also, it is important to note that problems of factor differentiation do not disappear miraculously at age 12 but may continue on into adolescence (Khan, 1970; Dye and Very, 1968) or even into adulthood.

A related question is the degree to which strategies for the solution of a task are related to factor structure. Studies by Fleishman and Rich (1963), Bunderson (1964), Kohfeld (1966), and Frederiksen (1969) all suggest "that the 'factorial composition' of a learning task reflects the kinds of strategies elicited by the task. Since strategies employed early in learning may be quite different from those employed late in learning, the consideration of strategies as mediating responses to the task situation may be important" (Frederiksen, 1969). Frederiksen found five strategies which were used in verbal learning. An earlier study of problem-solving strategies and their relation to the factor composition of tests (French, 1965), indicated that the use of a "system" to solve a test tends to reduce the factor loading probably because it allows solution of the test items by techniques different from those the test constructor had in mind. Considerably more research is needed on the relationship between strategies and the nature of factors.

Another concern has been the comparability of factors across cultures. Semler and Iscoe (1966) compared the structure of intellect of American White and Negro children ages 5 to 9 on the WISC and Progressive Matrices. They found a verbal, non-verbal, and motor factors for each group but noted some differences in the structure of these factors for each group. Lovinger et al. (1966) found that the factor structure for Negro adolescents on the WISC was congruent with the normative group although there were differences in level of scores.

Claeys (1967), El-Abd (1970) and Irvin (1966, 1969) have been concerned with comparison of abilities in Western and in African cultures. Claeys challenges the theory that the "nature of traits" is completely determined by cultural circumstances. He obtained factors similar to four of Thurstone's primary mental abilities. El-Abd administered seven tests from the 1963 Kit, 5 tests developed by Thurstone, as well as two of his own tests to high school and college students in Uganda. These measures were selected as "an American test battery" representing seven "already known psychological factors." He found that "the seven factors were identifiable in both samples, tending to sustain the assumption that the structure of mental abilities in East Africa is similar to that of Western students." Irvin (1969) has summarized a number of studies with subjects from Zambia, Rhodesia, and Kenya. He found that "tests tend to be classified the same way from sample to sample, and these classifications show the major cognitive dimensions of reasoning, verbal, numerical, and perceptual abilities."

The cognitive abilities of Canadian Eskimo, White and Indian-Metis children age 9 to 12 were studied by MacArthur (1969). He obtained two factors, verbal and reasoning from non-verbal stimuli, for each sample.

Lesser, Fifer, and Clark (1965) studied verbal, reasoning, number, and space conceptualization abilities in middle and lower class groups of Chinese, Jewish, Negro, and Puerto Rican six- and seven-year-old children. They found that, while "both social class and ethnicity affect the level of intellectual performance, only ethnicity fosters the development of different patterns of abilities."

Guthrie (1971) administered 11 non-verbal tests from the 1963 Kit to a group of Vietnamese and American helicopter mechanics. "The Vietnamese equalled or exceeded the American on numerical, visualization, perceptual speed, length/estimation, and flexibility of closure factors, but were significantly lower on spatial and mechanical knowledge." Guthrie concludes that when "testing conditions are equated, most differences in non-verbal abilities are reduced or disappear. The persistence of differences in spatial abilities, and to some extent mechanical knowledge, appears to be due to a failure to learn Western conventions for representation of three dimensions."

Vandenberg (1967) has compared mental abilities in South American and Chinese students using the Primary Mental Abilities Tests. He found factors of native language ability, verbal ability in English, memory, space, perceptual speed, number and reasoning in each sample. The coefficients of congruence for matching the factors across samples ranged from a high of .95 for the verbal and memory factors to a low of .78 for the reasoning factor.

Flores and Evans (1972) have compared cognitive abilities in Canadian and Filipino students using the Primary Mental Abilities Tests, Raven's Progressive Matrices, and several tests from the 1963 Kit. They found factors of relational thinking, automated learning, verbal comprehension, spatial fluency, numerical facility, memory, and ordering.

Sex-differences in cognitive factors have been explored by Meyer and Bendig (1961), Dye and Very (1968), and Very and Iacono (1970). These differences are probably largely attributable to differences in the socialization of males and females although genetic influences cannot be ruled out. However, MacArthur (1969) comments that he found no sex-differences in the factors in his study.

An extensive discussion of the relationship of age and sex to ability can be found in Cattell (1971).

Another area of difficulty is the lack of relevance of much of the factor analytic theories to "real world" situations. It is relatively easy to devise exotic paper and pencil tests which will fill a gap in a theory of cognitive structure but much more difficult to extract the structure of more usual human behavior. A number of attempts have been made in recent years which may make cognitive theories more relevant. These include Taylor's (1967) work on creativity, Cattell's objective test factors of personality, and Guilford's factors in the behavioral realm. An attempt must be made to integrate cognition, psychomotor skills, cognitive styles, and temperament factors into a meaningful whole and to relate this to experimental psychology and to neurological and genetic research rather than continuing to treat these as separate entities.

Current Status of Established Factors

In this section we will review the recent literature pertaining to each of the 24 factors included in the 1963 Kit of Reference Tests for Cognitive Factors.

Flexibility of Closure. The 1963 Kit manual defined this factor as "the ability to keep one or more definite configurations in mind so as to make identification in spite of perceptual distraction." Since that time, there have been several studies which suggest that this definition be revised. It now appears that the subject usually keeps only a single configuration in mind at one time when making the perceptual search; moreover the nature of the perceptual distraction is always some other design in which the given configuration is embedded. Royce (1973) defines flexibility of closure as "ability to 'hold in mind' a particular visual percept (configuration) and find it embedded in distracting material." There is now some question as to whether or not Guilford's Convergent Production of Figural Transformations (NFT) is the same as flexibility of closure. The best markers for NFT according to Guilford and Hoepfner (1971) are the Penetration of Camouflage Test, where the subject does not know the configuration for which he is searching, Hidden Figures, a five-option embedded figures test similar to Cf-1, and Internally Consistent Figures, which requires subjects to transform a representation from two-dimensional to three-dimensional in order to detect inconsistencies. There is a great need for further research on the flexibility of closure factor in order to increase our understanding of this ability. Wardell (1973) has suggested that flexibility of closure and figural adaptive flexibility may be the same.

The markers for flexibility of closure in the 1963 Kit were: (1) Hidden Figures, which requires the subject to decide which one of five figures is embedded in a more complex design, (2) Hidden Patterns, which requires the subject to decide whether or not a sample figure is embedded in a more complex design, and (3) Copying, which requires the subject to copy a simple figure onto a matrix of dots.

The Hidden Figures Test has proven to be less clearly related to the two better established types of flexibility of closure tests, Hidden Patterns (Cf-2) and Copying Tests (Cf-3) than is desirable. (See, for example, Ekstrom, 1967 or Kropp and Stoker, 1966.) It is hypothesized that this is because of the multiple-choice nature of the Hidden Figures Test which requires the subject to decide which one of five stimuli is embedded in a complex pattern. While this multiple-choice version has been shown to be useful in the selection of individuals for jobs such as military photo interpreter (Johnson, 1971), it is planned to revise this test so that a single stimulus figure is searched for in each item.

Another major question for further research is the relationship of flexibility of closure to the cognitive style of field-independence or field articulation as described in the work of Witkin and others. As was mentioned above, Royce (1973) considers flexibility of closure one of six factors which combine into a second-order visualization factor which then combines with two other second-order factors, scanning and reflection-impulsivity, into the field articulation factor. Hettema (1968) has suggested that field-dependence may be a separate factor lying conceptually between flexibility of closure and speed of closure. Witkin et al. (1971) have stated that "some of the well-known dimensions earlier identified in studies following a factor-analytic approach are very likely the same as, or at least very similar to the field-dependence-independence dimension - for example, the adaptive flexibility dimension of Guilford and his associates and the flexibility-of-closure dimension of Thurstone." Cattell (1971) calls this factor restructuring closure and thinks that it is an aptitude component of the personality trait, critical practicality. Kropp and Stoker (1966) have found flexibility of closure to be a significant predictor of the cognitive processes described by Bloom (1956) as knowledge, comprehension, application, analysis, evaluation, and synthesis.

Several researchers (Nasca, 1965; Kropp and Stoker, 1966; Ekstrom, 1967; Adcock and Martin, 1971) have used the Hidden Figures and Hidden Patterns Tests and obtained factors interpreted as flexibility of closure. Frederiksen (1965) used all three marker tests to obtain this factor. El-Abd (1970) and Reed (1966) used the Hidden Patterns and Copying Test and found a flexibility of closure factor. Other studies which obtained flexibility of closure factors are Carver et al. (1971), Hettema (1968) and Messick and French (1967).

However, in at least two studies (Holmberg, 1967; Ohnmacht et al., 1970) the two closure factors, Cf and Cs, are combined.

Speed of Closure. This factor was defined in the 1963 Kit as "the ability to unify an apparently disparate perceptual field into a single percept." Royce (1973) has defined it as "ability to 'take in' a perceptual field as a whole, to 'fill in' unseen portions with likely material and thus to coalesce somewhat disparate parts into a visual percept." Guilford and Hoepfner (1971) have raised two questions about the nature of this factor: (1) how much emphasis should be placed on acts of closure which require the subject to fill in gaps in objects in order to interpret them as unitary wholes, and (2) whether closure against distractions are a necessary part of this factor.

As was mentioned above in the discussion of flexibility of closure, there has been some evidence that these two factors tend to combine. As was suggested in the 1963 Kit manual, a major distinction between these factors may be whether or not the subject knows the configuration for which he is searching. A second problem is to determine whether there is a significant difference between the process of disembedding and of location of a figure amid perceptual distractions.

Frederiksen (1965) has shown that speed of closure is positively identified with the ability to recognize ambiguous visual stimuli due to the inference effects which are required for early identification of out-of-focus pictures. Hoffman et al. (1968) found a task requiring the identification of close-up pictures to load on speed of closure. Wardell (1973) suggests that speed of closure may be related to extensiveness of scanning.

Cattell (1971) considers that speed of closure is an aptitude component of the personality factor, restraint-timidity. Adcock and Martin (1971) have posited the existence of separate divergent and convergent forms of this factor. Both Adcock and Martin and Messick and French (1967) suggest that there may be both semantic and perceptual speed of closure factors.

Frederiksen (1965), used Gestalt Completion (Cs-1) and Concealed Words (Cs-2) and found a speed of closure factor. However, he questions the status of this factor "as a separate, unitary cognitive ability." He suggests that "tests for speed of closure may potentially involve the same interference effects which are observed in experiments in perceptual recognition."

The 1963 Kit included Gestalt Completion and Concealed Words as the reference tests for this factor. The former requires the subject to name the object or action which is being portrayed in black blotches which form an incomplete representation. The latter requires the subject to identify a word which has been partly erased.

There was some hesitancy about the inclusion of Concealed Words as a marker for this factor since there was some evidence that it might better represent the then inadequately researched verbal closure factor.

While fairly clear speed of closure factors involving both reference tests have been found by some (Kropp & Stoker, 1966; Ekstrom, 1967; El-Abd, 1970), evidence since the publication of the 1963 Kit has more often shown that Gestalt Completion and Concealed Words have failed to combine into a single speed of closure factor. Messick and French (1967), Haynes (1970), Adcock and Webberley (1971), and Adcock and Martin (1971) and Harris and Harris (1971) all found these two tests to load on separate factors. Gestalt Completion loaded with Word Patterns and Circle Reasoning Tests in Haynes study onto a factor which he describes as "the ability to organize incomplete stimuli into meaningful categories." Messick and French (1967) found Gestalt Completion to combine with Guilford's Hidden Picture Test on a factor they interpret as "speed of perceptual closure." Harris and Harris found their Gestalt Completion Test combining with a Spatial Relations Test which also requires "visualization of missing portions of figures." The Harrises found Concealed Words to load with Omlet and Spelling Tests on a factor which they interpreted as word fluency. Haynes described the factor on which Concealed Words loaded as "the ability to group symbolic material into class structure." Adcock and Webberley identified the factor on which Concealed Words loaded as "Word Gestalt Completion."

It is obvious that these two tests are not reliable markers for the same factor. More work needs to be done to determine if there are separate speed of perceptual closure and speed of semantic closure factors and to see how these and other tests relate to the factors.

The work by Frederiksen and by Guilford has suggested that identification of objects photographed at very close range and/or out-of-focus might be new marker tasks for speed of perceptual closure. Guilford has also used a speed of closure test called Hidden Print, which requires the subject to identify a letter hidden in a field of dots. A similar test was tried out for the 1963 Kit and was found wanting, perhaps (it now seems), because of the inadequacy of the other marker tests. A more complete discussion of verbal closure will be found in the section on newly established factors.

Associational Fluency. The definition of this factor in the 1963 Kit was "the ability to produce words from a restricted area of meaning."

Pawlik (1966) has pointed out that this factor is not "simple fluency of word production" but requires "quality rather than fluency of word production." This would suggest that a task requiring the selection of the "best" synonym might load on an associational fluency factor. Royce (1973) defines associational fluency as "facility in producing English words having somewhat similar meanings." There appears to be no evidence to suggest that this factor is confined to the English language. It would be interesting to determine if the

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ability to produce an appropriate word when translating a well-known foreign language would involve associational fluency.

The four fluency factors, associational fluency, expressional fluency, ideational fluency, and word fluency are, of course, closely related. Royce (1973) hypothesizes that they combine into one second-order factor.

The flexibility factors are also closely related to fluency and originality factors. There have been a number of discussions (such as Cropley, 1966; Fee, 1967; Murphy, 1973; & Ward, 1967) of the role fluency, flexibility, and originality play in various "creativity" tests, such as those of Torrance or Wallach and Kogan.

Cattell (1971) states that all of the fluency factors are related to such temperament factors exhuberance. He also points out the relationship between fluency and memory factors, since "ease of retrieval" plays a significant role in fluency.

Taylor et al. (1967) have found associational fluency related to ability to such activities as instructing others, conducting conferences and interviews, and writing reports.

Factor-analytic studies of the word association process provide some further insight into the nature of associational fluency. Nunnally and Hodges (1965) found separate factors for associations of antonyms, synonyms, and "spatial relations" (objects frequently seen together); additional hypothesized factors of active functions and passive functions were not found, however.

The tests recommended as markers for associational fluency were: (1) Controlled Associations, which requires the subject to write as many synonyms as possible for each stimulus word; (2) Associational Fluency, which also requires producing as many synonyms as possible, and (3) Associations IV, which requires the production of a word associated with two given words but which has a different meaning. Guilford now feels that Associations IV is a better marker for the originality factor than for associational fluency.

Controlled Association and Associations IV have been used in three factor analytic studies (Kropp & Stoker, 1966; Reed, 1966; Ohnmacht et al., 1970). Only the last named study yielded a clear associational fluency factor. However, lack of enough markers to determine all the expected factors was a problem in each of these studies. In many cases the associational fluency tests tended to load with vocabulary.

Other studies (Bereiter, 1960; Christensen & Guilford, 1963; Guilford, Fulgosi, and Hoepfner, 1970; Hoepfner & Guilford, 1965) have used Controlled Association or similar tests and Simile Insertions, a test which requires the production of a variety of adjectives to complete descriptive phrases, to mark associational fluency. Bereiter did not obtain an associational fluency factor but found that, for his sample of girls, Controlled Associations loaded on a factor which included Object Naming, Form Completion, and Brick Uses and which he interpreted as a personality factor arising from "differences in looseness or rigor with which Ss interpret the given restrictions." The Guilford studies found a clear associational fluency factor. In two of the Guilford studies, a test called Inventive Opposites, which requires producing two antonyms for a given word, also occurred on this factor.

Taylor et al. (1967) also obtained an associational fluency factor which included Suffixes and First and Letter Tests.

Getzels and Jackson's Word Association Test has also been used in factor analyses (Cave, 1970; Haag & David, 1969). Unfortunately, neither study in cluded enough other tests of associational fluency to allow this factor to emerge.

Expressional Fluency. This factor was defined in the 1963 Kit as "the ability to think rapidly of appropriate wording for ideas." It requires producing connected discourse in contrast to the production of isolated words required in associational fluency and word fluency. Expressional fluency differs from ideational fluency in requiring rephrasing of ideas already given instead of the production of new ideas.

Royce (1973) defines expressional fluency as "facility in finding an appropriate word or set of words to make a proper English expression." Pawlik describes expressional fluency as the ability to "supply proper verbal expressions for ideas already stated or to find a suitable expression which would fit a given semantic frame of reference" and suggests that it is related to Cattell's temperament factor "Surgency vs. Desurgency." Pawlik considers the Naming factor which has been found in studies by Carroll (1941) and by Guilford to be a sub-factor of expressional fluency. Taylor et al. (1967) found expressional fluency to be related to editing ability. Their Naming Facility factor appears to be a sub-factor of expressional fluency.

Guilford and Hoepfner (1971) state that the production of short sentences of about 4 words in length, with the initial letter of each word specified, is the optimal method of measuring expressional fluency. The Expressional Fluency Test (Fe-1) in the 1963 Kit meets these requirements exactly. The other two tests suggested as markers for this factor were Simile Interpretations (Fe-2), which require the subject to complete a sentence in as many ways as possible, and Word Arrangements (Fe-3), which requires the subject to write as many sentences as possible, each containing four specified words. These tests suggest the need for some revision of the factor definition since none of the markers require an appropriate wording for a given idea.

All three of these tests were used in studies by Bereiter (1960) by Christensen and Guilford (1963), and by Mullins (1967). In the Bereiter study, Simile Interpretations failed to load as heavily as expected on a factor with the other two expressional fluency tests. Simile Insertions and Object Naming Tests loaded on the factor with Expressional Fluency and Word Arrangement. In the Guilford study, a clear expressional fluency factor was obtained. Mullins also obtained a fairly clear expressional fluency factor but Simile Interpretations had nearly as high a loading on another factor which included inductive and deductive reasoning tests.

Hoepfner and Guilford (1965) and Brown et al. (1966) both found the factor with Expressional Fluency and Simile Interpretations, but the loadings were not completely clear. Taylor et al. (1967) found an expressional fluency factor marked chiefly by the Letter-Star Test.

Kropp and Stoker (1966) and Reed (1966) used Simile Interpretations and Word Arrangements. Neither obtained a clear expressional fluency factor, perhaps due to an insufficient number of marker tests for the factor.

In view of these studies, the expressional fluency factor appears to have little support. Certainly Simile Interpretations should not be used as a marker for this ability.

Ideational Fluency. This factor was defined in the 1963 Kit as "the facility to call up ideas wherein quantity and not quality of idea is emphasized." However, the definition was focused on the semantic aspect of this factor. There is a major question as to whether or not there is a separate figural ideational fluency factor or if the two factors are essentially comparable except for the content of the input and/or response.

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Royce (1973) defines ideational fluency as "ability to quickly produce ideas and exemplars of an idea about a stated condition or object." Pawlik (1966) describes ideational fluency as "the ability which provides for rapid production of ideas fitting a given specification." Taylor et al. (1967) have suggested that individuals with very high or low ideational fluency may be less effective in transmitting information than those with middle range scores on this factor.

The tests included in the 1963 Kit as markers for ideational fluency were Topics (Fi-1), which requires the subject to write as many ideas as possible on a given subject, Theme (Fi-2), which asks the subject to write as much as possible about a topic, and Things Category (Fi-3), which asks the subject to list as many items as possible that are alike in some way. Cattell (1971) also suggests Topics as a marker test for this factor. Other ideational fluency tests which he recommends are Riddles, Plot Titles, and Uses. Guilford and Hoepfner (1971) found Consequences, Ideational Fluency, Plot Titles, and Utility Test to be good markers for this factor. With both authors the scoring of these tests focuses on total production of responses, not on the number of unusual responses (probably an indication of originality) nor changes in response categories (an indicator of flexibility).

All three ideational fluency markers from the 1963 Kit were used by Kropp and Stoker (1966), Locke (1963), and Reed (1966). Only Locke obtained a clear ideational fluency factor. He found that Consequences, Categories, Pertinent Questions, and three sections from the AC Test of Creative Ability also loaded on this factor. Reed, however, found that the three ideational fluency tests did not combine on a single factor. Topics and Theme combined with Word Arrangement (Fe-3) and the Utility Test (scored for flexibility) while Thing

Categories appeared on another factor also with the Utility Test. Kropp and Stoker (1966) used Topics and Things Category. The ideational fluency and expressional fluency factors combined at each grade level of the Kropp and Stoker study; the Apparatus Test (Sep-1) and Plot Titles (O-1) also loaded consistently on this factor.

In studies from Guilford's laboratory (Christensen & Guilford, 1963; Hoepfner & Guilford, 1964; Brown, Guilford & Hoepfner, 1966; Hendricks et al., 1969; and Guilford, Fulgosi, & Hoepfner, 1970), Thing Listing (also called Ideational Fluency), Brick Uses, Plot Titles, and Consequences were important markers for the ideational fluency factor. In the 1963 study the Brick Uses Test produced a doublet on which both its flexibility and fluency score loaded. The 1969 study included idea production factors in the behavior areas as well as ideational fluency. In the 1970 study, tests of Agent-Action Relations, Class-Member Relations, and Whole-Part Relations load on ideational fluency as well as the two marker tests. However, the Ideational Fluency Test loaded as strongly on the associational fluency factor as on its own.

Taylor et al. (1967) found ideational fluency factors using tests such as Plot Titles, Brick Uses, Topics, Similes, and Consequences. Messick and French (1967) used Thing Categories, Brick Uses, Unusual Uses, and Object Naming and obtained a clear ideational fluency factor. May and Metcalf (1965) used a number of "Uses" and "Improvement" type tests adapted from materials by Guilford and by Torrance. They found two ideational fluency factors, one specific to fluency scores on uses tests and one specific to improvement scores on both fluency and flexibility tests. Similar factors have been found by McKenna (1968) using a test similar to Theme and by Adcock and Martin (1971) and Adcock and Webberley (1971) using a test calling for verbally stated ideas about ambiguously shaped ink blots.

An ideational fluency factor has also been found in two studies with six-year-old children (McCartin & Meyers, 1966; Orpet & Meyers, 1966). The Uses Test, the Monroe Language Classification Test, and an Action-Agent task loaded on this factor in both studies. The Monroe Test asks the child to name all the objects he can think of in a given category. The Action-Agent task asks the child to name as many examples as possible of agents which perform an action, such as sleeping, cutting, etc.

There appears to be a good deal of confusion still surrounding this factor. Because of the nature of the tasks used, it is often confused with flexibility. To some degree these must be considered correlated abilities since the more ideas the subject generates in his response the more opportunities occur for spontaneous flexibility. The confusion with other fluency factors has been explained by Guilford to be related to the degree of restrictiveness in the stimulus material. He suggests that the more restrictive the stimulus, the greater the loading on associational fluency instead of ideational fluency. Guilford also suggests that failure to specify an initial letter on word listing tasks could shift the factor loading toward ideational fluency and away from word fluency.

As was mentioned earlier in this discussion, there have been attempts to find one or more factors of figural fluency (Bereiter, 1960; Gershon et al., 1963; Guilford and Hoepfner, 1966). There is limited information about the nature of a figural ideational fluency factor but the evidence strongly suggests such an ability or group of abilities. Tests such as Guilford's Sketches or Decorations, which require adding lines or elaborations to basic shapes or objects, may be markers for figural ideational fluency. This factor will be further discussed in the section on new factors.

<u>Word Fluency</u>. This was the first of the fluency factors to be identified. It was defined in the 1963 Kit as "facility in producing isolated words that contain one or more structural, essentially phonetic, restrictions, without reference to the meaning of the words." Royce (1973) defines it as "facility in producing words in accordance with structural restrictions but without regard to meaning." It is similarly described by Pawlik (1966) who states, "this factor accounts for the ability to rapidly produce words fulfilling specific symbolic or structural requirements."

Taylor et al. (1967) found that word fluency was more predictive of communications skills than the other fluency factors.

The tests recommended in the 1963 Kit as markers for this factor were the Word Endings Test (Fw-1), which asks the subject to write as many words as possible ending with certain letters, the Word Beginnings Test (Fw-2), which asks the subject to write as many words as possible beginning with certain letters, and the Word Beginnings and Endings (Fw-3), which imposes restriction regarding both the beginning and ending of the words to be produced. Guilford and Hoepfner (1971) suggest that tests of word fluency should be limited to the specification of only one letter if contamination from verbal comprehension is to be avoided. They also suggest that shorter time limits for each item and more different items would offset any advantage obtained from a large vocabulary.

Two studies (Bereiter, 1960 & Dunham et al., 1969) have used Word Fluency, a test which requires the subject to write as many words as possible, and Suffixes, a test similar to Word Endings, as markers for the word fluency factor. A clear factor was obtained by Dunham and by Bereiter for his sample of girls but not for his sample of boys. In the latter case, the two tests split with Word Fluency loading on a factor with associational and expressional fluency tests while Suffixes formed a separate specific factor. The Suffixes Test has also been used in other studies (Christensen & Guilford, 1963; El-Abd, 1970). In both cases clear word fluency factors were found. In the Christensen and Guilford study, Word Listing and Rhymes Tests also loaded on this factor; in El-Abd's study, a First Letters Test similar to Word Beginnings also loaded on word fluency. Taylor et al. (1967) obtained a factor which may be word fluency marked by First and Last Letters; Abstracting, and Letter-Star Tests.

Harris and Harris (1971) have interpreted as word fluency a factor including Spelling, Concealed Words, Disenvoweled Words, and Omlet Tests. This appears to be more nearly a verbal closure factor.

Induction. As was discussed in the 1963 Kit manual, this may well be a second-order factor with several sub-factors such as figure classification and concept formation. The definition of induction in the 1963 Kit was "associated abilities involved in the findings of general concepts that will fit sets of data, the forming and trying out of hypotheses."

Royce (1973) has defined induction as "ability in forming and testing hypotheses directed at finding a principal of relationship among elements and applying the principal to identifying an element fitting the relationship." He hypothesizes that induction, deduction, syllogistic reasoning, and spontaneous flexibility combine into a second-order reasoning factor. Wardell (1973) suggests that inductive reasoning is largely synthesizing, unifying, or constructing a largely unstructured array while deduction involves analyzing, abstracting, or composing essential features from a largely structured array.

Pawlik (1966) is uncertain as to whether or not induction and reasoning are separate factors. This position seems difficult to justify since a number of studies have been reported in which both Induction and General Reasoning factors appear. Pawlik defines the induction factor as "reasoning from the specific to the general, in the sense of discovering a rule or principle in a given material and subsequently applying it correctly." Cattell (1971) also assumes that induction and general reasoning do not represent separate factors, although he thinks that induction could possibly be a figural reasoning factor. He points out the "relation-perception" lists in a classification task, as described by Butler (1968), include: (1) looking for differences, (2) looking for similarities, and (3) comparing similarities and differences.

Guilford considers induction in the area of cognition in his schema "because of its discovering properties." He states that there are 16 kinds of inductive ability represented in his structure of intellect model. Dye and Very (1968) suggest separate inductive reasoning and symbolic-inductive reasoning factors in addition to deductive reasoning, verbal reasoning, arithmetic reasoning, and general reasoning. In young children, higher error scores and faster response times on inductive reasoning tests have been found to be associated with impulsivity (Kagan et al., 1966).

The tests used in the 1963 Kit as markers for induction are Letter Sets (I-1), which requires the subject to find the rule which relates four groups of letters to each other and then mark a fifth group which does not fit the rule; Locations (I-2), which requires the subject to determine the rule for the location of a mark in each of four rows of dashes and spaces and then to choose the correct location for a mark in the fifth row; and Figure

Classification (I-3), which presents the subject with two or three groups of figures each of which are alike according to some rule and then asks him to assign test figures to the correct group.

Several studies (Bunderson, 1967; Kropp & Stoker, 1966; Manley, 1965; Mullins, 1967; Reed, 1966; and Singer & Roby, 1967) have utilized all three of these induction marker tests. Only the Bunderson study showed a clear induction factor. The induction factor was visible in the Kropp and Stoker subjects at grades 10, 11, and 12 but not at grade 9. In the other four studies, the results were less clear. The induction and syllogistic reasoning tests combined on a single factor in Reed's study; however, this factor was separate from a general reasoning factor. Both Manley and Singer and Roby found that the Letter Sets and Locations Tests loaded on the same factor while Figure Classification loaded on another factor but Mullins found that Locations and Figure Classification loaded on the same factor, one that also included Syllogistic Reasoning, while Letter Sets had significant loadings on three different factors. Two other studies (Dunham & Bunderson, 1969; Lemke, Klausmeir, & Harris, 1967), which used only two of the marker tests, do not clearly distinguish induction from the other reasoning factors. Dunham and Bunderson found that Letter Sets and Locations combined into a single induction factor but that two tests developed in Guilford's Laboratory, Logical Reasoning (Rs-2) and Ship Destination (R-3), also appeared on this factor. Lemke et al. found that Letter Sets failed to load on a factor with Locations but appeared on a separate factor while Locations appeared on a factor which included Ship Destination (R-3), Necessary Arithmetic Operations (R-4), and Nonsense Syllogisms (Rs-1).

Induction factors have been found by several other researchers (Dye & Very, 1968; Dunham et al., 1969; Follman et al., 1969; Harris & Harris, 1971; and

Very & Iacono, 1970) using other tests. The Harrises point out that their induction factor is limited to tests which do not employ semantic content. "Instead, when they are used, numbers and letters are used as symbols and words are used as forms rather than semantic units." Dye and Very (1968) have found a separate factor for symbolic reasoning as separate from other reasoning factors but this factor appeared only for male subjects. They comment that the induction factor becomes clearer with age and also is more differentiated in males than females. Both Dye and Very (1968) and Very and Iacono (1970) used tests from the Very Developmental Battery of Intellectual Abilities.

Dunham et al. (1969), like several other studies by Guilford and his associates, found at least two distinct factors, cognition of figural classes and cognition of symbolic classes, that appear to be related to induction. Tests of Figure Classification and Figure Class Inclusion were the major variables on the figural classes factor while Number Classification, Number Group Naming, and Letter Classification Tests had significant loadings on the symbolic classes factor. These authors discuss the possible relevance of these factors to concept learning tasks. The question of a separate concept attainment or concept formation factor will be discussed in a later section. The existence of two comparable common factors involving classification, in addition to an induction factor, in the Harris (1971) study supports the existence of multiple first-order factors in this domain.

It seems likely that the induction factor is relatively easy to breakdown into two or more separate factors. Redefinition needs to be done and particular attention focused on the non-semantic quality of the tests which seem to be the best markers for induction. Further research also needs to be done to clarify the nature of the induction sub-factors as well as to determine the relationships among these factors and other reasoning factors.

Length Estimation. This factor, which was included in the 1963 Kit, has been criticized because of its narrowness and failure to fit into most models of cognitive abilities. It is recommended that it be dropped from the next edition of the Kit.

Mechanical Knowledge. This is another relatively narrow factor and is the only factor in the 1963 Kit which is more nearly an achievement factor than an aptitude factor. For these reasons it is recommended that this factor be dropped from the Kit revision.

Associative Memory. This was one of two memory factors included in the 1963 Kit. Associative, or rote, memory was defined as "the ability to remember bits of unrelated material."

Royce (1973) defines this factor as "upon presentation of one part of previously associated but otherwise unrelated material, ability to recall another part." Pawlik (1966) points out that this factor may relate "to memory for non-meaningful material only" and, if so, that a corresponding factor for meaningful memory should exist.

On the other hand, Cattell (1971) states that meaningful memory is only a projection of intelligence into memorizing performance. "Our assumption is that rote memory represents a basic capacity to commit to memory and retain, which operates regardless of meaningfulness and complexity of material. Later research should probably separate the general effectiveness of committing to memory from the general retentivity, but at present they are probably confounded here." This factor is one of those basic to Cattell's Ability Dimension Analysis Chart.

Guilford and Hoepfner (1971) state that tests with other than paired associates formats, such as numerical operations test and a digit-symbol test, appear on the same factor and suggest that this is because "implications rather than relations are probably emphasized" in such learning. It may simply be that the numerical content of these tasks is sufficient to make them load with tests which require the pairing of numbers with other material.

Lumsden (1965) obtained separate factors for unrelated rote memory and related rote memory.

The tests used in the 1963 Kit as markers for the Associative (Rote) Memory factor were the Picture-Number Test (Ma-1), which requires the subject to learn pairs of pictures and numbers and then write the appropriate number when presented with the picture, the Object-Number Test (Ma-2), which pairs words and numbers in a similar manner, and the First and Last Names Test (Ma-3), which presents full names and later asks the subject to recall the first name when the last name is presented.

All three of these tests have been used together in several studies (Bunderson, 1967; Duncanson, 1966; Mullins, 1967; Traub, 1970). In each case a clear associative memory factor was obtained although Duncanson found that First and Last Names also had some slight variance on memory span and on a different factor which was specific to some of his verbal memory tasks. The Duncanson study suggests that different memory strategies may be employed with verbal and non-verbal (numerical and figural) material. It is uncertain whether this verbal memory is the same as the meaningful memory factor which has been found by others. The fact that Duncanson paired nonsense syllables with real words may suggest that the verbal rather than meaningful element is important, or it may mean that there are different memory processes used for abstract and for concrete imagery.

Several other studies (Dunham & Bunderson, 1969; Flores and Evans, 1972; Kropp & Stoker, 1966; Lemke et al., 1967; and Manley, 1965) employed two of these three marker tests. Again, each study showed a clear associative memory factor. Vandenberg (1967) found a memory factor marked by Word-Number Memory, Number-Number Memory, and Figure Recognition.

Tenopyr (1966) conducted an extensive study of symbolic memory abilities. Although she obtained all six of the structure of intellect symbolic memory factors hypothesized by Guilford, there was a need for redefinition of several of these factors. She suggests that paired-associates tasks define Guilford's memory for symbolic implications factor but disagrees with Guilford that numerical operations tests also belong on this factor. However, Hoepfner et al., (1970) obtained a factor which included both a number-letter association test and a numerical operations test. Tenopyr also suggests that list-learning tasks define the memory for symbolic units factor and that tests involving meaningful relationships define memory for symbolic relations.

Adcock and Webberley (1971) also found a factor which seems to be associative memory. Holtz (1971) has a factor based on learning radio codes and on memory for pitch; this may be an associative memory factor since it requires the association of symbols with other stimuli.

Considerably more work needs to be done to clarify the nature of this factor. However, the marker tests in the 1963 Kit should continue to be adequate.

Span Memory. This factor was defined in the 1963 Kit as "the ability to recall perfectly for immediate reproduction a series of items after only one presentation of the series." Royce describes it as the "capacity in number of distinct elements that can be maintained within the span of immediate awareness."

It has been suggested that span capacity and long term memory storage may be independent abilities (Jensen, 1964; Adams, 1967; Ryan & Whimbey, 1968;

Ellis, 1968). However, it is difficult to define just what differences might exist between these two kinds of memory. Two kinds of processes have been distinguished in long term memory: (1) reproductive processes, which are concerned with retrieving stored facts, and (2) reconstructive processes, which involves the generation of material based on stored rules. Ryan and Whimbey attempted to determine whether the type of test used would explain the lack of correlation between the span and long-term memory systems. In earlier studies, these authors had noted, "without exception, the materials used as stimuli differed, the format of presentation differed, and the possibilities of individual differences in strategy differed from one test to another." They concluded that there is a strong relation between the two systems and that material gets into long term memory via short term memory. A similar conclusion was reached by Ellis, who has described long term memory as selecting material by attention from the environment moving it to primary memory, which is perceptually dependent, where it must be acted upon through rehearsal strategies to prevent rapid loss. Other discussions of various memory systems may be found in Atkinson and Shiffrin (1968), Kumar (1971), or Norman (1970).

Cattell's Ability Dimension Analysis Chart, as discussed earlier, places considerable emphasis on the importance of memory. Three distinct processes related to memory are considered: (1) the amount of committing to memory (gramming), (2) the amount of retentive activity involved, and (3) the amount of retrieval activity. Cattell suggests that research should find factors which separate (1) and (2). He considers span memory too narrow to accept as a separate factor. Guilford and Hoepfner (1971) have stated that memory span factors are fairly test specific. They also describe the need for research to determine if recognition and recall memory are separate factors. The tests which were used in the 1963 Kit as markers of the memory span factor were auditory number span, digit span-visual, and letter span-auditory. All three of these tests were used by Lumsden (1965) and by Bunderson (1967). Both obtained a clear span memory factor. Bunderson also obtained a second factor involving memory span on tests of Binary Digit Span and Three Letter Span which he had hypothesized would measure a chunking memory factor. The chunking process is used to group material into bits which can effectively increase the capacity of immediate memory.

Other studies using some, but not all, of the Kit marker tests include Dunham and Bunderson (1969), Lemke et al. (1967), Duncanson (1966), and Traub (1970). All except Duncanson obtained a clear span memory factor. In the Duncanson study, the two memory span tests loaded on a factor which also included vocabulary tests as well as significant loadings on most of the Stanford Achievement Test subtests and the Kuhlman-Anderson IQ Test.

A span memory factor has also been found by researchers using other tests (Arnold, 1967; Games, 1962; Orpet & Meyers, 1966; Adcock & Webberley, 1971; Tenopyr, 1966). Adcock and Webberley concluded that "span memory is distinct from medium-term memory in the case of semantic material, but both load highly on a common factor with figural material," though their data does not seem to demonstrate this clearly. The possibility of a separate memory factor for figural material will be discussed in the section on new factors.

Number Facility. This factor was defined in the 1963 Kit as "the ability to manipulate numbers in arithmetical operations rapidly." Pawlik (1966) defines this factor as "facility in performing elementary arithmetical operations (typically under speeded conditions)" and points out that "the factor does not determine higher mathematical skills or complex mathematical reasoning." Royce (1973) defines number facility as "speed and accuracy in doing the basic operations of arithmetic" and thinks that this ability may combine with the perceptual speed factor to produce a second-order intellectual speed factor. Werdelin and Stjernberg (1971) have shown that the N factor is associated with easier visual perceptual tests.

As was pointed out earlier, Guilford thinks that numerical facility is a part of the memory factor, memory for symbolic implications. He bases his argument for this on two studies of the Wechsler scales (Davis, 1956; de Mille, 1962) where a numerical operations test loaded on a factor including the Digit-Symbol Test and upon two later studies (Hoepfner et al., 1970; Guilford et al., 1965) which showed a numerical operations test loading on the same factor as a number-letter association task.

In a study of simple, single-digit addition problems, Groen and Parkman (1972) discovered that two types of approaches are used. They conclude that adults usually use a memory look-up approach while children usually and adults occasionally use an incrementing counting process. This points out the need to determine the type of process or strategy a subject chooses to use in solving any test or problem. The possibility of more than one strategy being employed by subjects to solve even a simple addition problem indicates the folly of attempting to design tests without knowing the variety of approaches which may be used and also the problems resulting from analyzing the data as if the task necessitated a single approach.

Keats (1965) has suggested the existence of an automatic process factor that might include numerical facility as a sub-factor. Werdelin and Stjernberg (1971) also suggest that number facility is really an "automatization" factor. Flores and Evans (1972) found an automated learning factor that includes both numerical facility and perceptual speed, as well as a separate numerical facility factor. The tests used as markers for the numerical facility factor in the 1963 Kit were addition, division, and a test with both subtraction and multiplication problems. All of these tests are highly speeded.

Several studies (Duncanson, 1966; Kropp & Stoker, 1966; Manley, 1965; Mullins, 1967; Tenopyr, 1966; and Traub, 1970) have included both rote memory tests and number facility tests, allowing an opportunity to determine whether or not these factors are the same, as Guilford has suggested. In none of these six studies did the two groups of tests load on the same factor. This evidence clearly supports the existence of the number facility factor as separate from associative memory. However, the automated learning factor of Flores and Evans (1972) includes a moderate loading for an associative memory test as well as larger loadings for numerical facility and perceptual speed.

The question of numerical facility as a sub-factor of a larger automatic process or automatization factor has not been adequately explored. Werdelin and Stjernberg (1971) suggest that automatization involves problems in which roles are applied to a symbolism. Such an explanation would clarify the appearance of digit-symbol tasks on the number facility factor. It is also possible that the automatization factor could be defined as speed of response to over-learned material. This is partially suggested by the tendency of the numerical facility factor to combine in some studies with measures of perceptual speed (Duncanson, 1966; Strowig & Alexakos, 1969; Mukherjee, 1962; Dye & Very, 1968; Pounders, 1970; Very & Iacono, 1970; Khan, 1970; and Flores & Evans, 1972). Numerical facility factors have also been found by other researchers (El-Abd, 1970; Flores & Evans, 1972; Harris & Harris, 1971; Nasca, 1965; Osborne & Lindsey, 1967; and Vandenberg, 1967). It is possible that this factor should be more broadly conceptualized than merely numerical facility.

<u>Originality</u>. This factor was defined in the 1963 Kit as "the ability to produce remotely associated, clever, or uncommon responses."

Royce (1973) defines originality as "facility in conceptualizing phenomena in ways that in our culture are judged to be unusual and clever." Pawlik (1966) states that the originality factor "loads tests in which the subject is to invent uncommon and clever responses." He calls attention to its relation to Cattell's personality factor U.I.T. 25, Tense Inflexidia vs. Less Imaginative Realism and to Eysenck's Psychoticism factor.

Guilford and Hoepfner (1971) have described originality in terms of the uniqueness or uncommon response, remoteness of association, and cleverness of response. They describe this factor as being limited to semantic tasks and suggest Plot Titles (clever), Quick Responses, Figure Concepts (uncommon), and Consequences (remote) as tests which would represent the several aspects of this factor and serve as markers.

A number of studies (Ward, 1968; Fee, 1969; Cropley & Maslany, 1969; Murphy, 1973) have re-analyzed the Wallach and Kogan (1965) data; they fail to obtain separate factors for number of responses (ideational fluency) and unique responses (originality) on creativity tests.

Originality may be the same as Cattell's factor U.I. (6), Flexibility vs. Firmness. Cattell points out that this factor has associations with several personality factors.

Two of the tests mentioned above, Plot Titles and Consequences, were recommended as markers for the originality factor in the 1963 Kit along with a test of symbol production. The latter seems now to be a poor marker for the originality factor if the factor definition is, as the evidence now suggests, restricted to the semantic domain. Kropp and Stoker (1966) used both

Symbol Production and Plot Titles in the three analyses based on 10, 11, and 12th grade students. In each case, the two tests failed to load on the same factor. Plot Titles tended to combine with the fluency tests. An originality factor did appear in Hoepfner et al. (1970) with the Consequences Test having by far the largest loading on this factor probably because of the scoring approach. Two studies in Guilford's laboratory (Brown et al., 1966; Hendricks et al., 1969) obtained a good originality factor with Plot Titles and Consequences. Hoepfner and Guilford (1965) have what seems to be two originality factors, one with Plot Titles and one with three figural tests. The latter may be a figural fluency factor.

One problem in finding the originality factor is its relationship to ideational fluency. The more responses that are produced, the more likely is the subject to give a response that is clever or unusual or remotely associated. Harvey et al. (1970) correlated scores on the Torrance Tests of Creativity and found that originality and fluency scores correlated from .50 to .62. A factor analysis of the Minnesota Tests of Creative Thinking (Madeus, 1967) resulted in factors of verbal and non-verbal divergent thinking, rather than separate factors of fluency, flexibility, elaboration and originality.

It seems safest to limit the definition of this factor to semantic originality. Whether or not it is possible to develop adequate test scoring criteria to insure replicable measures of either semantic or figural originality remains to be demonstrated.

Perceptual Speed. This factor may be, as was pointed out in the 1963 Kit manual, the centroid of several sub-factors (including Form Discrimination and Symbol Discrimination) which can be separated but are more usefully treated as a single concept for most research purposes. The 1963 definition of the perceptual speed factor was "speed in finding figures, making comparisons, and carrying out other very simple tasks involving visual perception." This factor probably involves iconic memory, the relatively short persistence of a visual image after the stimulus has been terminated (Neisser, 1967).

Other definitions of perceptual speed are "speed in identifying specified, small elements of a visual pattern" (Royce, 1973) and "fast speed in comparing visual configurations" (Pawlik, 1966). Pawlik points out that the factor is "restricted to speed of performance on tasks emphasizing quick apprehension of a visual pattern and/or its identification among similar and therefore distracting configurations." He also stresses that, unless the task is relatively simple, the tests would load on a closure factor. Cattell (1971) notes that this factor is sometimes called "Figure Identification." Some additional hypotheses about the nature of the perceptu.l speed factor have been presented by Werdelin and Stjernberg (1969). They hypothesize that "the perceptual speed factor is defined by t. .s involving the visual perception of space" and that "the perceptual speed factor is a measure of capacity to automatize, by means of practice, the solution of perceptual problems, which have originally depended on the visual perception factors." It is possible that perceptual speed is analogous to flexibility of closure (restructuring closure) except for the disembedding aspect of the closure factor. In both cases the subject must hold a "model figure" in mind to compare with other figural material. Whether or not it is also the perceptual counterpart of numerical facility, with both factors representin- the "automatic process" developed from earlier learning, remains for further research.

A study by Kunnaras (1969) further indicates the complex natu. of the perceptual speed factor. He obtained three factors which he feels . count for

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variability in perceptual activities included in the Identical Pictures and Identical Numbers Tests: (1) perceptual fluency, or the "readiness with which the subject oscillates between alternating percepts," (2) decision speed, or the "readiness with which the choice is made when the response is not completely determined by sensory input," and which may be similar to Thurstone's speed of judgment factor, and (3) immediate perceptual memory.

Royce (1973) has suggested that perceptual speed may be a sub-factor of the cognitive style factor called scanning.

The tests which were included in the 1963 Kit as markers of the perceptual speed factor were Finding A's, which asked the subject to check each of five words containing an "A" in columns of 41 words, Number Comparison Test, which asks the subject to indicate whether pairs of multi-digit numbers are the same or different, and Identical Pictures Test, which asks the subject to check which of five similar figures is identical to a given sample figure.

These three tests have been used together in several studies (Khan, 1970; Duncanson, 1966; Traub, 1970). As was mentioned earlier, the number facility and perceptual speed factors combined in the Duncanson and Khan studies using children at grades 6, 7, and 9 although Khan did obtain two separate factors at grade 11. But Traub, who also used sixth grade children, obtained two distinct factors, numerical facility and symbol discrimination; he found that Identical Pictures failed to load significantly on any of his factors.

Other studies (Adcock & Webberley, 1971; Lemke et al., 1967; El-Abd, 1970; Orpet & Meyers, 1966) have used one or more of the Kit marker tests for perceptual speed. Adcock and Webberley found that the Identical Pictures test loaded on a factor which also included flexibility of closure measures. They concluded that "perceptual speed is primarily symbolic and verbal measures are just more contaminated forms which are of doubtful value." They also suggest that perceptual speed may be merely preferred speed, since accuracy tends to decline as speed is increased. Orpet and Meyers were unable to separate symbol discrimination from form discrimination in their sample of six-year olds; both groups of tests combined into a single perceptual speed factor.

Guilford and his co-workers use similar tests and obtain two perceptual speed factors, evaluation of figural units and evaluation of symbolic units. Gershon et al. (1963), and Hoepfner and Guilford (1965), include figural aspect of this factor, Tenopyr et al. (1966) includes the symbolic aspect of this factor, while Hoepfner et al. (1964) includes both in the same analysis. Hoffman et al (1968) found that a Judgment of Size Test loaded on the same factor with Identical Figures. They suggest that perceptual accuracy may better describe the process measured by this factor than perceptual speed.

Several researchers (Weiner, 1964; Droege & Hawk, 1970; Strowig & Alexakos, 1969) have found a perceptual speed factor in the GATB, although in one of these studies (Strowig & Alexakos) the perceptual speed and numerical facility factors tended to combine. Perceptual speed factors have been found in the analysis of other well-known tests (Mukherjee, 1962; Singer, 1965; Pounders, 1970). In the test battery developed by Very, perceptual speed and number facility factors combined at the seventh grade (Very & Iacono, 1970) and ninth grade levels (Dye and Very, 1968) but were separate for subjects at grade 11 and college-level.

Other studies which have included a perceptual speed factor are Cardinet and Rousson, 1967; Harris & Harris, 1971; Hettema, 1968; Meyers et al., 1964; Messick & French, 1967; and Vandenberg, 1967.

The nature of this factor is less clear than was formerly thought. There is not only the problem of understanding the relationship of the perceptual speed and number facility factors which have been found to combine in many studies using subjects younger than mid-adolescence, but there is also the question of whether or not more than one perceptual speed factor exists. One possible explanation would be the major role of speed in this area. Numerical facility and the several kinds of perceptual speed may represent different aspects of an automatic process factor that is best measured by simple but highly speeded tasks.

General Reasoning. There has been a good deal of difficulty in differentiating between this factor and other kinds of reasoning as well as between this factor and numerical facility. The 1963 Kit manual defines general reasoning as "the ability to solve a broad range of reasoning problems including those of a mathematical nature."

Royce defines general reasoning as "ability in organizing the relevant aspects of problems having an algebraic quality and reasoning through to find solutions for them." As was mentioned earlier, both Pawlik (1966) and Cattell (1971) have expressed doubts as to whether or not General Reasoning and Induction are separate factors. Cattell assumes that these are not separate because "general reasoning is nothing more than a partial perception of fluid intelligence, gf, in the first order." While Pawlik is "inclined to regard the two factors as different" he points out the difficulties of interpretation. "It may simply represent a general convergent reasoning factor the way Thurstone conceived of it; alternately R may constitute a principal determinant of general intelligence at the first-order level." Guilford and Hoepfner (1971) consider general reasoning to be "the ability to conceive of structures." They suggest that tests which are "designed to show what information is needed or relevant" should be good markers for this factor. However, in the re-analysis of an earlier study (Guilford, Kettner, & Christensen, 1956), the Necessary Arithmetic Operations Test appeared on their memory for symbolic implications factor with their Numerical Operations Test instead of appearing on general reasoning. Guilford and Hoepfner suggest that the ability to handle complicated procedures and/or trial-and-error manipulation may also play an important role in general reasoning.

The tests recommended in the 1963 Kit as markers for general reasoning were two mathematics aptitude tests, which required subjects to select an answer to word problems requiring arithmetic and/or very simple algebra; Guilford's Ship Destination Test, which requires the subject to utilize several pieces of information to compute effective distance of a ship to port; and Necessary Arithmetic Operations, which asks the subject to determine what numerical operations are necessary to solve a problem but does not require computation.

Guilford's re-analysis raises a question about the appropriateness of the Necessary Arithmetic Operations Test as a marker for this factor. Another concern is the relationship of this factor to estimation ability and/or category width. Messick and Kogan (1965) have discussed the relationship between category width and quantitative aptitude. This cognitive style may be functioning as a moderator variable in tests of general reasoning.

One or more of the reference tests for general reasoning have been used in a number of studies (Adcock & Webberley, 1971; Bunderson, 1967; Duncanson, 1966; Dunham and Bunderson, 1969; Kropp & Stoker, 1966; Lemke et al., 1967; Locke, 1963; Manley, 1965; Messick & French, 1967; Reed, 1966; Traub, 1970). Since several of these studies also included tests of deductive or syllogistic reasoning, they provide an opportunity to test Cattell's hypothesis that these factors are essentially the same. A clear and separate general reasoning factor was found by Bunderson, Dunham and Bunderson, and Reed. However, Dunham and Bunderson found the Ship Destination Test loaded almost as heavily on another reasoning factor, which included two tests of inductive reasoning and one test of syllogistic reasoning, as it did on the general reasoning factor. Since two of the four tests on this factor were developed in Guilford's laboratory, it is possible that variance due to authorship may have played a role here. In three other studies (Manley, Lemke et al., Kropp & Stoker), however, the general reasoning factor seemed to be confounded with syllogistic reasoning. Both Kropp and Stoker and Manley found that two syllogistic reasoning tests, Logical Reasoning and Inference, tended to load on the same factor with general reasoning tests, but Lemke found that Nonsense Syllogisms, but not Logical Reasoning, appeared with the general reasoning measures. Obviously, the answer to the relationship between these two reasoning factors cannot be resolved on the basis of these data. It is interesting to note that there is more difficulty in differentiation of factors using the tests developed or suggested by Guilford's work than using those closer to the Thurstonian measures for these factors.

Other tests have also been used in studies which sought to differentiate among the reasoning factors. Dye and Very (1968) found an arithmetic reasoning factor which appeared to be distinct from both numerical facility and from general reasoning. Their arithmetic reasoning factor included tests which "commonly require mathematical solution of verbally-stated problems" whereas their general reasoning factor was "a relatively undifferentiated reasoning factor with a quantitative emphasis" which became somewhat more specific with college-age males than with females or with younger subjects. In the college male group this general reasoning factor involved both quantitative and verbal reasoning.

A general reasoning factor has also been found in factor analysis of other tests (Cave, 1970; Flores & Evans, 1972; Keats, 1965; Montgomery, 1968; Pounders, 1970; Smith, 1966). Guilford and his associates interpret this factor as cognition of semantic systems; the factor was found by Nihira et al., 1964; Brown et al., 1966; Dunham et al., 1966; and Hoffman et al., 1968.

The relationship between difficulty and factor loadings has been explored by Werdelin and Stjernberg (1971) and sheds some light on the nature of the general reasoning factor. They found that, the more difficult a test was made, the higher the loading on R. The tests included arithmetic problems that could be solved by logical reasoning, a non-mathematical logical reasoning test, and a number series test. It is possible that the general reasoning factor represents an upper difficulty level of another factor or group of factors and is not a separate factor.

Semantic Redefinition. This factor was defined in the 1963 Kit as "the ability to shift the function of an object or part of an object and use it in a new way." This may be a bi-polar factor with the opposite pole being "functional fixedness." It is probably closely related to the flexibility factors.

Royce defines this factor as the "ability to imagine different functions for objects or parts of objects and thus use them in novel ways to accomplish stated purposes." He hypothesizes that semantic redefinition combines with sensitivity to problems and verbal comprehension to produce a second-order verbal factor. This factor is not discussed by Pawlik (1966) or by Cattell (1971), which is surprising in view of these authors' other work and the relationship that must exist between this factor and personality.

Guilford and Hoepfner (1971) present three hypotheses related to the redefinition factor: (1) that it involves perceptual-reorganization ability, (2) that it involves a shift of function, and (3) that it involves moving a part from one whole to another. Their analysis supported the second hypothesis as the most defensible and concluded that Gestalt Transformation, Picture Gestalt and Object Synthesis were the best test markers for this factor. These three tests were included in the 1963 Kit as markers for this factor.

Only a few studies using any of these tests have appeared in the last decade (Adcock & Martin, 1971; Adcock & Webberley, 1971; Fleishman & Dusek, 1971; Kropp & Stoker, 1966; Reed, 1966) and in almost all of these factor undetermination was a problem. Consequently, it is impossible to decide whether the failure to obtain a clear redefinition factor is due to the tests or to the experimental design. In the two Adcock studies, redefinition and spontaneous flexibility tests tended to combine on a single factor but this did not occur in the other studies. The redefinition tests split onto different factors in both Reed's study and in three of the four grade levels in the Kropp and Stoker study. Only the studies from Guilford's laboratory showed a clear redefinition factor. A factor determined in part by these Kit tests appeared in Nihira et al. (1964); Hoepfner and Guilford (1965); Brown et al. (1966); Dunham et al. (1966); Hendricks et al. (1969); and Hoepfner et al (1970); it was usually interpreted as divergent production of semantic classes.

In light of this evidence, the status of the semantic redefinition factor must be considered somewhat tentative. It may be a sub-factor of spontaneous flexibility or of a larger redefinition factor not restricted to the semantic domain. Much more research needs to be done in this area.

Syllogistic Reasoning. This is probably a sub-factor of the ability called Deduction by Thurstone. It was defined in the 1963 Kit as the "ability to reason from stated premises to their necessary conclusion."

Royce (1973) considers deduction and syllogistic reasoning separate factors. He defines deduction as "reasoning from the general to the specific; the ability to test the correctness of a meaningful conclusion by applying general principles to the individual case," and syllogistic reasoning as "ability in formal reasoning from stated premises to rule out nonpermissible combinations and thus to arrive at necessary conclusions." As was mentioned earlier, Pawlik (1966) feels that deduction is the only distinctly separate reasoning factor. He defines it as involving "reasoning from the general to the specific, the ability to test the correctness of a meaningful conclusion by applying general principles to the individual case." He points out that, while syllogistic reasoning tests are markers for deduction, figure classification tests show minor loadings on this factor.

Cattell (1971) suggests that deductive reasoning might also be called logical evaluation. He also points out that there are deductive steps in every inductive reasoning act. Guilford and Hoepfner (1971) point out that the ability called for in mnay syllogistic reasoning tests is not deduction, since the subject is not asked to provide an answer, but the ability to evaluate the correctness of the answer(s) presented. They suggest that there may be two kinds of deductive reasoning factors, involving relations and implications.

The tests included in the 1963 Kit as markers for syllogistic reasoning were Nonsense Syllogisms, which asks the subject to determine if the conclusion logically follows from the premises, Logical Reasoning, which asks the subject to select the conclusion that can be correctly drawn from the premises, and

Inference, which asks the subject to select the conclusion that can be validly drawn from earlier statements.

Several studies using these marker tests have appeared in the literature during the past decade (Bunderson, 1967; Dunham & Bunderson, 1969; Kropp & Stoker, 1966; Lemke et al., 1967; Manley, 1965; Mullins, 1967, Nihira et al., 1964; Reed, 1966). Only the Bunderson and Nihira and, to some extent Lemke, studies yielded a clear syllogistic or logical reasoning factor. Bunderson prefers to call this factor verbal reasoning and to define it more broadly than does the Kit. In the remaining studies Rs-1 tended to load on factors which also included induction tests, and Rs-2 and Rs-3 tended to load on factors with vocabulary and/or general reasoning tests. This suggests that these tests do not function similarly and that the markers for this factor should be reviewed.

Studies of other tests have also found deductive type reasoning factors (Dye & Very, 1968; Keats, 1965; Smith, 1966; Very & Iacono, 1970).

Spatial Orientation. There has been extensive discussion attempting to differ between this factor and the visualization factor. Spatial orientation was defined in the 1963 Kit as "the ability to perceive spatial patterns or to maintain orientation with respect to objects in space."

Various hypotheses have been presented to account for distinction between the spatial orientation and visualization factors. In the 1963 Kit manual it was suggested that spatial orientation involves "perception of the position and configuration of objects in space" with the observer himself as a reference point whereas visualization required the observer to manipulate the stimulus and alter its image. Werdelin (1961) pointed out that the entire figure is reacted to in spatial orientation but the figure must be broken into parts for visualization. In more recent studies, Werdelin and Stjernberg (1969 and 1971) have suggested that spatial orientation is dependent upon the perceptual speed factor and represents a more difficult or less practiced aspect of that factor. This partially confirms Zimmerman's (1954) hypothesis that item complexity accounts for some of the differentiation between spatial visualization test factors. Ian Smith (1964) has argued that the distinction between spatial orientation and visualization has not been clearly demonstrated.

Royce (1973) defines spatial orientation as the "ability to put together by visual imagination parts that are out of place in a visual pattern and to identify such 'out of place' percepts." Pawlik (1966) points out that some authors have considered that there may be two similar factors, spatial relations and spatial orientation. He defines the spatial relations factor as requiring the identification of an object when seen from different angles or positions. He describes spatial orientation as involving problems "in which the body orientation of the observer is an essential part of the problem."

Guilford (1967) considers spatial relations and spatial orientation to be a single factor designated in his structure of intellect model as the cognition of visual figural systems. He hypothesizes that this is a sub-factor of a broader ability which also includes kinesthetic and auditory systems. The kinesthetic sub-factor is based on the ability to make right-left discriminations while the auditory sub-factor involves perceiving similarities and differences in rhythms and melodies.

The tests included in the 1963 Kit as markers for spatial orientation were Card Rotations, which requires the subject to detect whether or not cards of various configurations have been turned over as well as rotated; Cube Comparisons, which requires the subject to determine whether or not two cubes are the same but rotated to different positions; and Spatial Orientation, a test from Guilford's laboratory which requires the subject to select the correct new position for the prow of a boat given the motion indicated in two pictures. The latter test would represent what Pawlik calls the spatial orientation factor while the first two would represent his concept of a spatial relations factor.

Two of these marker tests, Card Rotations and Cube Comparisons, have been used in several studies (Ekstrom, 1967; Frederiksen, 1965; Mullins, 1967; Nasca, 1965) all of which found fairly clear spatial orientation factors. Card Rotations and Spatial Relations marked a clear factor for Flores and Evans (1972). Hoffman et al. (1968) also used the Spatial Orientation Test and obtained a factor which seems clearly dependent upon relationship of the stimuli to the observer and his bodily frame of reference.

Four studies (Arnold, 1967; El-Abd, 1970; Messick and French, 1967; Vandenberg, 1967) have employed the Thurstone tests for this factor. Arnold, El-Abd, and Vandenberg all obtained clear spatial orientation factors but, in the Messick and French study, spatial and disembedding skills combined.

Several other studies (Anderson & Leton, 1964; Droege & Hawk, 1970; Keats, 1965; Strowig & Alexakos, 1969; Very & Iacono, 1970; Weiner, 1964) contain factors which may also represent this ability but which are difficult to interpret due to underdetermination of factors and/or inadequate descriptions of the tests.

Sensitivity to Problems. This factor was defined in the 1963 Kit as "the ability to recognize practical problems."

Royce (1973) defines it more broadly as the "ability to imagine problems associated with function or change of function of objects and to suggest ways to deal with these problems." The latter part of this definition may be questioned since two of the three marker tests do not require the subject to suggest changes or improvements, only to point out the problem. Royce hypothesizes that sensitivity to problems combines with verbal comprehension and semantic redefinition to form a second-order verbal factor. Pawlik (1966) describes this factor as "recognizing the existence of a problem" and comments that "no direct temperament correlates of the Sensitivity to Problems factor are known, although broader personality associations seem rather likely."

The tests selected as markers for the sensitivity to problems factor in the 1963 Kit were the Apparatus Test, which asks the subject to suggest improvements for common objects, Seeing Problems, which asks the subject to list problems that might arise in a given situation, and Seeing Deficiencies, which asks the subject to point out the fault in a plan of action.

Only two studies (Kropp & Stoker, 1966; Nasca, 1965) outside of Guilford's laboratory have attempted to find this factor. These were only partially successful. In both studies, the Apparatus Test and Seeing Problems were used. The two tests did load on the same factor in the oldest group of students studied by Kropp and Stoker, although this factor also included tests of ideational and expressional fluency. The Nasca study had a factor with loadings for Seeing Problems and a test called Seeing Science Deficiencies.

In the two studies done in Guilford's laboratory (Hoepfner & Guilford, 1965; Hoepfner et al., 1968) Seeing Problems was a strong marker for this factor once and the Apparatus Test was a strong marker once.

In light of the above data, there is some question as to whether the sensitivity to problems factor has been adequately enough demonstrated for inclusion in a revised Kit.

Spatial Scanning. The spatial scanning factor was defined in the 1963 Kit as "speed in visually exploring a wide or complicated spatial field."

Royce (1973) defines this factor as the "ability to quickly survey a complex field to find a particular configuration representing a pathway through the field." He considers that it is a component of a second-order visualization factor. Spatial scanning may also be a sub-factor of a broader factor of planning ability.

The tests developed as markers for the spatial scanning factor in the 1963 Kit were Maze Tracing Speed, which requires the subject to complete a series of pencil-and-paper mazes; Choosing a Path, which requires the subject to select the pair of wires which will complete an electric circuit; and Map Planning, which requires the subject to find the shortest route between two points without encountering any road blocks.

Several factor analytic studies have used two or more of these marker tests but only Bunderson (1967) and Lemke et al. (1967) found a clear spatial scanning factor. Moreover, in the Bunderson study Guilford's Planning Air Maneuvers Test, supposedly a marker of adaptive flexibility, loaded on the factor including two spatial scanning tests. Khan (1970) found that the spatial scanning factor was not differentiated at the grade 7 level but did appear clearly at grade 9. Frederiksen (1965) found that the Map Planning Test failed to appear on the same factor as the other two spatial scanning markers. Haynes (1970) used similar tests from Guilford's laboratory and did not obtain a spatial scanning factor, but a study by Hoffman et al. (1968) in Guilford's laboratory obtained a factor which appears to be spatial scanning.

It must be concluded that the marker tests for this factor may have to be revised. Maze Tracing appears to show some variance on perceptual speed, especially with younger subjects.

Verbal Comprehension. This factor was defined in the 1963 Kit manual as "the ability to understand the English language." The specificity of the factor to the English language is based on Guthrie's (1963) study which found separate verbal factors in both English and Tagalog with subjects who spoke both of these languages.

Royce (1973), in defining verbal comprehension as "facility in understanding of English words, sentences, and paragraphs" also considers this factor to be language specific while Pawlik (1966) defines it as relating to the "knowledge of words and their meaning as well as to application of this knowledge in understanding connected discourse."

A question regarding the breadth and language specificity of the verbal comprehension factor can be raised since Harris and Harris (1971) found a similar factor which includes "comprehension of information including induction of classes when verbal and pictorial semantic content is employed." This finding suggests a more general factor of verbal ability or it may represent the overlap between verbal comprehension and induction. Still another possibility is that this is Guilford's CMR, Cognition of Semantic Relations.

Two studies (Haag & David, 1969; Messick & French, 1967) have suggested a factor related to "availability and flexibility in the use of multiple meaning words" or flexibility of vocabulary which may be a sub-factor of verbal comprehension, a confounding of verbal comprehension with one or more flexibility factors, or a separate ability. Several of the factors in Nihira et al. (1964) could be interpreted as sub-factors of verbal comprehension; these include verbal relations and verbal implications.

The tests selected as markers for the verbal comprehension factor in the 1963 Kit are all vocabulary tests. Since other authors (Pawlik, 1966; Cattell,

1971) have suggested that the factor could also be marked with tests of reading comprehension, verbal analogies, matching proverbs, grammar and syntax, it may be valuable to reconsider having this factor marked solely by vocabulary tests.

Verbal comprehension factors have appeared in many studies during the past decade (Arnold, 1967; Brown et al., 1966; Cave, 1970; Droege & Hawk, 1970, Duncanson, 1966; Dunham & Bunderson, 1969; Dunham et al. 1966; Dye & Very, 1968; El-Abd, 1970; Flores & Evans, 1972; Gershon et al., 1963; Hendricks et al., 1969; Guilford et al., 1970; Hoepfner et al., 1964; Hoepfner et al.,1970; Hoffman et al., 1968; Khan, 1970; Keats, 1965; Kropp & Stoker, 1966; Lemke et al., 1967; Locke, 1963; McCartin & Meyers, 1966; Manley, 1965; Mullins, 1967; Nihira et al., 1964; Pimsleur, 1962; Pounders, 1970; Rankin & Thompson, 1966; Reed, 1966; Singer, 1965; Strowig & Alexakos, 1969; Tenopyr et al., 1966; Traub, 1970). Many of these appear to be broader than simply "the ability to understand the English language" and some seem to include verbal reasoning or to represent a confounding of verbal ability and reasoning. Vandenberg (1967) found both a factor for native language and a verbal comprehension factor marked by tests in English. This suggests that, for individuals fluent in more than one language, a separate verbal comprehension factor for each language.

Taylor et al. (1967), in a study of communication abilities, found that a vocabulary test appeared "to be one of the most factorially complex scores in the study" in contrast to most other studies which have found this type of test a relatively pure measure of verbal comprehension.

Khan (1972) has explored the relationship between vocabulary learning and the development of verbal ability.

Visualization. This factor was defined in the 1963 Kit as "the ability to manipulate or transform the image of spatial patterns into other visual arrangements."

Royce (1973) postulates visualization factors at both the first-order and second-order levels and suggests that visualization may be linked to field articulation. He defines visualization as the "ability to manipulate visual percepts (to image change in forms) and thus to 'see' how things would look under altered conditions." Pawlik (1966) describes visualization as "the ability to imagine properly the movement or spatial configuration of a configuration or some of its parts."

As was mentioned earlier, there has been frequent difficulty in differentiating between spatial orientation and visualization factors. Hypotheses have been made which suggest that visualization is simply a more difficult or complex type of spatial orientation, that the relationship of the stimulus to the observer is less important in visualization than in spatial orientation, or that visualization involves reacting analytically to the components of the stimulus rather than to the figure as a whole.

Cattell (1971) does not accept visualization as a primary factor, and concludes that the work by Horn (1965) has demonstrated that it is a higher-order factor. This second-order visualization factor includes spatial ability, adaptive flexibility, speed of closure, and flexibility of closure.

The marker tests for the visualization factor in the Kit were Form Board, which requires the subject to indicate which pieces will fit together to make a given outline; Paper Folding, which requires the subject to select the drawing that correctly shows where holes will be in an unfolded sheet of paper which has previously been shown folded and punched; and Surface Development which requires the subject to indicate on a flat form, which can be folded to make a solid figure, the points corresponding to those on the solid.

Apparently there has been very little interest in the visualization factor; only three factor analytic studies using these marker tests have appeared in the past decade (Frederiksen, 1965; Ekstrom, 1967; and Hoffman et al., 1968). All of these obtained a relatively clear visualization factor.

Figural Adaptive Flexibility. This factor, which has appeared primarily in Guilford's work, was defined in the 1963 Kit as "the ability to change set in order to meet new requirements imposed by figural problems."

It has been defined by Royce (1973) as the "ability to try out in imagination various possible arrangements of the elements of a visual pattern and thus to converge on one arrangement which satisfies several stated criteria." Royce hypothesizes that adaptive flexibility combines with several other factors to form a second-order visualization factor. As was mentioned earlier, Wardell (1973) thinks that adaptive flexibility is identical with flexibility of closure.

Cattell (1971) also believes that adaptive flexibility is a primary factor which is associated with the higher-order visualization factor. Pawlik (1966) points out that the emphasis in both flexibility factors "is not on quantity but diversity of ideas produced." Guilford and Hoepfner (1971) defines adaptive flexibility as "the ability to change set in order to meet requirements imposed by changing conditions."

There has been considerable controversy over the nature of flexibility and its relation to fluency and originality. Harvey et al. (1970) and Madaus (1967) found that the fluency and flexibility aspects of Torrance's tests combine into a single factor.

The tests selected for the 1963 Kit as markers for adaptive flexibility were two Match Problems Tests, which require the subject to indicate different patterns in which matches can be removed to leave a given number of squares or triangles, and Planning Air Maneuvers, which requires the examinee to select the most direct path for skywriting pairs of letters. Guilford (personal communication, 1971) has recently expressed doubts about the suitability of Planning Air Maneuvers as a marker for this factor. If only Match Problem Tests can mark this factor, it is probably too test specific for inclusion in a new Kit.

Five studies (Adcock & Martin, 1971; Bunderson, 1967; Hoepfner & Guilford, 1965; Hoffman et al., 1968; Kropp & Stoker, 1966) have used two or more of these tests. A clear adaptive flexibility factor appears in the Hoepfner study and in the Adcock and Martin study although, in the latter, the authors interpret it as figural fluency. In the Bunderson study, three Match Problems Tests loaded on the same factor but Planning Air Maneuvers loaded on a factor which was dominated by spatial scanning tests. The two adaptive flexibility tests (Match Problems and Planning Air Maneuvers) tended to load on the same factor at most grade levels in the Kropp and Stoker study but this factor also included tests from several of the reasoning factors as well, suggesting that there may be more than one type of strategy which can lead to high scores on these tests--creative or logical. The Hoffman study concluded that Planning Air Maneuvers is a convergent rather than divergent type task since the subject does not suggest new solutions to the problem.

It thus must be concluded that the nature of this factor has not been clearly demonstrated and that, if it is to be included in a future Kit, new types of marker tests will have to be developed.

Spontaneous Semantic Flexibility. This factor was defined in the 1963 Kit as "the ability to produce a diversity of verbally expressed ideas in a situation that is relatively unrestricted."

Royce (1973) defines spontaneous flexibility as "facility in imagining diverse functions and classifications for objects" and hypothesizes that it, with induction, deduction, and syllogistic reasoning, form a second-order reasoning factor. This conceptualization seems at odds with most other views of this factor that stress its set changing aspects. Pawlik (1966), for example, describes spontaneous flexibility as "the facility of producing a diversity of ideas." He also points out that "it differs from ideational fluency in that emphasis is not on quantity but on diversity of ideas produced."

Guilford and Hoepfner (1971) have suggested that spontaneous flexibility is the opposite of perseveration. They define this factor as "the ability to produce diversity into ideas generated in a relatively unstructured situation."

Cattell (1971) does not discuss spontaneous flexibility and considers that his ideational flexibility vs. firmness factor is comparable to originality. It seems more likely that Cattell's factor may be a combination of flexibility and originality.

The tests included in the 1963 Kit as markers for spontaneous flexibility were the Utility and Alternate Uses Tests, which require the subject to list different uses for an object, and which are scored for the number of times the class of uses changes, and Object Naming, which requires the subject to name as many objects as possible that belong to a given class.

Scoring of the tests which are based on class changes is difficult. Although categories for the classes of uses can be developed prior to scoring,

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it is necessary to have scorers read through each set of item responses before scoring to develop a "feel" for the subject's thought pattern and to sense the rare case when the a priori categories are inappropriate. The ethics of not telling the subject that he is to be scored for category changes has also been questioned; however, if the criterion of category change was revealed, these changes would no longer be "spontaneous."

One or more of these marker tests have been used in several studies during the past decade (Adcock & Martin, 1971, Brown et al., 1966; Dunham et al., 1966; Haag & David, 1969; Hendricks et al., 1969; Hoepfner & Guilford, 1965; Hoepfner et al., 1970; Holtz, 1971; and Reed, 1966). A fairly clear spontaneous flexibility factor appeared only in the studies from Guilford's laboratory. A test called Multiple Grouping, which asks the subject to produce as many different logical groupings of a list of objects as possible, was found by this laboratory to be a better marker for spontaneous flexibility than Object Naming.

In the studies done outside of Guilford's laboratory, the spontaneous flexibility factor did not fare as well. Adcock and Martin (1971) found that redefinition and spontaneous flexibility tests from the Kit combined into a single factor. Reed (1966) was unable to obtain a clear spontaneous flexibility factor although he used all three marker tests. Neither Holtz (1971) nor Haag and David (1969) clearly determined this factor due to underrepresentation. The Haag and David flexibility of vocabulary factor is probably a confounding of verbal comprehension and semantic flexibility.

Several other studies have employed Uses-type tests and obtained a flexibility score by counting the number of shifts in category (Biggs et al., 1971; Cave, 1970; Singer & Roby, 1967). However, factors were undetermir ' in most of these studies. Singer and Roby found that the Uses test loaded on a factor which also included scores on the Adventure and Self-Reliant scales of the D-F Opinion Survey.

May and Metcalf (1965) looked at the effects of different instructions and scoring procedures on tests of spontaneous flexibility. They concluded that:

1. Spontaneous flexibility is probably not a factor which is independent of scoring system, mental set induced by test instructions, and examination task.
2. Spontaneous flexibility probably should be measured with tests of uses rather than improvements, under a mental set of fluency rather than flexibility.
3. Spontaneous flexibility probably should be scored either by the "unconventional uses" scheme or the "categories" scheme, but not by the "principles" scheme.

It seems necessary to conclude that this factor has not been well-demonstrated outside of Guilford's laboratory. Object Naming should be dropped as a marker for this factor and the possibility of using a test such as Multiple Grouping as a marker explored. The problems of set as developed by instructions and of scoring need further research. Additionally, it seems important to determine whether or not the "spontaneous" aspect of this factor is important. If not, there seems little to differentiate it from Redefinition.

Possible New Factors

During the past decade, several new factors have been demonstrated clearly enough to warrant consideration for inclusion in a new Kit of Cognitive Factors. The criteria for inclusion of a new factor in the Kit is that the factor has been found in at least three different studies and by at least two different researchers or laboratories. In addition, this review will discuss factors approaching but not attaining these criteria.

These factors include: Automatic Processes, Cognition of Behavioral Systems, Concept Formation, Estimation, Experiential Evaluation, Figural Fluency, Figural Relations, Integration, Meaningful Memory, Memory for Order, Semantic Relations, Visual Memory, and Verbal Closure.

Automatic Processes. The existence of some type of automatic processes, automatization, or automated learning factor has been suggested in three studies (Werdelin, 1958; Keats, 1965; Flores & Evans, 1972). Each of these has suggested that this factor is related to the number facility factor and most suggest that it is also related to perceptual speed and, possibly to other areas as well.

Werdelin and Stjernberg (1971) have described the automatization process as "problems which involve the application of rules to a symbolism are practiced. The rules become automatized and the problems get loadings of the N factor." Flores and Evans state that their second-order factor is defined by "individual differences in processes that are susceptible to a high degree of automatization." This type of process clearly characterizes the elementary arithmetic operations, which are usually drilled. Simple clerical tasks such as checking A's or matching diagrams may also involve a quickly learned automated response. Coombs (1941) also interpreted the numerical facility factor in a similar manner.

There seems to be adequate evidence to suggest the existence of a factor which is based on response to overlearned material. A major question is whether this is merely a reconceptualization of the factors of numerical facility and/or perceptual speed or if it has broader implications. At present, the evidence for an automatic process factor does not warrant its inclusion in the revised Kit. There is also the question of the relationship of an automatic process factor to the automatization cognitive style which has been defined as "greater or lesser ability to perform simple repetitive tasks than expected from the individual's general level of ability." (Broverman et al., 1964).

The studies which suggest an automatic process factor again raise the question of the relationship of difficulty to factor structure. This has been discussed by Guilford (1941), Zimmerman (1954) and Werdelin and Stjernberg (1971) among others. It seems likely that, to the degree that increased test difficulty changes the subject's strategy or approach to the test items, difficulty can be a major determinant of a factor.

Behavioral Relations and Systems. Behavioral relations can be defined as the ability to judge the interaction between two individuals so as to indicate how one of the individuals feels about the situation. The behavioral relations factor has been found in three studies (O'Sullivan et al., 1965; Tenopyr et al., 1966; Hendricks et al., 1969) in Guilford's laboratory. The tests which appear to be the best markers for this factor are Social Relations, which requires the subject to select the statement that would best indicate the thoughts of a marked figure in a pair; and Silhouette Relations, which requires the subject to select the picture that shows the expression suggested by the relationship of the two figures.

A behavioral systems factor has also been found in three studies in Guilford's laboratory (O'Sullivan et al., 1965; Tenopyr et al., 1966; Hendricks et al., 1969) but not elsewhere. This factor involves "a temporal sequence of events in which human interactions are the important links between events." The tests which have been the best markers for the factor are Missing Cartoons, which requires the subject to select a scene to fill the gap in a series of four pantomimes; Missing Pictures, which is similar to Missing Cartoons but photographic form; and Facial Situations, which requires the subject to select the best alternative to explain the expressions on the faces of a pair of figures.

Very little work on behavioral factors has been done outside of Guilford's laboratory. Other factor analyses of social intelligence (Thorndike, 1936; Woodrow, 1939; Wedeck, 1947; El-Abd, 1963) have produced behavior-type factors but none are clearly related to either of the Guilford factors which are discussed here. Consequently, it must be concluded that behavioral factors, while promising, have not been adequately enough demonstrated for inclusion in the revised Kit.

Chunking Memory. The capacity of the memory to use a limited number of symbols to represent larger amounts of information has been called "chunking" (Miller, 1956).

The existence of a chunking memory factor was hypothesized by Bunderson (1967). He developed two tests, Binary Digit Span and Three-Letter Span, which because of patterns and redundancies in the content were expected to encourage the chunking process. A clear chunking memory factor did emerge in his analysis, Moreover, this factor bore an important relationship to learning measures and "is quite central to much high-level thinking." This factor appears to offer great promise for investigators interested in memory because of its correpondence to a process that has appeared in laboratory studies of memory. Unfortunately, it has not been replicated in other factor studies and so cannot be included in the revised Kit.

Concept Formation. This factor is a sub-factor of induction. Despite this, it is suggested that it be included in the revised Kit as a separate factor to allow researchers to differentiate between the two steps in the inductive reasoning process: (1) the attainment of the concept from the stimuli, and (2) the selection of other stimuli which do or do not exhibit the concept.

A concept formation factor was first found by Adkins and Lyerly (1952). This factor had its major loadings tests of Picture-Group Naming, which requires the subject to assign to a group of objects that are alike in some way a name under which all the objects could be subsumed; Word-Group Naming, which is a verbal counterpart of the preceding test; and a verbal analogies test. Since a separate factor readily identifiable as induction and loading on different tests also appears in the same study, there is support for presenting concept formation and induction as separate factors.

A similar factor, initially called abstraction naming and later re-named convergent production of semantic units in the SI schema, has appeared in studies in Guilford's laboratory (Guilford et al., 1952; Guilford, Kettner, and Christensen, 1956; O'Sullivan, Guilford and de Mille, 1965; and Dunham et al., 1966). Guilford (1967) reports that the strongest tests for this factor are Picture-Group Naming, Word-Group Naming, Verbal-Relations Naming, and Number Group Naming. However the similarity among these measures suggests that this could also be a method-of-testing factor. It would be interesting to determine if the concept formation factor is related to Halstead's (1947) abstraction factor.

Several of Gulliksen's students have studied the relationship of concept learning to abilities (Allison, 1960; Bunderson, 1967; Duncanson, 1966; Manley, 1965). The concept formation tasks in these researches are more complex than the naming tasks making their relationship to the previous studies somewhat uncertain. Duncanson obtained a factor on which only the concept learning tasks had significant loadings and which did not include any of the factor marker tests from the Kit. Allison's four verbal concept learning tasks loaded on a single factor which was related to most of the reference factors, especially those identified as intellectual and numerical ability. He also found a spatial concept learning factor. Manley found three concept learning factors, one each for verbal tasks, for card sorting tasks, and for Goldstein tasks. His verbal concepts factor appears to be identical to Allison's but no reference tests were strongly related to his concept learning factors. Bunderson found that different kinds of abilities were important at different stages of concept learning.

Lemke et al. (1967) also found a concept attainment factor which had its main loadings on tests requiring the ability to present or state a given concept. Again, marker tests for induction and for other reasoning and memory factors did not load on the concept attainment factor.

The components of concept learning have also been studied by Dunham et al. (1968). They concluded that there were "common variances represented by the learning task scores that were not common to the tests" and that "there are factors common to both tasks and tests." They point out that the NMU factor can only appear in learning studies if the learners have mastered the concepts.

While some of these factors could be explained as being attributable to the testing method employed, it seems at least equally likely that they represent a concept attainment factor. Unlike Pawlik (1966), we do not consider the ability to name a concept to be a sub-factor of expressional fluency. It seems important to differentiate between Carroll's (1941) factor of facility in attaching appropriate names of symbols to stimuli and this concept naming factor. This factor may also be related to the feature extraction or naming process which occurs when material is being transferred among the memory systems. A discussion of this process may be found in Atkinson and Shiffrin (1968) or in Kumar (1971).

The above material supports the inclusion of a concept attainment factor in the revised Kit. The concept attainment factor will be defined as "the ability to cognize an abstract class or relation, usually by naming." It is suggested that tests similar to Word-Group Naming, Picture-Group Naming, and Naming Meaningful Trends be used as markers for this factor. However, the method of testing needs to be varied more than is currently the case with these tests.

Estimation. Three studies have found a factor which seems to be related to estimation ability (Dye & Very, 1968; McKenna, 1968; Very & Iacono, 1970).

McKenna found a factor which involves quantitative aptitude, category width as determined from an estimation questionnaire, and accuracy of spatial judgment. This may be an estimation factor or may be more closely related to cognitive style or to general reasoning. As was mentioned earlier, Messick and Kogan (1965) have discussed the relationship of cognitive style to estimative solutions to quantitative problems.

Dye and Very (1968) and Very and Iacono (1970) both found an estimative ability factor which appeared to involve two tests requiring an estimative approach to quantitative problems and the ability to evaluate hypotheses. This may be a confounding of estimative ability and other factors.

The evidence from these three studies does not seem to be clear enough to warrant the inclusion of an estimation factor in the revised Kit.

Figural Fluency. Figural fluency factors have appeared in several studies (Bereiter, 1960; Gershon et al., 1963; Hoepfner & Guilford, 1965; Hoffman et al., 1968; and Cave, 1970). There may be several distinct sub-factors in this area; for example, Guilford and Hoepfner (1971) describe a figural elaboration factor, divergent production of figural implications, and a factor of divergent production of figural systems while Bereiter hypothesized separate factors for figural and structural ideational fluency.

The tests which have been used to mark this factor require the subject to elaborate on an existing figure, such as in Guilford's Decorations or Production of Figural Effects tests, to produce a number of figures in response to a given stimuli, such as in Guilford's Alternate Signs Test, or to produce as many different figures as possible from a limited number of elements, as in Guilford's Designs, Make a Figure, Make a Mark, or Making Objects tests. In each case, the ease of producing many different figures in response to the situation is the essence of the process. As is the case with ideational fluency, quantity is emphasized, not quality, set shifting, or innovation.

Figural Illusions and Perceptual Alternations. Two different factors or sub-factors which appear to be related have been found. One has to do with susceptibility to optical illusions, the other with perceptual alternation in tests of reversible perceptions.

Both of these were originally found by Thurstone (1944). More recently, an illusion factor has been found clearly in a study by Hettema (1968) and much more tentatively in a study by Aftanas and Royce (1969). A perceptual alternations factor found by Kunnapas (1969) and defined as the "readiness with which the subject oscillates between alternating percepts," may be similar to Thurstone's perceptual alternations factor.

These factors are important because of their relationship to personality. Hettema (1968) has described the relationship of his illusion factor to the cognitive styles of field dependence and leveling-sharpening. Allport (1955) has also suggested that there may be a relationship between illusions and field dependence by his statement that illusions are "situations in which a part embedded in the context of the whole appears different from its appearance when it is perceived separately."

More work is necessary to establish the nature of these factors and to learn more about their relationship to the closure factors and to cognitive styles. They are not yet clearly enough established for inclusion in the revised Kit.

Figural Relations. In a number of studies, primarily in Guilford's laboratory, it has been suggested that the induction factor would be better handled as several sub-factors one of which would be a figural relations factor. It was earlier argued that concept attainment, also probably an induction sub-factor, should be treated independently because it represents a step in the inductive reasoning process which can stand by itself and which can be demonstrated without the presence of other steps in the inductive process. Does figural relations also involve a separate and distinctive reasoning process or is it the same process as is applied in solving problems of symbolic or semantic relations?

Separate figural relations factors, such as cognition of figural classes and cognition of figural relations, have appeared in three recent studies in Guilford's laboratory (Gershon et al., 1963; Hoepfner & Guilford, 1965; Dunham et al., 1966). Additionally it has appeared in the Harrises (1971) re-analysis of two of Guilford's earlier studies (Guilford et al., 1952; Guilford et al., 1956). The comparable common factor technique yielded in each study a factor which appears to be figural relations factor, with major loadings on tests such as Figure Analogies, Figure Classification, Figure Matching, and Figure Matrix, as well as a separate factor involving similar tests in the verbal and pictorial domain. This suggests that a figural relations factor may be independent of the methodological techniques used in Guilford's laboratory, although perhaps dependent on the same tests. A figural reasoning factor was found in preschool children by Meyers et al. (1964).

However, there does not seem to be sufficient evidence as yet, to justify inclusion of a figural relations in the revised Kit.

Integration. This factor was defined by French (1951) as "the ability simultaneously to bear in mind and to combine or integrate several conditions, premises, or rules, in order to produce the correct response." It first appeared in the Army Air Forces study (Guilford & Lacey, 1944). It was more clearly identified by Lucas and French (1953). More recently Traub (1970) has also obtained an integration factor marked by one of French's following directions tests and by another similar test. Rankin and Thompson (1966) found a factor which they interpret as "non-intellectual following of directions" which may be related to integration but their factor is not determined by an adequate number of variables.

A similar and possibly identical factor, identified as internalization appears in Droege and Hawk (1970). They describe the tests on this factor as having in common "a requirement of internalized rules, internalizing useful approaches to doing the items, or memorizing materials." These authors suggest that this factor is similar to Guilford's memory of symbolic relationships and that it supports Coombs (1941) and Werdelin (1958) in "the theory that numerical ability is characterized by a facility in manipulating a symbolic system according to a specified set of rules."

It is recommended that a factor called integration and marked by following directions tests which require the retention of rules be included in the revised Kit. Further research is necessary to determine the nature of this factor.

Meaningful Memory. This factor was found by Kelley (1954) and by Jones (1954). As Lumsden (1965) has commented, the term meaningful memory seems too general since in both these studies the factor was restricted to verbal material. Tests loading on the meaningful memory factor in these studies included Memory for Words, Sentence Completion Memory, and Memory for Limericks. "Other tests using material which was apparently equally meaningful (e.g., Memory for Relations, Picture Memory, Paragraph Memory) had low loadings on the factor," (Lumsden, 1965).

Brown et al. (1966) suggest that Kelley's meaningful memory factor is either memory for semantic systems or a confounding of that factor and memory for semantic implications. This interpretation seems doubtful in light of Brown's later definition of memory for semantic systems as "the ability to remember the ordering of meaningful material." Brown's memory for semantic relations appears close to Kelley's meaningful memory factor. Order does not appear to be a relevant aspect of either Kelley's or Jones' meaningful memory factor. None of the studies of memory done in Guilford's laboratory have found a factor which appears identical to meaningful memory although Dunham et al. (1966) memory for semantic classes seems close.

Cattell (1971), as was earlier mentioned, has stated that meaningful memory "represents only a projection of intelligence into memorizing performance."

Lumsden (1965) suggests that the meaningful memory factor might be better conceptualized as a related rote memory factor defined as "the ability to retain substance related to existing contents of memory." He obtained a related rote memory factor in his study as well as other memory factors which suggest a splitting of meaningful memory as it was hypothesized by Kelley. Tenopyr (1966) has also suggested that there might be an associative (or rote) memory factor which involves "relations more meaningful than contiguity" in addition to a memory factor defined in terms of paired associates learning.

McKenna (1968) found a factor interpreted as memory for emphasis which may be related to meaningful memory.

Arnold (1967) attempted to obtain a meaningful memory factor. She did so, but the results are unclear because of too few tests to determine the factor. The markers appear on only a very weak factor of their own, while they have higher loadings on a verbal factor.

Petrov (1970) has found both a verbal memory factor and a factor of long-term retention of verbal material.

This evidence does not support the existence of a meaningful memory factor. It does suggest that there may be a somewhat similar factor involving the rote memory of related material. Perhaps it is a memory for concrete (as opposed to abstract) material. More research needs to be done in this area.

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<u>Memory for Order</u>. This factor, called memory for position temporal succession, was first found by Christal (1958). In this study, the factor was marked by tests of Sequence Memory, Position in Succession, and Position Recall.

As was mentioned previously, Brown et al (1968) consider that the factor memory for semantic systems involves the ability to remember order. Tenopyr (1966) obtained a memory for symbolic systems factor, which also involves order as a memory system.

In a study of six-year-old children, Orpet and Meyes (1966) found a factor which includes the Knox Cube Tapping Test, which requires the subject to tap cubes in the same sequence as the examiner, and the WISC Digits Forward. Although the authors consider this factor to represent visual memory for figural units, it is suggested that it may be a memory for order factor.

This evidence is not strong enough to recommend the inclusion of a memory for order factor in the revised Kit. More research needs to be done to ascertain whether this factor might be a sub-factor of rote or meaningful memory.

<u>Visual Memory</u>. This factor was first suggested in a study by Carlson (1937) which was later re-analyzed by Humphreys and Fruchter (1945). It also appeared in several studies conducted by the Army Air Force (1944). Later studies by Guilford, Fruchter, and Zimmerman (1952), Roff (1951, 1953), and by Christal (1958) helped to confirm it.

However, there has been considerable debate as to whether or not the visual memory factor was due to test content. Thurstone (1946) believed that "the memorizing factor transcends the nature of the content" while others (for example, Humphreys & Fruchter, 1945) have stated that "memory factors can probably be multiplied almost indefinitely by relatively slight changes in the format and contents of memory tests." Recent work in memory (for example, Neisser, 1967) has demonstrated the existence of iconic memory, which is used to store visual impressions. This suggests that visual memory is not simply the result of test content but also involves a cognitive process different than that used in other memory factors.

Guilford and Hoepfner (1971) describe six visual-figural memory abilities. These were investigated in Bradley et al. (1969). However, only the factor memory for figural systems has been replicated in their laboratory (Hoffman et al., 1968). It seems likely that this is the same aspect of visual memory involved in the Air Force (Guilford & Lacey, 1944) and Christal (1958) studies. Other studies in the past decade which include factors that may be visual memory are Duncanson (1966) and Orpet and Meyers (1966). Petrov (1970) has found both an iconic memory factor and a factor for short-term retention of visual material.

The tests which appear to be the best markers for the memory for figural systems sub-factor are System-Shape Recognition, which requires the subject to recognize the positions and orientations of simple figures studied earlier; Monogram recall, which requires the subject to sketch arrangements of groups of three letters studied earlier; and Orientation Memory, which requires the subject to recall the locations of buildings on a previously studied map. The tests which seemed to be the best markers for visual memory in other studies include Map Memory, which requires the subject to select the one of five small maps that is an accurate reproduction of a section of a large map previously studied; Plane Formation, which requires the subject to indicate the sections of a grid where planes were seen in a study picture; Position Memory, which requires the subject to recall the items as they appeared on a study page; and Space Memory, which requires the subject to identify the sumbols that were located in each section of a study page.

It is recommended that a visual memory factor be included in the revised Kit. Research is needed to determine if there is more than one factor in this domain.

Verbal Closure. This factor, which can be defined as the ability to solve problems requiring the identification of words when some of the letters are missing, disarranged, or mixed with other letters, was first found by Pemberton (1952) and by Mooney (1954). It appears to be simjiar to Guilford's factor called cognition of symbolic units. Messick and French (1967) have suggested that there may be separate factors or sub-factors for speed of verbal closure and for flexibility of verbal closure.

In the past decade verbal closure factors have appeared in studies by Adcock and Webberley (1971), Harris and Harris (1971), Messick and French (1967) and, somewhat less clearly, in several studies in Guilford's laboratory (Gershon et al., 1963; Hoepfner et al., 1964; Hoepfner & Guilford, 1965; Tenopyr et al., 1966; and Hoepfner et al., 1968). Additionally, three factor analytic studies of the cloze technique (Carver et al., 1971; Ohnmacht et al., 1970; Weaver & Kingston, 1963) suggest that this procedure is probably related to semantic or verbal closure.

Tests which are suggested as markers for the verbal closure factor include Anagrams, which requires the subject to rearrange the letters of one word to form another word; Incomplete Words, which requires the subject to fill in the missing letters of common words; Four Letter Words, which requires the subject to locate four-letter words in a line of letters; and Scrambled Words, which requires the subject to unscramble four-letter nonsense words to make common words.

The evidence for this factor is sufficiently strong to recommend its inclusion in the revised Kit.

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