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# Intelligence Tests in the Year 2000:

## What Forms Will They Take and What Purposes Will They Serve?

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Technical Report No. 16
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LEVEL II

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# Six Authors in Search of a Character:

# A Play about Intelligence Tests in the Year 2000

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Running head: Six Authors



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## Abstract

Six points of view regarding the future of intelligence testing are considered, and a combined, "prototypical" point of view is synthesized that seems to represent a consensus of authors regarding the directions in which intelligence testing and research on intelligence are going. The past history and present status of intelligence testing and research are briefly considered, and then their future is discussed. The future seems to include assessment of various kinds of components of intelligence--performance components, acquisition components, transfer components, and metacomponents. The distinction between academic and everyday intelligence is discussed, as are the cultural and temporal limits of any one notion of intelligence. Finally, the usefulness of the notion of intelligence as a prototype of people's beliefs is considered.

# Six Authors in Search of a Character:
# A Play about Intelligence Tests in the Year 2000

It is with pleasure that I welcome you to the sixth and last act of the world's premiere performance of "Six Authors in Search of a Character," a play about intelligence tests in the year 2000. The plan of the play is clear and simple, although it is only now, as a prelude to the final act, that the plan can be revealed: Put together an outrageous assemblage of six authors and see whether a character emerges. The character is an important one, because it is he (which I use in a generic sense to include she as well) who will rule the Land of Intelligence. As you know, most inhabitants of this land are required to take written tests demonstrating their competency in the laws of the land, and the ruler largely determines what forms these tests will take, and what functions they will serve.

As an author-critic in this particular play, I am happy to announce that, in my opinion, a character has emerged. Before introducing you to this character, however, I would like to reintroduce you to two of his progenitors. These progenitors were creations of earlier plays and earlier times. In retrospect, we may wonder how these earlier rulers ever ascended to their respective thrones. But we must be cautious in our criticisms of earlier playwrights, lest we, too, be ridiculed by the authors of a play on intelligence tests in the year 3000, or even 2100.

Let me remind you first of Factorman, believed by some to have been created by parthenogenesis. Factorman first appeared near the turn of the century, and at times has seemed to have the staying power of Methusaleh. Factorman divided the Land of Intelligence into a series of governing districts called "factors," no doubt in honor of Factorman himself. A general factor contained the highest

governing body, which passed and enforced laws relevant to all of the factors considered collectively. Specific factors passed and enforced laws relevant to each of them individually.

Factorman encountered serious problems during his rule. One of these was that within a few years, a host of pretenders to the throne emerged, all of whom claimed to be the true Factorman. All of these putative Factormen agreed that the factorial organization of government was the proper one; but they disagreed as to how many factors there should be, how these factors should be organized, and what these factors should be called. One "Factorman" disdained the near-autocracy of the general factor, and argued for a system of states' rights, according to which each of seven or so factors would be viewed as equally primary. Another "Factorman" was a federalist, and believed that a strictly hierarchical arrangement of factors served best. Another "Factorman," believed by some to harbor anarchist sentiments, argued for as many as 120 independent factors, each responsible only to itself. And the worst problem of all was that after a while, it was clear neither who was the true "Factorman," nor how one could even devise a way of telling who this individual was. A desperate attempt was made to reveal the true Factorman by having the whole bunch of "Factormen" appear on a television show, "To Tell the Truth," but when the emcee asked the true Factorman to stand up, all chairs were vacated instantly. A system was suggested whereby each Factorman would rule in rotation, but no one could agree as to what rotational plan to use: There seemed to be no good criterion for choosing one over another. Most seriously, the governmental structure was not accompanied by a well-worked out governmental process: The system seemed not to provide for a clear way to execute and enforce laws once they were made.

During the 1960's and 1970's, the "Factormen" were overthrown by a young and hearty challenger for the throne, Componentman. The relative present strength of Componentman, and the concomitant weakness of Factorman (whoever he may be) is shown by the fact that Factorman has received only passing references during the course of this play, whereas Componentman has been a central figure, and seemingly, at times, villain: Neisser seems to have intimated that Componentman should be overthrown; Horn, Resnick, Brown, and Turnbull seem to have agreed that Componentman should be demoted to a position of lesser influence, and I find myself in agreement with these authors. Who is this Componentman, whose rule is in such jeopardy?

Componentman organized a government that differed in a key respect from the government of Factorman: The new government emphasized the processes of governing rather than the structure of government. Componentman divided the Land of Intelligence into a set of components, again, no doubt, in honor of himself. Each component was to be responsible for a separate governmental process. Since single components would clearly be insufficient to carry out laws of any complexity, components were allowed to engage in cooperative ventures called "strategies." These strategies were able to solve complicated problems that no single component could have solved alone.

At one time, Componentman seemed to offer a nearly complete package of government. Through him it became possible to identify the elementary information processes (components) that carried out intelligent behavior; It became possible, moreover, to specify the representations upon which these components act; to estimate the latencies, difficulties, and probabilities of component execution; to identify the strategies into which components combined; and to assess how consistently these strategies were executed (see Sternberg, 1977, 1978a, 1979). Why, then, are even some of the strongest former backers of

Componentman, including some of the authors of this play (and certainly myself), backing off? The reason seems to be that although Componentman has offered a nearly complete package of government, what is missing is fundamental, and perhaps more fundamental to good government than what Componentman has to offer. What is missing is the set of higher-order processes that decide what lower-order processes should be used to solve problems. Components provide the means by which the laws of the Land of Intelligence can be carried out and enforced. But how are decisions made as to what laws to enact in the first place? How is it decided what components, representations, strategies, and speed-accuracy trade-offs to use? Componentman remains embarrassingly silent on these issues.

Enter Metacomponentman. If there is any consensus at all among the authors of this play, it is that Metacomponentman is the legitimate heir to the throne, and that he should take it over as soon as possible. Metacomponents supplement components by supplying the decision-making and planning that are necessary for the components to carry out their functions. Whereas components solve problems, metacomponents decide how the problems will be solved, and even what problems need to be solved in the first place (Sternberg, 1979).

When a new challenger seeks ascension to the throne, initial bursts of enthusiasm often substitute for empirical research. Some of this substitution has occurred in the study of metacomponents. Nevertheless, there has been at least some initial solid progress on the metacomponential front, which I will note here.

The work of Brown and her colleagues, cited in Brown and French's contribution to this play, represents one direction in which work on metacomponents is likely to progress. Comparing various kinds of atypical performance to more typical kinds of performance makes one aware not only of what particular decisions are made, but of what decisions actually need to be made. As

ethnomethodologists have so ably pointed out in the sociological realm, it is often not until norms are violated that we become aware of what the norms are. Markman's (in press, Note 1) work on comprehension monitoring seems to fall into the metacomponential domain, as does some of the work that has been done on metamemory (see Flavell & Wellman, 1977, for a review). My own work on the development of intelligence (see Sternberg, Note 2) also addresses issues in the metacomponential domain. In this work, as in Brown's, the contrast between more and less able groups provides a basis for understanding just what decisions need to be made in intelligent functioning.

The problem in metacomponential research (however it has been called) has been that metacomponents have resisted experimental isolation in much the same way that components once did (see Sternberg, 1977, 1978b): We have been no more able to isolate metacomponential decision times or difficulties than we were once able to isolate componential execution times and difficulties. As a result, we talk about metacomponents in a rather fuzzy way, identifying them in indirect ways that do not permit systematic study of their properties. Bill Salter and I have devised two methods we believe enable one to isolate these metacomponents, however, and thus to go beyond somewhat obscure references to homunculi, control processes, or executive processes. We are studying these metacomponents in the laboratory now, in the hope that by the year 2000 plus or minus, we will be able to isolate them in practical settings. I will describe these two methods here for the first time.

The method of structural precueing is a development emanating from the original method of precueing, which is used to isolate information-processing components (Sternberg, 1977, 1978b). In the method of structural precueing, each test trial occurs in two parts. In the first part, the subject receives some advance (precueing) information that may or may not be helpful in solving

the test item; in the second part of the trial, the subject receives the full problem and solves it. The first part of the trial can vary in the amount of advance information presented. In one condition, subjects receive no advance information: The first part of the trial consists merely of the presentation of a blank, lighted field. As soon as they are ready, subjects press a button indicating their desire to see the full problem. In another condition, subjects receive the structure of the problem, but not its content. For example, if the problem consists of a standard analogy with three answer options, subjects would see the structure, X : X :: X : (X, X, X), with each X indicating a word whose identity has yet to be disclosed. Subjects take as long as they need to view this structure, understanding that their task is to do as much strategy planning as is possible on the basis of this structural information. When a subject is ready to see the actual problem, he presses a button, and the actual analogy (with content) appears, for example, LAWYER : CLIENT :: DOCTOR : (MEDICINE, PATIENT, NURSE). The problem latencies of primary interest are contrasts between the two conditions of pre-cueing for each part of the trial. The facilitation obtained on account of structural precueing is viewed as strategy-planning time. The facilitation can be measured either by taking differences between the first parts of the trials under each of the two conditions, or by taking differences between the second parts of trials under each of the two conditions. The second difference measure is probably of greater interest, since it involves actual solution of the full problem. In order to use this method, it is necessary that problems vary in their structures and in the strategies that can be employed to solve the problems of varying structure. In the analogies study, for example, problems vary in the number of locations in which variable options occur (one, two, or three), in the number of options at each location (two or three), and in the

particular locations in which options rather than given terms occur. Thus, one item might be a standard analogy such as the one presented earlier; another might be a nonstandard analogy of the form exemplified by LAWYER : (CLIENT, JUDGE, JURY) :: DOCTOR : (MEDICINE, PATIENT, NURSE). Each of the twenty structural variations used in our experiment requires at least some change in strategy, and each subject receives each variation under each condition of structural precueing. Note that it is essential that each structural variation require a different strategy: If each successive problem required the same strategy, the precueing would serve no purpose. This fact forms the basis for the second method Bill Salter and I are using to isolate strategy-planning time.

The method of mixed-versus-blocked trials eliminates the need for precueing. Subjects receive full analogies (or other kinds of problems) with varying structures requiring varying strategies. Problems are presented either in blocked form or in mixed form. When presented in blocked form, all trials in a given set of items involve problems with identical structures. Once the subject has formulated a strategy for the first item, he can use that strategy for each successive item in the set. When presented in mixed form, each trial in a given set of items involves a problem with a different structure that requires a different strategy. The strategy used for a given problem is not applicable to the next problem, so that it is necessary to formulate a new strategy on each successive trial. Metacomponential time for strategy planning is obtained by subtracting for each subject mean blocked-trial time from mean mixed-trial time.

Although all authors of this play seem to agree that Metacomponentman should ascend to the throne as soon as possible, the authors seem determined not to repeat past mistakes, which have allowed essentially autocratic rule by

a single individual. The authors have specified other governmental roles as well, and although these roles are subordinate ones, they are important in their own right. Let us consider these roles now.

The role of learning in the government of the Land of Intelligence has been a variable one over the years. Some years, Learningman is to be found in the government; other years he's not. This year, apparently, he's been elected by a unanimous vote: All of the authors have mentioned the importance of learning to the theory and testing of intelligence, noting also that its importance has been ignored of late. Turnbull refers to the importance of short-term prediction of learning. Resnick has observed that although much recent research has been devoted to isolating components of performance on intelligence-test items, virtually no research has been devoted to understanding the acquisition of these components. Horn contrasts learning in different modalities. Brown and French have introduced to us the Vygotskian concept of a "zone of potential development," which seems to refer to the difference between developed ability and total (including unused) capacity.

Can learning be broken down into a set of elementary acquisition components, and if so, how can these components of acquisition be isolated? Brown and French suggest one way. In their method, based upon that used in Soviet psychology, subjects receive successive cues in a problem task, with the zone of potential development estimated on the basis of the number (and perhaps types) of cues needed before the subject can proceed to solve the problem on his own. This method resembles my own method of precueing in some respects, and the resemblance leads me to question whether the method suggested by Brown and French really isolates acquisition components, or whether instead it isolates performance components, as does the method of precueing. Suppose that a task requires information-processing components a, b, c, and d for its solution, and suppose that the components are executed in that order. Suppose

also that each of two subjects would be able to solve the problem, but for the lack of one component. Subject 1 lacks component a, and Subject 2 lacks component d. If cues are presented in a successive order, allowing problem solution from beginning to end, then one cue may be sufficient to enable Subject 1 to pursue solution independently; Subject 2, however, might need as many as three cues before being able to solve the problem in its entirety. There may be ways of getting around this problem, but whatever they may be, the method still seems like one for isolating components of performance rather than components of acquisition. It functions much the way the method of precueing does in componential analysis, removing certain components from information processing to allow isolation of other components. The results reported by Brown and French are consistent with this type of analysis. If, for example, learning disabled subjects are able to solve problems with fewer prompts than are mentally retarded subjects, it could well be because they lack fewer components, or are able to access these components with less cueing.

Janet Powell and I are currently engaged in attempting to isolate components of acquisition in one of the tasks mentioned by Resnick--vocabulary. It is not surprising that vocabulary items have been neglected in the current wave of research on information-processing components of performance on intelligence-test items: The items simply provide no basis for the analysis of task performance. But they do seem to provide a basis for the analysis of what we call acquisition components. We believe that these acquisition components are responsible for vocabulary's being the best single measure of intelligence available. In our current research, subjects are presented with a series of narrative passages of the kind found in newspapers, textbooks, magazines, and other everyday sources of information. The passages are typical in every respect except that they contain embedded within them one or more words of extremely low frequency in the

English language. After reading each passage, subjects answer a number of questions about it, including one about the meaning of one of the low-frequency words. Structural variables in the narrative passages are used to predict the relative difficulties of learning the various words from context, and to predict individual differences in learning from context. These variables are the independent variables used to estimate the difficulties of the various acquisition components: Presumably, subjects who are better able to use these structural variables in acquiring the meanings of words are those who ultimately end up with better vocabularies.

Still another representative in the government of the Land of Intelligence would seem to be Transferman. The importance of transfer to the government of the land is mentioned by several authors of this play: Horn discusses the importance of transfer between sensory modalities; Brown and French discuss the role of transfer in their learning tasks; Turnbull notes the problem of transferring measured ability from a primary language to a secondary one, or vice versa. The importance of Transferman follows almost immediately from the importance of Learningman, since they are twins: You can't have one in a theory without the other. Fortunately, the two cooperate rather than compete.

Judy Sprotzer and I have been investigating what we refer to as "transfer components" in the context of (what else?) an analogical reasoning task. Trials of analogy solution are presented in pairs. In the first trial of the pair, subjects are presented with a standard analogy, such as LAWYER : CLIENT :: DOCTOR : (MEDICINE, PATIENT, NURSE). In the second trial of the pair, subjects receive an analogy that overlaps with the first analogy in some subset of analogy terms, for example, LAWYER : PARALEGAL :: DOCTOR : (PATIENT, MEDICINE, NURSE). In fact, for each base analogy, there are fifteen other analogies that differ in all

possible subsets of terms (including the null set). It is possible to construct a set of linear equations that provides the basis for estimating components of transfer for the different operations used to solve analogies (see Sternberg, 1977), for example, encoding of analogy terms, inference of the relation between the first term of the analogy and the second, or mapping of the relation between the first term of the analogy and the third. These transfer components measure the time saved by the subject's ability--in the second analogy of a pair--to profit from having already performed an operation. For example, in the pair of analogies above, five of the six terms to be encoded in the second problem have already been encoded in the first problem; the inference between the first and second terms of the second analogy is new (that is, different from the inference in the first analogy); the mapping between the first and third terms is the same as in the first analogy. Isolating transfer components should enable us to determine the loci of transfer of training in reasoning and other tasks.

The idea of a distinction between academic and everyday intelligence appears explicitly in two acts of this play--those of Neisser and of Brown and French--and implicitly in other acts as well. The idea of a distinction between academic and everyday (or social) intelligence has long been an appealing one, and has even made its way into some theories of intelligence (e.g., Guilford, 1967). The problem with the distinction is that evidence in support of a separate unified construct of everyday or social intelligence has been practically nonexistent (see, for example, Keating, 1978). It is hard to know what to make of the lack of evidentiary support for the construct. Tests of everyday intelligence, like those of creativity, are so inadequate to the construct they seek to measure that one cannot decide the theoretical issue on the basis of the operational measures currently used to address the issue.

The issue is unlikely to die, anymore than the issue of creativity and how to measure it has died. Despite the inadequacy of the tests that are presently available, it is difficult to believe that there are not forms of everyday intelligence (and creative intelligence) that differ from what standard intelligence tests measure. It may be that there is no one unified construct of everyday intelligence, but several constructs. Such multiplicity of constructs would explain why no one trait has emerged in the research that has been done to date. The problem seems to remain one of finding appropriate tests to measure the trait or traits.

Another theme common to several acts of this play--particularly to those of Neisser, Horn, and Turnbull--is that of cultural relativity in the meaning of intelligence. Horn supplements this theme with one of temporal relativity--what we call intelligence at a given time in a given culture may not be the same as what we call (or should call) intelligence at a different time in (ostensibly) the same culture. This change may occur in part because of subtle changes in the culture that we are only barely aware of. Previous research certainly reinforced the notion that what is viewed as intelligent behavior in one culture may be viewed as quite unintelligent in another (see, for example, Cole, Gay, Glick, & Sharp, 1971; Goodnow, 1976). To the extent that intelligence is defined, stipulatively, in terms of behaviors that are adaptive within a given culture, there can be no doubt that intelligence must be defined relatively, that is, within a given cultural context. However, this divergence in stipulative definitions of intelligence should not obscure communalities in basic processes that probably do exist cross-culturally: The same performance components, acquisition components, transfer components, and metacomponents seem likely to be used by all people, regardless of their culture. What probably differs across cultures is the importance of these components in

adapting to everyday life, and it is for this reason that the nature of intelligence is variable across cultures.

I have saved for last a discussion of what I believe to be one of the most interesting ideas to have emerged from this play--the idea of intelligence as a prototype, as suggested by Neisser. My agreement with this framework for viewing intelligence could not be expressed any more strongly than by my pointing out that this entire act of the play has consisted of an attempt to form a prototype representing the collective views of the six authors who have contributed to the play. The techniques used by Rosch (see, for example, Rosch, 1978) for studying prototypes, plus new techniques, might open up new avenues of research on intelligence. I think a few caveats need to be stated, however.

First, the idea of intelligence as a prototype, as the idea now stands, is a point of view rather than a theory. I find it useful heuristically in much the same way that I find the notion of scripts (or frames) useful. In the case of the present notion, the theoretical content needs to be filled in, and empirical demonstrations are required to show that the point of view really does have interesting researchable implications. Such research, I think, is most worthy of further pursuit, and likely to be profitable.

Second, because the notion of intelligence as a prototype is a point of view, it is not inconsistent with my own or other theories of intelligence. Society has created an essentially arbitrary concept, and society's prototype would seem to give us a fair representation of what that stipulative concept is. But I believe that there are fundamental aspects of human cognition that are nonarbitrary--namely, the performance components, acquisition components, transfer components, and metacomponents of human information processing. And a useful purpose would be and has been served by

trying to relate these various kinds of components to intelligence as it is defined by society. Today, the intelligence test seems to serve this reference function, at least for what Neisser refers to as academic intelligence. Perhaps one direction in which Neisser's thoughts might lead is toward better reference criteria; but for the time being, there seems to be no well worked out alternative to intelligence tests.

Finally, as Neisser points out, the existence of a "positive manifold" for intelligence tests argues in favor of a prototype, or underlying unitary construct, of intelligence. This construct has often been referred to as g. Calling this general factor or common something a prototype seems like a good first step toward understanding it. Discovering people's intuitions regarding what behaviors characterize the prototype seems like a good second step. But there is a third step that must follow these two, namely, the seeking of understanding of the psychological mechanisms underlying the objects of people's intuitions. If one of the characteristics of an intelligent person is (according to Cornell undergraduates) that he or she is "able to think logically," then we must understand how people do logical thinking. As it happens, this has been a major goal of my own research program directed toward the understanding of intelligence. I believe, therefore, that Neisser's notions complement, rather than contradict, many of my own regarding the nature of intelligence.

I would like to conclude by thanking the authors of this play for not taking its title too seriously. If they had, a one-liner might have sufficed for any given act: "Intelligence Tests in the Year 2000: They're Here!" Instead, the authors have pointed out multifarious directions in which intelligence testing might move, if not by the year 2000, then by some years thereafter, hopefully, not too many. My intepretation of their suggestions is that we will

see more, not less, of what I have called componential analysis. But the scope of componential analysis will have to be expanded to include kinds of components other than the performance components I and others have concentrated upon to date. We will seek to understand as well the components of acquisition and transfer, as well as the metacomponents that control componential activities. It is not clear to me, as it is not clear to Turnbull, that componential types of tests will replace refinements of the tests now in existence. But if our ultimate goal is to understand as well as to measure intelligence, it seems that as a bare minimum, componential tests will be wanted to supplement what we already have.

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