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Inner-Outer Compatibility Principle Model: Functionalism*1) and Computationalism

Jung-Ho Kim
Duksung Women's University

In the present paper Inner-Outer Compatibility Principle model was proposed as a general model of information processing and discussed in relation with Functionalism and Computationalism. It was emphasized that the measurement of inner-outer compatibility should be done so as to be used practically for better human information processing. In this regard it was held that pragmatic spirit of Functionalism should be reintroduced into the investigation of information processing and that Computationalism, a current dominant approach of cognitive psychology and cognitive science, needs some adjustment

I. Inner-Outer Compatibility Principle Model

Inner-Outer Compatibility Principle model was originally proposed to explain memory phenomena coherently incorporating various memory models (Kim, 1985, 1986b). (The term model is employed to denote a conceptual framework.) The memory models can be largely classified into non-relativity models and relativity models.

1. Models of Memory

A. Non-relativity Models of Memory

Levels-of-Processing (LOP) model, Elaboration model, and Schema model are among the non-relativity models.

LOP model was first suggested by Craik and Lockhart (1972) to emphasize the importance of level or depth of processing at encoding in memory. Craik and his colleagues showed that the deeper the processing at encoding the better the memory performance at retrieval (Craik & Tulving, 1975).

While LOP model stresses the quality of processing, Elaboration model emphasizes the quantity of processing. According to Elaboration model the more adds a subject further relevant information to the encoding of to-be-remembered event, the better he or she remember it at retrieval (Anderson, 1976, 1983; Anderson & Reder, 1979; Bradshow & Anderson, 1982). Although LOP model accepts that amount of elaboration at a level of processing induces better memory performance, it insists that levels of processing cannot be reduced to amount of processing (Jacoby & Craik, 1979).

According to Schema model we have organized

*1: In this paper Functionalism means one that is used in the context of the history of psychology not in the context of philosophy or cognitive science.

knowledge (named schema (Bartlett, 1932); script (Schank & Abelson, 1977); frame (Minsky, 1975); or description (Norman & Bobrow, 1979)), which determines what is encoded. Generally the more relevant to schema to-be-remembered event is, the better it is understood and remembered.

Although LOP model, Elaboration model, and Schema model are different from each other in details, they are the same in that they accept that goodness of memory is determined at encoding.

B. Relativity Models of Memory

Encoding Specificity Principle (ESP) model and Transfer-Appropriate Processing (TAP) model are among relativity models of memory.

ESP model was proposed by Tulving and his colleagues to emphasizes the importance of retrieval in memory (Tulving, 1979, 1983; Tulving & Thomson, 1973). According to ESP memory performance is determined by the compatibility between encoding and retrieval. In other words memory performance is not determined absolutely by encoding processes but relatively by the compatibility between encoding and retrieval.

TAP model presented by Bransford and his colleagues also stresses the relativity of memory. They hold that the value of encoding activity is determined relatively by the situation where the encoding activity is utilized (Bransford, Franks, Morris & Stein, 1979; Morris, Bransford & Franks, 1977; Stein, 1977, 1978). TAP model is not concerned with as much retrieval of specific information as transfer of certain processing.

Although ESP model and TAP model are different each other in that ESP model assumes specific memory trace, while TAP model does not, they are the same in that they emphasize the importance of retrieval situation and relation between encoding and retrieval.

2. Inner-Outer Compatibility Principle Model

Inner-Outer Compatibility Principle holds that in every information processing, whether at encoding or at retrieval, there exists specific relation between the inner and the outer, which is called inner-outer compatibility. Inner-Outer Compatibility Principle also holds that the inner-outer compatibility is specific to the to-be-required or to-be-constructed information. For example, the compatibility between a person and "APPLE" is different according to the information to be required. In relation with the research of LOP, semantic information of "APPLE" is better constructed than its rhyme information, which again, is better constructed than its orthographic information. In other words, in general, the compatibility between a person and "APPLE" for semantic information is higher than that for rhyme information, which is higher than that for orthographic information. Accordingly inner-outer compatibility is defined as the goodness or ease with which the inner and the outer as a whole construct certain information.

A. Incorporation of Non-relativity Models and Relativity Models of Memory with Inner-Outer Compatibility Principle Model

Non-relativity models and relativity models of memory can be incorporated in Inner-Outer Compatibility Principle model. Encoding effects emphasized by non-relativity models reflect inner-outer compatibility effects. Because some information is better processed or constructed according to inner-outer compatibility, it is better processed at encoding and at retrieval. Thus LOP effects are due to the differences of inner-outer compatibility of to-be-constructed information. That is, semantic information is better or more easily constructed than rhyme one, which is better or more easily constructed than orthographic one. Incidentally the fact that we are primarily concerned with semantic information reading a text reflects that superiority of semantic information in compatibility between the inner (a reader) and the outer (a text). Elaboration can be regarded as a way relating to-be-remembered information to that having higher inner-outer compatibility. Schema model can be thought as a way of explaining differences of inner-outer compatibility in terms of the inner.

ESP model and TAP model can be considered as models reflecting changed inner-outer compatibility after encoding some information. However, we had better assume that only one or two processings generally do not change the inner greatly. Thus the effects of levels-of-processing, elaboration, and schema still remain even after considering the relation between

encoding and retrieval.

Someone may suppose two compatibility: one at encoding and the other at retrieval. Thus LOP effects may be due to the inner-outer compatibility at encoding and ESP effects to that at retrieval. In terms of Inner-Outer Compatibility Principle model, however, we need not assume two compatibility. At any moment, whether at encoding or at retrieval, information processing is determined by the compatibility between the inner and the outer at the moment, though the inner-outer compatibility changes continuously with processing. In fact the terms encoding and retrieval are those defined relatively. When we are encoding some information other related information is being retrieved and vice versa. (For more detailed discussion of the above issue refer to Kim (1985, 1986a, and 1986b).)

B. Inner-Outer Compatibility Principle Model As a General Model of Information Processing

Although Inner-Outer Compatibility Principle model has been generally applied to the domain of memory phenomena, it can be also applied to information processing in general. Inner-Outer Compatibility Principle model assumes that information processing is dynamic meeting between the inner and the outer. Through information processing both the inner and the outer may change and therefore the inner-outer compatibility changes. From the perspective of the inner the dynamics of information processing reveals the adaptability of humans. Humans, like other organisms, try to adapt themselves to the environment through the information processing. In other words, humans manage to increase the inner-outer compatibility in their every information processing. Thus Inner-Outer Compatibility Principle model is concerned with not only memory phenomena but also information processing in general.

A model which tries to explain everything may explain nothing. Inner-Outer Compatibility Principle model can be considered as such a model. However, I want to insist that Inner-Outer Compatibility Principle model can be regarded as a meta-strategy or a general conceptual framework for better research in information processing in general. In that sense the term model might be ill employed. But we will continue to use the term model for convenience sake.

C. Measurement of Inner-Outer Compatibility

Inner-Outer Compatibility Principle model encourages that we should consider adaptability or flexibility of human information processing and measure the inner-outer compatibility. At first sight it seems unreasonable to hold both the adaptability of human information processing and the measurement of inner-outer compatibility. How can we measure inner-outer compatibility and what implication does the compatibility have for practical use, if we continuously adapt ourselves changing ourselves? In general, however, humans do not change abruptly. Thus we may be encouraged to measure the inner-outer compatibility. Besides, adaptability of human information processing and measurement of the inner-outer compatibility are very closely related each other, because the measurement can be used for better adaptation of human, that is, higher compatibility between the inner and the outer in information processing.

Someone may insist that the measurement of inner-outer compatibility seems to be in another difficulty in reality. For there may be as much inner-outer compatibility for an individual as the number of the outer domains. But however diverse the outer domains are, they can be classified into manageable size. And the inner-outer compatibility can be practically measured for our purposes.

For the measurement of inner-outer compatibility, first of all, we should specify information. As we said before, inner-outer compatibility is specific to the to-be-constructed information. To describe information is not easy work. It is also related with the problem of defining what meaning is. Still we have no consensus on what meaning is. Some theorists search meaning of meaning in our mind (e.g., Fodor, 1980, 1987, 1991). Others search it in the outer world (e.g., Putnam, 1975).

In this paper I will not deal philosophically with what meaning is or what information is in detail. Rather, I define information pragmatically as whatever we construct. That is, we have definition of information if and only if we have ways of manipulating or operating information, whatever they are. Of course, when we say we construct information, it does not mean that information is merely what we imagine, regardless of the outer. It also reflects the characteristics of the world. Thus information is what is constructed by both the

inner and the outer. We may say that what we know about the world and ourselves is a network of information which we have constructed. That is, the world as we know it is a network of information and the mind as we know it is also a network of information. Therefore specification of information is related with measurement of both the inner and the outer. (Refer to Kim (1991) for more detailed discussion on this issue. However, let me add one thing; we never deal with Ding-An-Sich (things-themselves) but constructs.)

There can be various ways to measure the outer according to the specification of information. For example, a word can be measured according to meaningfulness (Noble, 1952), imagery values (Paivio, Yuille, & Madigan, 1968), or frequency (Zipf, 1935). A sentence can be measured according to the number of words consisting the sentence, syntactic structure, or semantic contents. And a text can be measured in terms of propositional cohesiveness or interestingness. Likewise there can be various ways to measure the inner according to the specification of information. For example, we can measure a person in terms of his or her capability constructing meaning or imagery of words, or experience history (or frequency) of words. We can measure a person in terms of his or her capability managing syntactic or semantic relations, or number of words which he or she can remember after listening them once. And we can also measure a person in terms of his or her capability constructing semantic structure of a text.

With the above discussion we can say that various measurements of the inner and the outer can be used for the measurements of inner-outer compatibility. Inner-outer compatibility is determined by measuring a person (the inner)'s performance upon a test (the outer) in terms of constructing specific information. In this case we should already have the way to analyze the test (the outer) and his or her performance according to the specific information. (Further discussion on the measurement of inner-outer compatibility can be found in Kim (1986b).)

The emphasis of the measurement of inner-outer compatibility and the above discussion on the issue are based on the belief that psychology in general and especially cognitive psychology and cognitive science should be more pragmatic or functionalistic. The current dominant approach of cognitive psychology and cognitive science is Computationalism, which pursues describing detailed algorithms of mental processes. But It seems that Computationalism have gone too far. I think Computationalism needs some adjustment. Meanwhile, we had better reintroduce Functionalism into cognitive psychology and psychology in general. In the following sections we are going to deal with the relations of Inner-Outer Compatibility Principle model with Functionalism and Computationalism.

II. Functionalism

1. Functionalism in Psychology

Functionalism was originally established and developed in psychology as a school in the early 20th century by William James, John Dewey, and their students. It was much influenced by Darwin's evolutionary theory. Accordingly Functionalism had much interest in how the mind functions for the adaptation of a persons to his or her environment. It also had great concern for individual differences. It broadened the scope of the subject matter of psychology which had been restricted within narrow limits under Structuralism, which was the first school in psychology. It was also permissive in adopting various methodology, only if they induced fruitful results.

As Functionalism had overshadowed Structuralism, an antagonist of Functionalism, it stopped existing as a separate school of thought. In a sense there was no longer any need for it to retain the characteristics of a school because of its success, as Schultz (1981) mentioned. However, Behaviorism, the next school of psychology, narrowed again the subject matter as well as methodology of psychology. Behaviorism approved observable behavior only as the legitimate subject matter of psychology and excluded mind from the realm of psychology. Behaviorism also rejected method of introspection. With Cognitive Revolution in the 1950s psychology has regained the lost subject matter and equipped with more various methodology. For example, methods of computer simulation and protocol analysis (Ericsson & Simon, 1984), which can be regarded as a method of introspection, have been introduced. However, it does not seem that psychology

has recovered fully the functionalistic or pragmatic standpoint of Functionalism.

2. Functionalism Again With Inner-Outer Compatibility Principle Model

In many respects Inner-Outer Compatibility Principle model follows the tradition of Functionalism. Most of all it is pragmatic. Inner-Outer Compatibility Principle model regards information processing as means of adaptation to the environment (or the outer). With experience we develop the inner to be more compatible with the outer or change the outer to be compatible with the inner for better information processing. In short, through information processing both the inner and the outer change together or coevolve aiming for higher compatibility between the inner and the outer.

A. Mental Test Movement Again

Without measurement of individual differences we cannot expect pragmatic or functionalistic psychology. In the hay days of Functionalism we had experience great surge of mental test movement. In this regard mental test movement is very congenial to the spirit of Inner-Outer Compatibility Principle model in that Inner-Outer Compatibility Principle model emphasizes the measurement of inner-outer compatibilities. This is closely related with development of various mental tests. The inner-outer compatibilities are measured in the mental tests.

With the cognitive revolution we accepted the importance of prior knowledge of a person in information processing. For example, we hold that one's organized knowledge, or schema plays a great role in comprehension and memory (Anderson & Pichert, 1978; Bransford & Johnson, 1972). However, we have few ways to measure one's schema (or schemata). This is closely related with nowadays' dominant approach to cognition, Computationalism, and will be dealt with again in detail in the next section. With Computationalism most of the cognitive psychologists explain cognitive performance in such a way like that if there are such and such cognitive structure and processes then such and such cognitive behavior will be performed. However, without ways of measuring a specific individual's cognitive structure and processes, we are remained ignorant of his or her inner charateristics and can hardly explain his or her cognitive performance. Moreover we cannot develop programs to help his or her cognitive performance. We badly need to develop mental tests or ways to measure the inner characteristics. Of course we should not forget that the measurement of the inner is closely connected with that of the outer, as mentioned in the previous section.

B. Some research paradigm in Functionalism again

In Functionalism adjustment of an individual was one of the greatest interest. With the adjustment of an individual, Functionalism emphasized dynamics of human information processing. (Though at that time the term information processing was not formally used.) An individual changes continuously throughout his or her life interacting with the environment. Transfer, proactive interference, and retroactive interference research in the domain of learning and memory reflect the dynamics of human behavior. Most of such research, however, were performed in the period of Behaviorism which regarded highly, most of all, the strictness of research, and were restricted within narrow limits. The materials of transfer, proactive interference, and retroactive interference research were mostly nonsense syllables and words. Besides, interest of most of the research was on quantity rather than quality of learning and memory. They were generally concerned with the amount of transfer and interference.

The emphasis of dynamics of human information processing is compatible with a tenet of nowadays cognitive psychology. Most of the cognitive psychologists accept that our mental structure and processes change with information processing and the changed mental structure and processes again influence successive information processing. We can find research related with such issues in cognitive psychology. Research of schemata effect on comprehension and memory (Anderson & Pichert, 1978; Bransford & Johnson, 1972) can be regarded as that of transfer. However, as we mentioned before, schemata research has limitations in that the measurement of schemata is not well developed. Accordingly, as Eysenck & Keane (1990) indicated; "... schema theories tend to be good at accounting for results in an ad hoc fashion but are not as predictive as one would like them to be" (284). Besides, there is not

much research on how the schemata are established and changes.

Research about reconstruction in story recall (e.g., Spiro, 1977, 1980) and eye-witness report (e.g., Loftus, 1979; Loftus & Palmer, 1974) can be regarded as retroactive interference research, though in the research qualitative changes by retroactive influence were of interest. However, we can only scarcely find research manipulating systematically original and interpolated learning in cognitive psychology (Among the rare research are Kim (1989), Thorndyke (1977), and Thorndyke & Hayes-Roth (1979).) Larsen (1982) mentioned a reason that the retroactive influence on previous knowledge, "updating" in his term, had been ignored by discourse processing research, one of the main research domain in cognitive psychology; "[I]nterest has been focused on previous knowledge of a general nature, variously called schemata, frames, scripts, story grammars, etc. (Johnson and Mandler, 1980). Since such knowledge structures are not specific to any particular episode, they cannot be updated by information about specific events" (p. 207). Thus systematic manipulation of original and interpolated learning following the spirit of Functionalism is needed now in cognitive psychology, though the learning materials had better be more realistic.

Strangely enough, however, Functionalism paid little attention to mental function or process itself. The term function can be used as an activity or process, or a service to the whole organism. Such a classification of the usage of the term function can be found in one suggested by Ruckmick as early as 1913. Functionalism, however, seems to have used the term function mostly as a service to the whole organism. Even when Functionalism used the term function as mental activity or process, it stressed physiological process (or hardware) rather than abstract process (or software). The usage of the term function as mental process became prevalent after the cognitive revolution. Although the usage of the term function as mental process also needs more elaboration, we will deal with it in the next section. In this section suffice to say that with reintroduction of Functionalism we also regard mental process itself and take it into account in measuring inner-outer compatibility.

III. Computationalism

1. What is Computationalism?

Computationalism is a current dominant approach of cognitive psychology and cognitive science (Boden, 1988; Johnson-Laird, 1988). With computational approach human information processing is understood in terms of his or her mental structure and processes, the structure and processes being specified in explicit and formalized statements. Further it deals with the architecture of cognition as a grand theory of cognition (e.g., Anderson's (1983) Act* and Newell's (1989) SOAR).

The development of Computaionalism was greatly influenced by the advent of the computer, which enabled a machine to show intelligent behavior. According to Physical Symbol System Hypothesis proposed by Newell and Simon (1976) who were among the early researchers engaged in the field of A.I. (Artificial Intelligence), a system will be capable of intelligent behavior if and only if it is a physical symbol system. A physical symbol system is a system capable of manipulating symbols. It need not be necessarily a biological organism. A computer can input, output, store, and modify symbols. It is a physical symbol system which can perform intelligent behavior.

Psychologists who follow the computational approach use computer simulation as well as traditional experimentation as their research methodology. Computer simulation has facilitated the research of cognition. Without detailed structure and processes computer cannot simulate human behavior. Accordingly when a computer with a program actually simulates a certain behavior of human, computationalists regard the structure and the processes which are stated in the program as a model of human cognition, though the program fulfills only a sufficient condition to be a real structure and processes of human (cf., Howard (1983, pp. 200-204)). Even many psychologists of computationalism who mostly use traditional experimentation as research methodology manage to develop a detailed model of mental structure and processes, examining the congruency between what expected to be performed by their models and actual performance of human subjects.

Recently a new approach, named Connectionism, has appeared (Hinton & Anderson, 1981; McClelland & Rumelhart, 1986; Rumelhart & McClelland, 1986). Connectionism is both similar to and different from classical computationalism. Connectionism is different from classical computationalism in that it does not stipulate the existence of underlying symbolic representations. Under Connectionism the substrate of cognitive processes is assumed as a large neuron-like associative network. However, Connectionism is similar to classical computationalism in that its system follows rigorous rules in its operation, though they are implicit and tacit rather than explicit. In this respect, we can consider Connectionism as pursuing development of models of cognitive structure and processes especially through computer and regard it as belonging to computationalism.

Computational approach has brought much productive research in many domains of cognition including object perception, memory performance, problem solving, and so on. However, it has not gone unchallenged. Especially in the realm of philosophy of psychology there are much disputes over the value of computationalism.

J. A. Fodor (1980), for example, proposing methodological solipsism, confines computational psychology within the mind. He insists that computational psychology can deal only with mental states and processes and that it can have nothing to say about how mental states map onto the world. Yet he holds that computational psychology is the only theoretical psychology we can ever hope to achieve.

However, Searl (1980) is an unsympathetic critic. He regards computational psychology as essentially worthless. He insists that computational models which are simulated by computers cannot explain how the human mind employs symbols properly. He means that nothing can think, or understand solely in virtue of its instantiating a computer program.

We still can find more disputes over computationalism. In this paper, however, I will not deal with such disputes. Rather I am going to discuss some practical issues around Computationalism from the viewpoint of Inner-Outer Compatibility Principle Model.

2. Adjustment of Computationalism with Inner-Outer Compatibility Principle Model

Generally computational approach is congenial with Inner-Outer Compatibility Principle Model. Specifying mental structure and processes is a way of measuring the inner. Accordingly by considering both specified mental structure and processes with measurement of given specific domain of the outer, we can measure inner-outer compatibility in constructing specific information (or, in performing a task).

From the functionalistic point of view, however, current Computationalism needs some adjustment. Computationalism contributed mainly, to the psychology of computers but not much to that of humans. I do not mean that computer programs or computer simulations by the programs do not have the power of explanation for or the relation with human cognition. They make good models of human cognition. They give us good explanations of human cognition. However, what relations do they have with practical purposes for human cognition? I mean that most of the computational models of cognition which have merits for the development and refinement of the performance of computers have poor implication for better performance of humans. In other words, they are not much helpful to measure inner-outer compatibility of individual humanbeings, which is essential for understanding and developing their information processing. Why not? Let me use an analogy.

There can be several ways to understand movement of a car driven by a person. One of the ways is to describe the relation between the environment of the car and the movement of it only from the outside of the car. For example, if it meets a red traffic light, it stops; if a green traffic light turns on, it starts; and so on. This strategy is similar to that of Behaviorism in explaining human behavior. Another way is to describe the mechanics of the car. For example, when such and such elements of the car are working it stops; when such and such elements of the car are working it starts; and so on. In this case there can be two versions of approach. One is to describe the physical details of the elements (i.e., hardware) of the car and the other is to describe the abstract function of the element (i.e., software) of the car. The latter approach is that engaged by current

cognitive psychologists and cognitive scientists and the former approach is that engaged by physiological psychologists. Still another way to understand the movement of the car is possible. When the driver pushes the brake with his foot, the car stops. When he moves the handle, it changes its running directions. When he varies the pressure on the accelerator, its running speed changes. This strategy of understanding movement of a car belong to the strategy of describing the abstract relation of the elements. However, in this case the elements which are included in the description are those which are at the interface between a car and a driver, and thus can be controlled directly by a driver.

With the above analogy let's call the structure and function of elements in a car molecular structure and molecular function, and the structure and function of elements at the interface between a driver and a car molar structure and molar function. Molar structure and processes are those which are apt to be measured or operationalized and used by humans. They are best exemplified by our conscious strategies to perform a task, though they can become unconscious ones after repeated practice. In principle they can be learned or taught by humans with appropriate endeavour. On the contrary, molecular structure and processes are those that are hard to be used consciously by humans. Now we can say that current Computationalism mainly deal with molecular structure and processes and scarcely with molar structure and processes. Though the former is useful for running computers but not helping cognitive performance of humans. And for the latter the reverse is the case. Now let's clarify the issue of the distinction between molecular and molar structure and processes using an example in the research of information processing.

As an example of molecular approach which pursues modeling mental structure and processes at a molecular level, let's examine Sternberg's model of retrieval from STM (Short-Term Memory) (Sternberg, 1966, 1969, 1975). He suggested that four stages of processing are involved in retrieving information from STM in his memory search task; encoding stage, comparison stage, decision stage, and overt response stage. And he proposed three possible models which could explain his subjects' performance in the task (a serial exhaustive scanning model, a serial self-terminating model, and a parallel scanning model) and chose the serial exhaustive scanning model as the fittest one. However, Sternberg's serial exhaustive scanning model has difficulty in explaining serial position effects (Burrows & Okada, 1971; Clifton & Birenbaum, 1970; Raeburn, 1974) and repetition effects (Baddeley & Ecob, 1973). It was also suggested that Sternberg's observations also can be explained by parallel processing models (Corcoran, 1971; Townsend, 1971, 1974). If the retrieval phenomenon can be equally explained by both serial and parallel processing models, no one can be persuaded to pursue the issue of serial and parallel processing. The issue is not empirically decidable. (Incidentally, the imagery-propositional debate (Pylyshyn, 1973, 1979, 1981, 1984; Kosslyn, 1980, 1981), which, I think, was possible because of current dominancy of molecular approach, turned out to be empirically indeterminable.)

Besides, from a point of functionalistic view, we can put questions of utility of his model or his approach (choosing one among the models mentioned above) for improving human performance. Whether our retrieval from STM is explained by a serial exhaustive scanning model, a serial self-terminating model, or a parallel scanning model, does such a model of retrieval have any implication for our retrieval? I think such a model tries to explain mental structure and processing at a molecular level. Rather we had better approach the retrieval phenomena at a molar level. What effects does number of items in memory set have on strategies subjects use? What effects do required tasks have on subjects' retrieval strategies? Or what is the best strategies to manage a required task? These questions will lead to modeling mental structure and processing at the molar level.

As indicated by Wessells (1982); "it is inappropriate to ask whether scanning is serial or parallel. Scanning can and does occur in many ways that depend in part on the subject's history of practice" (p. 114). In other words, human information processing is highly flexible. We had better ask how the human adapt himself or herself to the environment according to his or her required goal.

As I mentioned before, I do not mean computational approach does not explain human cognition. I do mean that there are many ways to explain human cognition and that we should try to follow more pragmatic

approach in explaining human cognition. In fact, different programs, which may be regarded as models of mental structure and processes, can show one and the same performance. They fulfill the sufficiency criterion of model testing. All the programs showing one and same behavior are of practical use for computers, though their efficiency may be different from each other. However, few of them may be of practical use for humanbeings. In this regard I think we had better pay more attention to the structure and functions of the mind at a molar level rather than those of at molecular one.

Finally, we should not assume that molecular and molar approaches are mutually exclusive. Their relations can be complementary. Moreover some existing models of molecular and computational approach can be adapted to be those of molar and functionalistic approach as we mentioned before. For example, Sternberg's approach also can be adapted for practical usage. Without mentioning his molecular explanation we can use his test as a mental test. In fact Darley, Tinklenberg, Hollister, & Atkinson (1973) used the test to inquire the effects of marihuana on retrieval from STM. Unpublished work by Checkosky cited in Sternberg (1975) used the test to measure the differences among alcoholics, schizophrenics and normal college students in retrieval from STM. We can also find some other researches which used the test to measure differences among various groups (Hunt, 1978). Thus I never hold that Computationalism should be replaced by Functionalism but that it had better accept molar computation as well as molecular one.

IV. Concluding Comments

Psychology can be defined as a science of human information processing, or broadly information processing in general. Inner-Outer Compatibility Principle describes characteristics of human information processing. Inner-outer compatibility is goodness or ease with which the inner (human) processes or constructs certain information from the outer (environment). In other words, there exits compatibility between the inner and the outer in constructing certain information. (Of course Inner-Outer Compatibility Principle can be applied to information processing in general. The inner can be an animal, a computer, or even an immune system.)

Then what implications does Inner-Outer Compatibility Principle model have for human information processing? In a sense it seems to be a large cloth which wraps anything. Someone may say that Inner-Outer Compatibility Principle model seems to give plausible explanations about any information processing phenomena but the explanations are only ad hoc and circular. Inner-Outer Compatibility Principle model, however, emphasizes that we should measure the inner-outer compatibility in many areas of information processing. With such measurement we can get rid of the circular and ad hoc explanations.

It was emphasized, in relation with the measurement of inner-outer compatibility, that Functionalism should be reintroduced in the research of information processing. Functionalism, which was much influenced by Darwin's evolutionary theory, had great concern for the adaptation of humans to their environment, and developed mental tests to measure individual differences. Thus measurement of inner-outer compatibility is related with measurement of individual differences in information processing. However, Functionalism did not develop elaborated models of the structure and processes of the inner. In this regard Computationalism, current dominant approach of information processing, is superior to Functionalism. But not a few models of the mental structure and processes developed under Computationalism are too sophisticated to be helpful to individual humanbeings. Thus it was suggested that we had better pursue modeling or measurement of the inner structure and processes at a molar level, though modeling or measurement at a molecular level should not be ignored. In short we are encouraged to measure the inner-outer compatibility to be practical for individual humanbeings.

Inner-Outer Compatibility Principle model is far from an elaborated system of explanation. As I mentioned at the beginning of this paper, the term model denotes a conceptual framework (or a set of orienting attitudes). However, I think, it can show us a good way to investigate information processing in general and to integrate various models on it into a general framework. Now we have much to do for the measurement of inner-outer compatibility in every domain of information

processing.

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안-밖 합치도 모형: 기능주의및 계산주의와 관련하여

김 정 호
덕성여대 심리학과

본 논문에서는 안-밖 합치도 모형을 정보처리의 일반적 모형으로 제안하였으며 기능주의및 계산주의와 관련하여 논의하였다. 안-밖 합치도의 측정이 인간의 보다 나은 정보처리를 위한 방향으로 실용적으로 이루어져야 함을 강조하였다. 이러한 관점에서 기능주의의 실용주의 정신이 정보처리 연구에 재도입되어야 하며, 현재의 인지심리학과 인지과학의 지배적 접근법인 계산주의에 조정이 필요함을 논의하였다.