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ABSTRACT

An information-processing approach to language learning is examined; language aptitude is factored into the approach, and the role of working memory is discussed. The process of learning includes two processes that make heavy use of working memory is: automatization and restructuring. At first, learners must make a conscious effort to remember and apply a new concept, but later can apply the same concept without conscious effort. The initial stages of learning involve the slow development of skills and the gradual elimination of errors as the learner attempts to automatize aspects of performance. With regard to restructuring, individual language learning aptitude differences are suspected to be the result largely of the joint function of the availability of knowledge about the target language and the speed and efficiency of working memory, which affects the extent to which the individual succeeds in generalizing and altering (restructuring) the cognitive data required at various language processing stages. It is concluded that in second language learning, working memory relates to the degree to which individuals can restructure and reconfigure linguistic representations flexibly and consistently. (Contains 56 references.) (MSE)

APTITUDE FROM AN INFORMATION PROCESSING PERSPECTIVE

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For some years now I have been wrestling with the question of aptitude from within an information processing perspective. In this paper I will briefly outline the approach that I take, examine how aptitude is conceptualized in this framework, and discuss one possible component of second language aptitude, working memory.

Information Processing

Because human learners are limited in their information-processing abilities, only so much attention can be given to the various components of complex tasks at one time. In order to function effectively humans develop ways of organizing information. Some tasks require more attention; others that have been well practiced require less. The development of any complex cognitive skill involves building up a set of well-learned, efficient procedures so that more attention-demanding processes are freed up for new tasks. In this way limited resources can be spread to cover a wide range of task demands.

In this framework, learning is a cognitive process because it is thought to involve internal representations that regulate and guide performance. In the case of language learning, these representations are based on the language system and include procedures for selecting appropriate vocabulary, grammatical rules, and pragmatic conventions governing language use. As performance improves (becomes more automatic), there is constant restructuring as learners simplify, unify, and gain increasing control over their internal representations (Karmiloff-Smith 1986). These two notions—automatization and restructuring—are central to the information processing approach.

The Routinization of Skills

Several researchers (Hasher and Zacks 1979, Posner and Snyder 1975, Schneider and Shiffrin 1977, Shiffrin and Schneider 1977) have conceived of the differences in the processing capacity necessary for various mental operations in a dichotomous way: either a task requires a relatively large amount of processing capacity, or it proceeds automatically and demands little processing energy. Furthermore, a task that once taxed processing capacity may become, through practice, so automatic that it demands relatively little processing energy.

Automatic processing involves the activation of certain nodes in memory each time the appropriate inputs are present. This activation is a learned response that has been built up through the consistent mapping of the same input to the same pattern of activation over many trials. Because an automatic process utilizes a relatively permanent set of associative connections in long-term storage, most automatic processes require an appreciable amount of training to develop fully. Once learned, however, automatic processes occur rapidly and are difficult to suppress or alter.

The second mode of information processing, controlled processing, is not a learned response, but instead a temporary activation of nodes in a sequence. This activation is under the attentional control of the subject and, because attention is required, only one such sequence can normally be controlled at a time without interference. Controlled processes are thus tightly capacity-limited, and require more time for their activation. But controlled processes have the advantage of being relatively easy to set up, alter, and apply to novel situations. The clearest example of this distinction that I can think of is writing with one's right and left hand. Assuming that you are a right-handed person, writing with that hand is automatic, but writing with the left hand requires controlled processing.

Consider the following report of a schizophrenic patient:

> I'm not sure of my own movements any more.... I found recently that I was thinking of myself doing things before I would do them. If I'm going to sit down for example, I've got to think of myself and almost see myself sitting down before I do it. It's the same with other things like washing, eating, and even dressing—things that I have done at one time without even bothering or thinking about at all....I take more time to do things because I am always conscious of what I am doing. If I could just stop noticing what I am doing.... I have to do everything step by step now, nothing is automatic. Everything has to be considered (from McGhie 1969).

Of course, this is a very dysfunctional situation. If we had to think through ordinary activities before we did them, we would not be able to manage our lives very well.

What we see in this patient is a breakdown in the automaticity that is so important for normal functioning. We perform numerous complex tasks in our daily lives automatically, without thinking about them. But this was not always the case; we had to learn to perform the operations involved in these complex skills by focusing attention on them.

Learning to drive using a clutch or attempting to master the backhand in tennis are tasks that require a great deal of attention—or what I am referring to here as "controlled processing." After one has practiced the task, components of these skills become automatic, and controlled processing is required only in unusual cases. When you have been driving for many years, you can carry on a conversation as long as no emergencies arise; but if you have to drive on a very icy road, controlled processing is called into play and it is difficult to keep a conversation going.

With enough practice, it is possible for people to carry out quite amazing feats. In one experiment, after extended practice, subjects were able to read a story aloud while writing down another story from dictation (Solomons and Stein, 1896, cited in Howard 1983). In this case, presumably, reading had become so automatic that the subjects could devote attention to the other task. Note that from an information-processing perspective, the same principles apply to complex skills such as reading, writing, or learning a second language as apply in the case of motor skills such as driving, typing, or playing tennis.

In short, within this framework, complex cognitive skills are learned and routinized (i.e., become automatic) through the initial use of controlled processes. Controlled processing requires attention and takes time, but through practice sub-skills become automatic and controlled processes are free to be allocated to higher levels of processing. Thus controlled processing can be said to lay down the "stepping stones" for automatic processing as the learner moves to more and more difficult levels (Shiffrin and Schneider 1977).

In this conceptualization, complex tasks are characterized by a hierarchical structure. That is, such tasks consist of sub-tasks and their components. The execution of one part of the task requires the completion of various smaller components. As Levelt (1978) noted, carrying on a conversation is an example of a hierarchical task structure. The first-order goal is to express a particular intention. To do this, the speaker must decide on a topic and select a certain syntactic schema. In turn, the realization of this schema requires sub-activities, such as formulating a series of phrases to express different aspects of the intention. But to utter the phrases there is the need for lexical retrieval, the activation of articulatory patterns, utilization of appropriate syntactic rules, etc. Each of these component skills needs to be executed before the higher-order goal can be realized, although there may be some parallel processing in real time.

Note the importance, in this framework, of practice. The development of any complex cognitive skill is thought to require building up a set of well-learned, automatic procedures so that controlled processes are freed for new learning. From a practical standpoint, the necessary component is overlearning. A skill must be practiced again and again and again, until no attention is required for its performance. *Repetitio est mater studiorum*—practice, repetition, time on task—these seemed to be the critical variables for successful acquisition of complex skills, including complex cognitive skills such as second-language learning.

This conceptualization, however, leaves something out of the picture, and runs contrary to the experience of researchers in the second-language field. As Patsy Lightbown wrote in a review paper:

> *Practice does not make perfect.* Even though there are acquisition sequences, acquisition is not simply linear or cumulative, and having practiced a particular form or pattern does not mean that the form or pattern is permanently established. Learners appear to forget forms and structures which they had seemed previously to master and which they had extensively practiced. (Some researchers have referred to 'U-shaped development.')

She went on to discuss some of her own research:

> Learners were—for months at a time—presented with one or a small number of forms to learn and practice, and they learned them in absence of related contrasting forms. When they did encounter new forms, it was not a matter of simply adding them on. Instead the new forms seemed to cause a restructuring of the whole system (Lightbown, 1985, p.177).

Restructuring and Reading

These comments made sense, and helped clarify some puzzling data from a study of second-language reading (McLeod and McLaughlin 1986). The data came from an analysis of errors that speakers of differing degrees of proficiency in English made when reading aloud. We found that the errors that beginning ESL students made were primarily nonmeaningful, which was seen to be due to these students focusing on the graphic aspects of the text. That is, they would make errors like "She shook the piggy bank and out came some many" (for 'money'); whereas native speakers were more likely to make meaningful errors, such as "She shook the piggy bank and out came some dimes." It was expected that the proportion of meaningful errors for advanced ESL students would fall somewhere between what was found for beginning ESL students and native speakers. But instead, it was found that advanced ESL students, who had a much superior grasp of the syntactic and semantic constraints of English (as shown by their performance on a cloze test), made as many nonmeaningful errors as the beginning students.

Research on reading indicates that beginning readers who have mastered the mechanical aspects of reading continue to process the text word by word, not using contextual semantic relations and syntactic information to comprehend meaning (Cromer 1970). What was surprising to us was that more advanced second language learners in our study were apparently doing the same thing. Their errors showed that they were not utilizing semantic and syntactic cues as well as they could have. They were not approaching the task as "a psycholinguistic guessing game," in which graphic cues were used to make predictions about what the printed text means—even though the evidence from the cloze test suggested that they were quite capable of making such predictions. Their increasing syntactic and semantic competence enabled them to make nearly twice as many accurate predictions as the beginners on the cloze test. Yet they had not applied this competence to their reading behavior.

This suggests a process of restructuring had not yet occurred. What seemed to be happening was that the advanced subjects were using old strategies aimed at decoding in a situation where their competencies would have allowed them to apply new strategies directed at meaning. Their performance on the cloze test indicated that they had the skills needed for "going for meaning." Presumably they read this way in their first language. But they had not yet made the shift (restructured) n their second language. In this language, they did not make strategic use of the semantic and syntactic knowledge at their disposal. Indeed, other researchers obtained very similar results in second-language reading (Clark 1979).

The Restructuring Concept

The concept of restructuring can be traced in the psychological literature to the developmental psychologist, Jean Piaget. The Piagetian structuralist approach maintains that cognitive development is an outcome of underlying structural changes in the cognitive system. Just what constitutes structural change has been a topic of some debate (see Globerson 1986; Karmiloff-Smith 1986). Suffice it to say that there appears to be agreement that not just any change constitutes restructuring. Restructuring is characterized by discontinuous, or qualitative, change as the child moves from stage to stage in development. Each new stage constitutes a new internal organization and not merely the addition of new structural elements.

Recent concern with restructuring in developmental psychology reflects a new emphasis on the dynamics of change and a reaction to what had became known as the "snapshot problem." That is, developmental psychologists became concerned that their knowledge of cognitive growth consisted of a series of "snapshots" of the child's abilities at various points in development, but that they knew little about how the child progressed from snapshot to snapshot. The analogy in the field of second-language research is the concern—expressed by a number of authors (e.g., Hatch 1978; Huebner, 1983; Long and Sato 1984)--that there is more known about linguistic products, but little known of the dynamics of psycholinguistic processes.

From an information processing perspective, restructuring can be seen as a process in which the components of a task are coordinated, integrated, or reorganized into new units, thereby allowing the procedure involving old components to be replaced by a more efficient procedure involving new components (Cheng 1985). To study restructuring is to focus on the mechanisms of transition that are called into play as the learner modifies internalized, cognitive representations.

In short, learning inevitably goes beyond mere automaticity. There is a constant modification of organizational structures. Rumelhart and Norman (1978) identified restructuring as a process that occurs "when new structures are devised for interpreting new information and imposing a new organization on that already stored" (p. 39). They contrasted this process of learning with (a) accretion, whereby information is incremented by a new piece of data or a new set of facts, and (b) tuning, whereby there is a change in the categories used for interpreting new information. In tuning, categories, or schemata, are modified; in restructuring, new structures are added that allow for new interpretation of facts.

Rumelhart and Norman argued that learning is not a unitary process, but that there are different kinds of learning, one of which is restructuring. Whereas some learning is thought to occur continuously by accretion, as is true of the development of automaticity through practice, other learning is thought to occur in a discontinuous fashion, by restructuring. This discontinuity accounts for the second-language learner's perceptions of sudden moments of insight or "clicks of comprehension." At such moments, presumably, the learner can be said to understand the material in a new way, to be looking at it differently. Often learners report that this experience is followed by rapid progress, as old linguistic information and skills are fit into this new way of understanding. As Kolers and Roediger (1984) put it, learning involves a reassembly and refinement of procedures of the mind.

Second-Language Learning As a Complex Cognitive Skill

Applying these notions more specifically to second-language learning, one can say that from an information-processing perspective, second-language learning, like any other complex cognitive skill, involves the gradual integration of sub-skills, as controlled processes initially predominate and later become automatic. Thus the initial stages of learning involve the slow development of skills and the gradual elimination of errors as the learner attempts to automatize aspects of performance. In later phases, there is continual restructuring as learners shift their internal representations. Although both processes occur throughout the learning of any complex cognitive skill, gains in automaticity are thought to be more characteristic of early stages of learning and restructuring of later stages.

For the most part, second-language researchers have been more concerned with the development of automaticity than with restructuring, though there has been some recognition of the role restructuring plays in second-language acquisition. A number of authors have commented on discontinuities in the second-language learning process (e.g., Pike 1960, Selinker 1972). Lightbown (1985) pointed out that second-language acquisition is not simply linear and cumulative, but is characterized by backsliding and loss of forms that seemingly were mastered.

Restructuring provides an explanation for examples of U-shape developmental functions in language learning, where performance declines as more complex internal representations replace less complex ones, and increases again as skill becomes expertise. There are many examples of such U-shaped functions in the literature on first- and second-language learning (see McLaughlin 1990). One example is a common strategy adopted by young second-language learners (and, perhaps by more older second-language learners than we realize) to memorize formulas (Hakuta, 1976, Wong Fillmore 1976). Some children are capable of amazing feats of imitation, producing multi-word utterances, which, it turns out, they understand only vaguely. Such unanalyzed chunks appear to show evidence of a sophisticated knowledge of the lexicon and syntax, but it has become clear that such holistic learning is a communicative strategy that second-language learners use to generate input from native speakers (Wong Fillmore 1976).

Subsequently, such formulas are gradually "unpacked" and used as the basis for more productive speech. At this stage, the learner's speech is simpler but more differentiated syntactically. Whereas utterances were as long as six or seven words in the initial stage, they are now much shorter. The learner has at this point adopted a new strategy, one of rule analysis and consolidation.

Expert Systems

Now I would like to turn to the question of what makes a successful language learner. When I ask my students this question, they inevitably answer that you have to have an ear for languages. Some of them say they do not have such an "ear," and cannot learn second languages. As researchers and practitioners, we know that there is not much evidence for a "language ear." There has been some work on the relationship between learning a second language and musicality, but correlations are modest or nonexistent. This is generally true of research directed at the personality characteristics of "the good language learner." In this tradition, researchers studied traits of good learners—musicality, intelligence, extraversion, empathy, and the like. Other researchers examined self-esteem (Heyde, 1977), tolerance of ambiguity (Naiman, Frohlich, Stern, and Todesco, 1978) or the role of motivational and attitudinal variables (Gardner and Lambert, 1972; Nelson and Jakobovits, 1970).

I (Nation and McLaughlin 1986) have argued that three problems beset these efforts. First, there is the problem of the difficulty of obtaining valid and independent measures of personality traits and motivational variables (Oller, 1981). There is considerable shared variance between many of these variables and it is difficult to tease out effects due to each separately. Second, there is the issue of trait by instruction interactions (McLaughlin, 1980). In the real world, it may be that some instructional methods work better than others for individuals with certain personality traits. The good language learner in one context may not be a good language learner in another. Finally, there is the question of causal direction. There may in fact be instances where the direction of causality is from learning to personality factors rather than the other way around. Some evidence for this notion comes from studies on attitudes and language learning in children (Hermann, 1980; Strong, 1984), which suggest that acquiring skill in a languages influences attitudes toward acquisition.

Because of the problems inherent in an approach that looks at person factors, my colleagues and I have taken another tack—one that focuses on process. Specifically, we suggest that "expert" language learners use different information-processing strategies and techniques than do more "novice" learners. This appears to be true in other domains. For example, Chase and Simon (1973) replicated de Groot's(1965) finding that Master chess players reconstructed with greater than 90 percent accuracy midgame boards they had seen for only five seconds. They observed that Master players recalled clusters that formed attack or defense configurations, whereas beginners lacked the skill to form such abstract representations. Strategy differences were also reported by Adelson (1981), who found that expert computer programmers used abstract, conceptually based representations when attempting to recall programming material, whereas novices used more concrete representations. Differences between experts and novices have also been found in research on learning mechanisms in physics (Chi, Glaser, and Rees, 1981), arithmetic (Brown and Burton, 1978), algebra (Lewis, 81), and geometry (Anderson, Greeno, Kline, and Neves, 1981). For the most part, these studies show that experts restructure the elements of a learning task into abstract schemata that are not available to novices, who focus principally on the surface elements of a task. Thus experts replace complex sub-elements with single schemata that allow more abstract processing.

In the realm of language learning, we argued that experts are those individuals who have learned a number of languages. There is considerable anecdotal evidence that once a person has learned a few languages, subsequent language learning is greatly facilitated. Presumably, there is some positive transfer that results from the process of language learning and carries over to the learning of a new language. Unfortunately, there is very little experimental evidence for such a positive transfer hypothesis. Hence, we have conducted a number of studies using miniature linguistic systems to ascertain what makes more experienced language learners different from novices.

Nation and McLaughlin (1986) carried out an experiment in which we contrasted information processing in multilingual, bilingual, and monolingual subjects learning a miniature linguistic system. We wanted to see how "expert" language learners (multilingual subjects) compared in their performance with more "novice" language learners. Subjects were asked to learn a finite-state Markov grammar under conditions in which they were merely exposed to the system without instructions to learn it (Implicit learning) or under conditions in which they were told that the system was rule-based and they should learn the rules (Explicit learning).

Multilingual subjects were found to learn the grammar significantly better than bilingual or monolingual groups when the instructions called for "Implicit" learning, but not when the instructions called for "Explicit" learning. We argued on the basis of the subsequent analyses that the superior performance of the multilingual subjects on the Implicit-learning task was the result of better automated letter- and pattern-recognition skills.

In general, it may be that individuals with more language-learning experience build up certain basic skills that transfer to new language-learning situations. These skills might include automated auditory recognition skills, pattern recognition skills, word-decoding skills, and superior auditory memory. Because these sub-skills of the task have become relatively automatic in multilingual subjects, attention is freed up to be devoted to the recognition of rule-governed regularities.

In another experiment from our laboratory (Nayak, Hansen, Krueger, and McLaughlin, 1990), monolingual and multilingual subjects were exposed to a limited subset of permissible strings from an artificial linguistic system. We were interested in whether they could apply generalizations derived from the learned subset to novel strings and if so, what was the nature of these generalizations. Subjects were exposed to "sentences" in a grammar ranging in length from two to five words. Words were CVC trigrams. Above each word abstract forms appeared, which were the referents for that word. Subjects were assigned at random to one of two learning conditions: (a) a memory condition, in which they were told to memorize the strings, or (b) a rule-learning condition, in which they were told to look for underlying rules. Subsequent to the learning phase, subjects were shown abstract forms coupled with CVC words and were asked to decide whether the word was matched with the correct form. Subjects were also asked to decide whether novel strings were acceptable in the linguistic system they had been exposed to.

The results of this study indicated that there were differences in learning, in that subjects in the memory condition did better on the vocabulary task than did subjects in the rule-learning condition, while the reverse was true for decisions about the acceptability of novel strings. However, the general level of performance of multilingual and monolingual subjects did not differ: the "experts" were not better than the "novices" in either the vocabulary or the syntax acceptability task, but there were differences in how the two groups went about the tasks.

To examine these differences we had asked subjects at three points during the learning phase to verbalize for another potential subject exactly what they were doing and what strategies they were using. We coded the verbalizations of all subjects into four categories. The first two referred to strategies that involved the use of **mnemonic** devices, either *visual*—for example:

> First, I was trying to look at the abstract form above the word and just try and remember what they looked like, see if there's some type of correlation....CAV looked like a cave. KOR was similar to a Russian word, I tried to associate the words with the symbols.

or *verbal*—e.g.:

> ... I tried looking at the words themselves and seeing if I could eliminate certain letters, like the first letter of each thing, if I could form a word out of that or I kept just trying different combinations to see if by reading it backwards and forwards and all these different ways, if it would make some sense.

Two other categories reflected the use of **linguistic** strategies, either *structural*:

> This time it seems like I'm inclined to finding places more than... I uh, it seems like I'm splitting them up into nouns and verbs and objects, and if one goes into a place where, say if an object goes into a place where I think a verb should be, I think it shouldn't be there....

or referring specifically to *word order*:

> I still feel like the rectangular one goes at the beginning, and then either the straight line or the zigzag lines comes in second place, and then the CAV or DUP usually are at the end. When they come into the middle, I feel like the sentence isn't in its proper order.

We found that multilingual subjects were more likely to use mnemonic devices than linguistic strategies in the memory condition, but that in the rule-discovery condition, both groups of subjects preferred linguistic strategies to mnemonic devices, although the difference was statistically significant only for the multilingual subjects.

In addition, we found that multilingual subjects used a wider variety of different strategies in the rule-discovery than in the memory condition, and that no such difference existed for the monolingual subjects. This suggests that one difference between more and less experienced language learners relates to flexibility in switching strategies. This is consistent with the research of Nation and McLaughlin (1986), who found that multilingual subjects were able to avoid perseveration errors more than were other subjects in their experiment. Similarly, Ramsey (1980) reported that multilingual subjects demonstrated greater flexibility in "restructuring mental frameworks" than did monolingual subjects.

Thus there is some evidence to suggest that more expert language learners show greater plasticity in restructuring their internal representations of the rules governing linguistic input. This ability to exert flexible control over linguistic representations and to shift strategies may result from "learning to learn," in the sense that experience with a number of languages may make the individual more aware of structural similarities and differences between languages and less constrained by specific learning strategies. More experienced learners may more quickly step up to the metaprocedural level and weigh the strategies and tactics they are using.

Such a conclusion needs to be tempered by noting that in our research the differences between more and less successful language learners were relatively subtle. There are still many questions remaining—especially the question of what makes it possible for some individuals to be more flexible than others in forming mental representations of a new linguistic system? What is the reason for differences in information-processing strategies? This brings me to the issue of aptitude. Specifically, I would like to talk about a possible components of language aptitude, working memory.

Working Memory and Aptitude

At first glance, introducing the notion of aptitude may appear to lead us back to innate personality traits, but, as I will argue in more detail later, it is not necessary to think of aptitude as a fixed capacity. Instead, I suggest that we conceptualize aptitude as modifiable by previous learning and experience. Novices can become experts with experience. In the case of multilinguals, experience with several languages provides them with strategies and metacognitive skills that generalize to subsequent languages.

The classic work on aptitude, of course, is that of John B. Carroll. In a 1981 paper, Carroll argued that the tasks contained in aptitude tests are similar to the processes described in information-processing accounts of cognitive functioning. He speculated, for example, that individual variation in the ability to recognize grammatical functions and to match functions in different sentence structures may reflect differences in the ability to operate in "executive" working memory and to store and retrieve information from short-term memory. This line of thinking anticipated recent work on expert systems and is quite consistent with the framework I am advocating. In particular, recent work on the concept of "working memory" fits in very well with the way Carroll conceptualized language learning aptitude.

The concept of working memory is relatively new in cognitive psychology, and refers to the immediate memory processes involved in the simultaneous storage and processing of information in real-time. The term dates to Newell (1973) and is distinguished from the more traditional understanding of short-term memory as a passive storage buffer. Working memory is assumed to have processing as well as storage functions; it serves as the site for executing processes and for storing the products of these processes. For example, in processing a second language, the learner must store phonological, syntactic, semantic, and pragmatic information and must use this information in planning and executing utterances. This information can become a part of working memory via a number of routes: it may be perceptually encoded from the input of an immediate interlocutor, it may be sufficiently activated so that it is retrieved from long-term memory; or it can be constructed as speech is planned.

Working memory is assumed to be limited in its capacity. Working memory limits constrain the development of complex cognitive tasks at several stages. Assuming that the mastery of such complex tasks requires the integration of controlled and automatic processing (e.g., LaBerge and Samuels, 1974; Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977), one would expect that more working-memory capacity is required at the attention-demanding initial phase when controlled processes predominate. Later, when subtasks that once taxed processing capacity become so automatic that they require little processing energy, working-memory load is reduced.

A second limitation of working memory on the acquisition of a complex cognitive skill occurs later as automaticity builds up and memory load is reduced. Anderson (1983) has suggested that, although initial formation of automatic processes reduces working-memory load, subsequent skill improvement actually increases working-memory load. The reason for this is that the size of subtasks (or what Anderson calls "composed productions") increases. Larger subtasks require more conditions to be active in working memory before they can execute. This may be an explanation for the kind of effects that occur as learners impose organization on information that has been acquired.

What I am suggesting is that increased practice can lead to improvement in performance as sub-skills become automated, but it is also possible for increased practice to create conditions for restructuring with attendant decrements in performance as learners reorganize their internal representational framework. In the second case, performance may follow a U-shaped curve, as was discussed earlier, declining as more complex internal representations replace less complex ones, and increasing again as skill becomes expertise. The reason for such U-shaped functions is that integrating large subtasks makes heavy demands on working memory, and hence performance is actually worse in subsequent stages than it is initially.

Recent research on working memory shows links to vocabulary development, speech production, comprehension, and phonological memory (Gathercole and Baddeley, 1993; Harrington, 1992; Service, 1992; Speidel, 1993). Nonetheless, several hypotheses remain to be tested: first, the question of whether working memory in the first and second language are independent or two aspects of the same thing. If relative processing efficiency is independent of specific language development, it is expected that relative working memory capacity in the first language will also be evident in the second. Further, it would be expected that individuals with larger first language working memory capacity will be better, possibly faster learners of the second language. Second, there is the question of the development of second-language working memory across time. Longitudinal studies are needed to provide a profile of how second-language working memory capacity and second-language proficiency co-vary in the course of development. Such research is important to demonstrating a causal link between working memory and second-language learning.

Can Aptitude Be Learned?

Although much research remains to be done on the role of working memory in second-language learning, I suspect that individual differences in language learning aptitude are due in large measure to the joint function of availability of knowledge about the target language and the speed and efficiency of working memory—which affects the extent to which the individual succeeds in generating and altering the cognitive data required at various processing stages. That is, in second-language learning working memory relates to the degree to which individuals can more flexibly and consistently restructure and reconfigure linguistic representations.

I believe that there are strategies that can be taught to increase the efficiency of working-memory processes. Indeed, within an "expert systems" framework, Faerch and Kasper (1983), McGroarty (1989), Oxford (1986), and O'Malley and Chamot (1989) have attempted to specify strategies that good language learners use and to teach them to less expert learners. The ultimate goal of much of this research has been to expand and refine the repertoire of strategies of poor learners so that they may benefit from strategies used to good effect by "expert" learners. This work on strategy differences that distinguish good from poor language learners (O'Malley and Chamot, 1989; Oxford, 1986; Wenden, 1987) is important for teaching learners to be more efficient information processors. Indeed, experimental research (e.g., Chase and Ericcson, 1982) has shown that working-memory capability can be greatly expanded as a function of relevant knowledge structures and strategies.

In conclusion, I think there is an answer to students who complain that they just do not have any aptitude for languages. My response is that, although some students definitely have an advantage in language learning because of strategies they have developed and their knowledge base, this does not mean that other students cannot develop similar strategies and build up their knowledge base. Of course the goal for researchers and practitioners is to identify the relevant strategies and help students use them to build up their knowledge of the language and skill in using it.

References

Adelson, B. (1981). Problem Solving and the Development of Abstract Categories in Programming Languages. *Cognition, 9*, 422-433.

Anderson, J. (1983). *The Architecture of Cognition*. Cambridge, MA: Harvard University Press.

Anderson, J. R., Greeno, J. G., Kline, P. J., and Neves, D. M. (1981). Acquisition of Problem-Solving Skills. In J. R. Anderson (Ed.), *Cognitive Skills and Their Acquisition*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, J. S., and Burton, R. R. (1978). Diagnostic Models for Procedural Bugs in Basic Mathematical Skills. *Cognitive Science, 2*, 155-192.

Carroll, J. B. (1981). Twenty-Five Years of Research on Foreign Language Aptitude. In K. C. Diller (Ed.), *Individual Differences and Universals in Language Learning Aptitude*. Rowley, MA: Newbury House.

Chase, W. C., and Ericcson, K. A. (1982). Skill and Working Memory. In G. H. Bower (Ed.), *The Psychology of Learning and Motivation*, 16, New York: Academic Press.

Chase, W. C., and Simon, H. A. (1973). Perception in Chess. *Cognitive Psychology, 4*, 55-81.

Cheng, P. W. (1985). Restructuring Versus Automaticity: Alternative Accounts of Skill Acquisition. *Psychological Review, 92*, 214-223.

Chi, M., Glaser, R., and Rees, E. (1981). Expertise in Problem Solving. In *Advances in the Psychology of Human Intelligence*. (Vol. 1). Hillsdale, NJ: Lawrence Erlbaum Associates.

Clark, M.A. (1979). Reading in Spanish and English: Evidence from Adult ESL Students. *Language Learning, 29*, 121-47.

Cromer, W. (1970). The Difference Model: A New Explanation for Some Reading Difficulties. *Journal of Educational Psychology, 61*, 471-483.

de Groot, A. D. (1965). *Thought and Choice in Chess*. Paris: Mouton.

Faerch, C. and G. Kasper (Eds.) (1983). *Strategies in Interlanguage Communication*. London: Longman.

Gardner, R. C., and Lambert, W. E. (1972). *Attitudes and Motivation in Second Language Learning*. Rowley, MA: Newbury House.

Gathercole, S. E. and Baddeley, A. D. (1993). *Working Memory and Language*. Hillsdale, NJ: Erlbaum.

Globerson, T. (1986). When Do Structural Changes Underlie Behavioral Changes? In I. Levin (Ed.), *Stage and Structure: Re-opening the Debate*. Norwood, N. J.: Ablex Press.

Harrington, M. (1992). Working Memory Capacity as a Constraint on L2 Development. In R. J. Harris (Ed.), *Cognitive Processing in Bilinguals*. Elsevier, Netherlands: North Holland.

Hakuta, K. (1976). Becoming Bilingual: A Case Study of a Japanese Child Learning English. *Language Learning, 26*, 321-351.

Hasher, L. and Zacks, R. T. (1979). Automatic and Effortful Processes in Memory. *Journal of Experimental Psychology: General, 108*, 356-388.

Hatch, E. (1978). Discourse Analysis and Second Language Acquisition. In E. Hatch (Ed.), *Second Language Acquisition: A Book of Readings*. Rowley, MA: Newbury House.

Hermann, G. (1980). Attitudes and Success in Children's Learning of English as a Second Language: The Motivational Versus the Resultative Hypothesis. *English Language Teaching Journal, 34*, 247-254.

Heyde, A. (1977). The Relationship Between Self-Esteem and the Oral Production of a Second Language. In H. D. Brown, C. Yorio, and R. Crymes (Eds.), *On TESOL '77. Teaching and Learning English as a Second Language: Trends in Research and Practice*. Washington, TESOL.

Howard, D. V. (1983). *Cognitive Psychology: Memory, Language and Thought*. New York: Macmillan.

Huebner, T. (1983). *A Longitudinal Analysis of the Acquisition of English*. Ann Arbor: Karoma Publishers.

Karmiloff-Smith, A. (1986). Stage/Structure Versus Phase/Process in Modelling Linguistic and Cognitive Development. In I. Levin (Ed.), *Stage and Structure: Re-opening the Debate*. Norwood, N. J.: Ablex Press.

Kolers, P. A., and Roediger, H. L. (1984). Procedures of Mind. *Journal of Verbal Learning and Verbal Behavior, 23*, 425-449

LaBerge, D. and Samuels, S. J. (1974). Towards a Theory of Automatic Information Processing in Reading. *Cognitive Psychology, 6*, 293-323.

Levelt, W.J.M. (1977). Skill Theory and Language Teaching. *Studies in Second Language Acquisition, 1*, 53-70.

Lewis, C. (1981). Skill in Algebra. In J. R. Anderson (Ed.), *Cognitive Skills and Their Acquisition*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Lightbown, P. M. (1985). Great Expectations: Second-Language Acquisition Research and Classroom Teaching. *Applied Linguistics, 6*, 173-189.

Long, M., and Sato, C. J. (1984). Methodological Issues in Interlanguage Studies: An Interactionist Perspective. In A. Davies, C. Criper, and A. P. R. Howatt (Eds.), *Interlanguage*. Edinburgh: Edinburgh University Press.

McGhie, A. (1969). *Pathology of Attention*. Baltimore: Penguin.

McGroarty, M. (1989). *The "Good Learner" of English in Two Settings*. University of California, Los Angeles: Center for Language Education and Research.

McLaughlin, B. (1980). Theory and Research in Second-Language Learning: An Emerging Paradigm. *Language Learning, 30*, 331-350.

McLaughlin, B. (1990). Restructuring. *Applied Linguistics, 11*, 1-16.

McLeod, B. and McLaughlin, B. (1986). Restructuring or Automaticity? Reading in a Second Language. *Language Learning, 36*, 109-123.

Naiman, N., Frohlich, M., Stern, H. H. and Todesco, A. (1978). *The Good Language Learner*. Toronto: The Ontario Institute for Studies in Education, Rowley, MA: Newbury House, 1972.

Nation, R. and McLaughlin, B. (1986). Experts and Novices: An Information-Processing Approach to the "Good Language Learner" Problem. *Applied Psycholinguistics, 7*, 41-56.

Nayak, N. Hansen, N., Krueger, N. and McLaughlin, B. (1990). Language-Learning Strategies in Monolingual and Multilingual Subjects. *Language Learning, 40*, 221-244.

Nelson, R., and Jakobovits, L. A. (1970). Motivation in Foreign Language Learning. In J. Tursi (Ed.), *Foreign Languages and the New Student: Reports of the Working Committees*. New York: Northeast Conference on the Teaching of Foreign Languages.

Newell, A. (1973). Production Systems: Models of Control Structures. In W. G. Chase (Ed.), *Visual Information Processing*. New York: Academic Press.

Oller, J. W. (1981). Research on the Measurement of Affective Variables: Some Remaining Questions. In R. W. Andersen (ed.), *New Dimensions in Second Language Acquisition Research*. Rowley, MA: Newbury House.

O'Malley, J. M., and Chamot, A. U. (1989). *Learning Strategies in Second Language Acquisition*. New York: Cambridge University Press.

Oxford, R. L. (1986). *Second Language Learning Strategies: Current Research and Implications for Practice*. University of California, Los Angeles: Center for Language Education and Research.

Pike K. (1960). Nucleation. *Modern Language Journal, 44*, 291-295.

Posner, M. I., and Snyder, C. R. R. (1975). Attention and Cognitive Control. In R. L. Solso (Ed.), *Information Processing and Cognition: The Loyola Symposium*. Hillsdale, NJ: Erlbaum.

Ramsey, R. M. G. (1980). Language-Learning Approach Styles of Adult Multilinguals and Successful Language Learners. *Annals of the New York Academy of Sciences, 345*, 73-96.

Rumelhart, D. E., and Norman, D. A., (1978). Accretion, Tuning, and Restructuring: Three Modes of Learning. In Cotton J., Klatzky R. (Eds.). *Semantic Factors in Cognition*. Hillsdale, N.J: Lawrence Erlbaum Associates.

Schneider, W. and Shiffrin, R.M. (1977). Controlled and Automatic Human Information Processing: 1. Detection, search, and Attention. *Psychological Review, 84*, 1-66.

Selinker, L. (1972). Interlanguage. *IRAL, 10*, 209-231.

Service, E. (1992). Phonology, Working Memory, and Foreign Language Learning. Quarterly Journal of Experimental Psychology: *Human Experimental Psychology, 45*, 21-50.

Shiffrin, R. M., and Schneider, W. (1977). Controlled and Automatic Human Information Processing: II. Perceptual Learning, Automatic Attending, and a General Theory. *Psychological Review*, 84, 127-190.

Speidel, G. E. (1993). Phonological Short-Term Memory and Individual Differences in Learning to Speak: A Bilingual Case Study. *First Language*, 13, 69-91.

Strong, M. (1984). Integrative Motivation: Cause or Result of Successful Second Language Acquisition? *Language Learning*, 34, 1-13.

Wenden, A. L. (1987). Metacognition: An Expanded View on the Cognitive Abilities of L2 Learners. *Language Learning*, 37, 573-598.

Wong Fillmore, L. (1976). *The Second Time Around: Cognitive and Social Strategies in Second Language Acquisition*. Doctoral Dissertation, Stanford University.

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