Dexterity and Its Development in EFL
—Beyond input-output paradigm—

YAMAMOTO, Akio

This paper tries to examine the concept of 'dexterity' and seeks a way to apply it to an EFL context. A Russian scientist in biomechanics and physiology called Nicholai A. Bernstein wrote a book "*On Dexterity and its Development*" more than half a century ago, but it was not published because of the political situation in those days in U.S.S.R. It appeared in print in 1991. Although it was written more than sixty years ago, his works still stimulate our imagination in the field of cognitive science. Dexterity is a capacity or an ability which defines the relationship between the nervous systems and skills. It is a motor ability to quickly find a correct solution for a problem in any situation, which is to exhibit motor wits in any conditions. It may enable us to learn how we acquire skills of a foreign language not through the viewpoint of linguistics but through that of biomechanics and physiology.

Key Words: dexterity, EFL, input-output, repetition, skills

1. Introduction

Some people who have a good command of English as a foreign language may say that learning English is just like playing sports. You require a lot of practice in order to acquire language skills. It would be better to go out and use English than to stay at a desk and chair for rote learning. Such people may believe that foreign language learning is a skill-getting activity just as sports.

The analogy of comparing foreign language learning to sports is not new, but few people clarify what they have in common theoretically.

The skill-based viewpoint of foreign language learning tends to be considered not an academic issue but a practical one. Bernstein's view in biomechanics and physiology may help us grasp the image of language skill acquisition.

2. Dexterity

2.1. Bernstein

I.M. Feigenberg and M. L. Latash (1996) introduce a brief biography of Bernstein and his works. Nicholai Aleksandrovich Bernstein was born in 1896 in Moscow. His father was a famous

psychiatrist, Alexander Nicholaevich Bernstein and his mother was a nurse before having children. Nicholai was interested in natural history and cultural history. He liked music very much and used to play the piano along with well-known professional musicians. His hands were quick and skillful like his mother's. He built steam engines and trains out of tin cans. His uncle was Sergey Natanovich Bernstein, a talented mathematician who studied at the Sorbonne in Paris and solved one of the most famous Hilbert problems. Later he became an academician, one of the leaders in Russian mathematics.

Nicholai Aleksandrovich Bernstein graduated from the Medical Department of the Moscow Imperial University in 1919 and worked as a physician in the Red Army. In 1922 he became the head of the newly organized Biomechanics Laboratory in the Central Scientific Institute of Physical Culture in Moscow. He started to study the simplest element of labor movements: hitting a chisel with a hammer. He believed that the knowledge of the basic principles of brain functioning should be expanded in the study of the biomechanics of hitting in the first place. In some places, movements of athletes were studied. At others, the movements of people suffering from different motor pathologies, at others the developmental aspects of movements, biomechanics of playing the piano, and so on.

After the severe life endured in World War II, the summary of his prewar studies was published in 1947. The name of the book is "*On the Construction of Movements.*" The book was a huge success. He received an award called the Stalin Award from the government.

However, under the national pseudo-patriotism in the U.S.S.R., references to foreign authors in scientific books and dissertations were considered "adoration of the West." A wave of state anti-Semitism rose. Jews had trouble trying to find jobs and entering a graduate school or a university. Some scientists criticized Bernstein because he referred to foreign articles and he neglected the works of I. P. Pavlov, the greatest hero of the age in the U.S.S.R.. He was also attacked by Pravda, the official paper of the U.S.S.R. Around that time his new book "*On Dexterity and its development*" was finished and submitted to a publisher. It was about to come out. Unfortunately, he was fired and all of his laboratories were closed because of the criticisms against his works. The publisher did not risk publishing the book.

The book "*On Dexterity and its development*" did not appear in print until 1991, a quarter century after the death of its author. I.M. Feigenberg happened to browse through the dusty bookshelves in Bernstein's room by permission of Bernstein's stepdaughter, T. I. Pavlova, who was planning to move into another apartment, years after his death. On the very top, just below the ceiling, he found a dusty plastic bag containing sheets bound with a cardboard cover. On the cover there was a handwriting which was very familiar to I.M. Feigenberg — "N.A. Bernstein. "*On Dexterity and its development.*" I.M. Feigenberg read the sheets and thought he had to publish the book.

If N.A. Bernstein had not been criticized under the national pseudo-patriotism in the U.S.S.R. and "*On Dexterity and its development*" had been published all over the world, the history of psychology might have been changed. Behaviorism, which raised its head due to the works of John B. Watson and B. F. Skinner, American psychologists as successors of Pavlov's stimulus-response theory, would not have come in fashion as we know in the history of psychology. We had to wait for the appearance of cognitive science by George Miller, who was a professor at Princeton University and famous for the Magical Number Seven, in 1956 (Gardner, 1985: 28) in order to break a spell of Behaviorism.

2.2. Dexterity

The word dexterity is a derivative of the root *catch* in Russian. The original meaning of this word relates to hunting, trapping, and fishing. Dexterity refers to quickness, agility, flexibility, and skillfulness of our body. I. Brazhnin, a master of sport in Russia, tries to define dexterity and cites *Thesaurus* by V. Dahl: dexterous means "harmonious in movements." However, Bernstein is not satisfied with this definition. Bernstein prefers building the definition of dexterity to discovering it somewhere.

Dexterity, force, speed, and endurance are four notions that are commonly addressed as psychophysical capacities (Bernstein, 1996: 10). It is certainly more flexible and more universal than any other capacity like force, speed, and endurance. Dexterity is a kind of currency for which all other currencies are readily traded. It is a trump suit that beats all other cards. (Bernstein, 1996: 11). Dexterity is in finding a motor solution for any situation and in any condition (Bernstein, 1996: 21). *Dexterity is a capacity or an ability* defining the relationship between the nervous systems and skills. The level of motor dexterity defines how quickly and successfully a person can develop a certain motor skill and what level of perfection he or she is able to reach. Although both *exercisability and dexterity* are certainly *excercisable capacities*, they both stay *above all the skills*, ruling them and defining their essential features (Bernstein, 1996: 208).

2.3. Levels

There are four levels to reach a high level of dexterity. The earlier three levels, Level A , Level B, and Level C, are about the movements of our body parts.

Level A controls the neck and trunk movements and posture (Bernstein, 1996: 103). The neck and trunk movements and posture are not often observed, but those movements and the posture are the basis of human activities.

Level B is the level of muscular-articular links (Bernstein, 1996: 121). Each movement of nerves and muscles is articulated and synthesized to do one movement.

Level C deserves attention already because it is the first level to possess extensive, extremely

rich sets of independent movements, not just background corrections (Bernstein, 1996: 130). It provides the basis for many of the movements of interest to an athlete: virtually all movements in gymnastics, track-and-field, acrobatics, and many other areas of movements, not to mention the many background corrections which it provides for all the sport and athletic movements. The basis of Level C is a complex, finely structured synthesis, which is called the space field (Bernstein, 1996: 133).

Level D, different from the other earlier levels, deals with our actions. Actions are not simply movements (Bernstein, 1996: 146). In most cases, actions are whole sequences of movements that solve a motor problem together. Those sequences or chains consist of different movements that replace each other systematically, leading one to a solution for the problem. All the movements, parts of such a chain, are related to each other by the meaning of the problem. If you miss one of the links of the chain or mix up their order, you will fail to solve the problem (Bernstein, 1996: 146). Bernstein (1996: 145) says that perhaps humans became human largely thanks to this level and in relation to it.

You will find out that small actions in everyday life such as putting on a shirt, washing our hands, making tea consist of tens of consecutive movements if you count. In professional life, there must be a countless number of actions to complete a single problem. Professional actions like pitching a ball into the same position of a catcher's mitt are "just an infinitesimally small group of actions selected at random from the ocean of professional labor (Bernstein, 1996: 147).

Level D can be found easily in your daily life and you do such actions without any effort. You do not usually pay attention to each movement of an action when you perform it. However, you may pay attention to each movement if it is the first time for you to do it. If you are "good" at something, reading for example, few brain regions are active, and neurons need less glucose to do it. If you are bad at something, huge areas of the brain gobble glucose. The brain lights up like a Christmas tree (Diane McGuinness, 1997: 154).

Learning words and structure in a foreign language and the practice or drills for doing this may be categorized into Level A to C. The use of a foreign language seems to be categorized into Level D.

2.4. Stages

Bernstein (1967, Newell, 1996: 412–415) proposed three stages of learning. These stages capture the change in the major qualitative categories of movement dynamics in motor learning and development. Newell (1996: 413–415) briefly outlines the framework.

Stage 1: Freezing Degrees of Freedom

The first stage in learning is characterized by coordination solutions that reduce

the number of degrees of freedom at the periphery to a minimum. This freezing strategy effectively reduces the number of biomechanical degrees of freedom that need to be coordinated and controlled.

Stages 2: Release of Degrees of Freedom

The second stage is to release the freeze on the constrained degrees of freedom. Eventually, the coordination solution of a skilled performance will incorporate all possible degrees of freedom at the periphery.

Stage 3: Use of Reactive Phenomena

The most advanced level of motor learning corresponds to the system's utilizing entirely the reactive phenomena that arise from the interaction of the organism with the environment. In this stage, the coordination solution exploits, rather than resists.

3. Repetition

It goes without saying that repetition is important in language learning. However, our repetition is totally different from that of machines and tools.

Machines and tools *deteriorate* as you keep using them. They wear out, loosen up, and generally become *worse.* The best machines are those that do not require repair for long periods of time. The situation with the "human machine" is the opposite. The longer a human participates in a certain activity, the better he or she performs it. A living organism not only does not deteriorate during work but, quite the opposite, becomes stronger, quicker, more enduring, more adroit and dexterous, particularly with respect to the type of activity that has been performed. This feature of living organisms has been termed *exercisability* (Bernstein, 1996: 171).

3.1. Pavlov

A famous Russian physiologist, I.P. Pavlov, who by that time had already been awarded the Nobel prize for his studies of digestion, discovered the following fact. If a hungry dog heard a bell or a whistle, saw a light of a certain color turned on, or experienced some other stimulation each day half a minute prior to feeding, repeatedly for many days, the animal gradually started to salivate, not when it received the food or not even when it saw the food, but when the stimulating signal was activated. It was found that this method could turn away signal into a salivation-reflex inducer. After a hundred presentations of the combined signal and feeding, one could force a dog to salivate by pricking certain parts of its body, by scratching, blinking, coughing, chirping, crackling, by anything (Bernstein, 1996: 173).

3.2. Mastery

In the process of mastery, the repetition of the same act is more than Pavlovian conditioning. It seems the same act, but each act in each time is different each other. We unconsciously try to adjust ourselves to each task, even when we remove our cell phones out of our pockets. It is called Microslip (Yamamoto, 2004).

The accumulation of learning in a specific domain may allow us to acquire a skill or knowledge for a specific domain and to enable us to use it in such a specific domain, but that's not what happens. We are sometimes able to use such a skill or knowledge in different situations and become more creative (Nomura, 2002: 110).

4. Linguistic-based v.s. skill-based knowledge and curriculum

There has been a long history that the curriculum and textbooks of English in Japan are grammar-oriented. Teachers tend to think of the knowledge of grammar and vocabulary as main English abilities.

Research on English abilities as a foreign language (EFL) or second language (ESL) has also been largely grammar-oriented. In the morpheme studies the acquisition of grammar items are focused or dominantly linguistic-oriented.

The concept of input-output has been considered as a counterpart of Pavlov's stimulus-response theory. In the behavioristic view like B.F. Skinner, what is taught should be learned. S. Krashen points out that language acquisition is far from that simple. He tries to figure out the mechanism of language acquisition referring to his famous Monitor Model, such as differences between acquisition and learning, an acquisition order, and affective filters. Teachers and learners are still interested more in how many words and expressions they teach and learn in class than in how many skills they acquire.

Both researchers who are Krashen's followers and those who are adversary have been interested in how much input or output the learners have in certain circumstances and how much they acquire the target language. They want to find the effects of some learning and teaching techniques or methods concerning for how much input or intake they can receive and they try to control the learning or teaching environment surrounding the learners. However, the more they try to control the environment in order to identify the pure results of the effects, the less realistic the learning and teaching are. The researchers have focused more on the amount of linguistic knowledge they acquire as the results of learning. They have tried to reduce the factors of the learning environment. Therefore, the researches tend to be more laboratory experiments.

The problem of the linguistic-oriented research is the same as the ones of Pavlov's stimulus-response theory. Bernstein's works may guide us to another type of research in order to solve

Pavlov's problems in EFL and ESL.

Since a task-based syllabus was introduced in 1980's, the curriculum and textbooks at school have been gradually changing. They have focused more on four skills of language use, which are listening, reading, speaking, and writing, than on grammar knowledge. The rise of interest in vocabulary learning since 1990's has created a lot of task-based activities. However, we can say that EFL and ESL research still have the Pavlovian problems. The evaluations of most studies are based on how much input and output the learners have before and after its learning.

4.1. Anderson's ATC-R model

Learning a lot of knowledge of words and expressions is necessary to acquire a foreign language. However, we are not satisfied with just knowing them. It is easy to find those learners who know a lot of words but cannot use them in real settings. The researchers try to identify the quality of knowledge when they find some learners who know a certain thing but cannot use it properly.

According to Anderson's ATC-R model, there are two types of knowledge: declarative knowledge and procedural knowledge. Knowledge usually starts out in declarative form, goes through a stage of compilation/ proceduralization, and then finally through a long stage of fine-tuning of procedural knowledge before performance reaches the asymptote of the learning curve (DeKeyser, 2001: 132). Declarative knowledge is knowing THAT, e.g. Washington D.C. is the capital of the US; procedural knowledge is knowing HOW to do something, e.g., shifting gears in a car or using the right form of a verb. Procedural knowledge takes the form of production rules: condition-action pairs of the form if x is the case, then do y (DeKeyser, 2001: 132).

The questions the researchers have are in what way declarative knowledge can change into procedural knowledge, and what EFL and ESL learners do in order to acquire procedural knowledge. Some researchers believe that the deeper the input processing is, the more procedural knowledge the learners acquire. However, how deep and what kind of deep input would be effective is unclear.

4.2. Expert Study

What can provide the researchers with an indication of acquiring the target language instead of the amount of input, output, and intake? What makes your declrative knowledge change into procedural knowledge? How can you explain the change of declarative knowledge into procedural knowledge in learners' mind? Dreyfus and Dreyfus (1986: 16–51) deny that skills are not acquired by piling up knowledge of language but by experiencing the use of language.

Dreyfus and Dreyfus propose five steps from novice to expert in all of our human activities. They show an example of riding a bicycle and remind us that we possess something called "know-how" of riding a bicycle, but it is difficult for us to explain what we have learned that makes us able to ride a bicycle. It means that "know-how" is not accessible to us in the form of facts and

rules although we acquire them.

The following is the summary of the five stages on skill acquisition:

Stage 1: Novice

Elements of the situation to be treated as relevant are so clearly and objectively defined for the novice that they can be recognized without references to the overall situation in which they occur. We call such elements "context-free." The rules that are to be applied to these facts regardless of what else is happening are called "context-free rules." The manipulation of unambiguously defined context-free elements by precise rules is called "information processing."

One example of this stage is a beginning automobile driver. The beginning automobile driver learning to operate a stick-shift car is told at what speed (a context-free feature) to shift gears and, at any given speed, at what distance (another such feature) to follow a car preceding him. These rules ignore context. They do not refer to traffic density or anticipated stops.

Stage 2: Advanced Beginner

Through practical experience in concrete situations with meaningful elements, which neither an instructor nor the leaner can define in terms of objectively recognizable context-free features, the advanced beginner starts to recognize those elements when they are present.

Stage 3: Competence

With more experience, the number of recognizable context-free and situational elements present in a real-world circumstance eventually becomes overwhelming.

In general, a competent performer with a goal in mind sees a situational as a set of facts. The importance of the facts may depend on the presence of other facts. He has learned that when a situation has a particular constellation of those elements a certain conclusion should be drawn, decision made, or expectation investigated.

As an example of a competent performer, a complete driver is no longer merely following rules designated to enable him to operate his vehicle safely and courteously but drivers with a goal in mind. If he wishes to get from point A to point B very quickly, he chooses his route with attention to distance and traffic, ignores scenic beauty, and as he drives selects his maneuvers with little concern for passenger comfort or courtesy. He follows other cars more closely than normally, enters traffic more daringly, and even violates the law.

Stage 4: Proficiency

Up to this point the learner of a new skill, to the extent that he has made decisions at all rather than merely following rules, has made conscious choices of both goals and decisions after reflecting upon various alternatives.

Usually the proficient performer will be deeply involved in his task and will be experiencing it from some specific perspective because of recent events. Because of the performer's perspective, certain features of the situation will stand out as salient and others will recede into the background and be ignored. As events modify the salient features, plans, expectations, and even the relative salience of features will gradually change. No detached choice or deliberation occurs. It just happens, apparently because the proficient performer has experienced similar situations in the past and memories of them trigger plans similar to those that worked in the past and anticipations of events similar to those that occurred.

While intuitively organizing and understanding his task, the proficient performer will still find himself thinking analytically about what to do. Elements that present themselves as important, thanks to the performer's experience, will be assessed and combined by rule to produce decisions about how best to manipulate the environment. The spell of involvement in the world of the skill will thus be temporarily broken.

Let me show an example of a proficient driver. On the basis of prior experience, the proficient driver, approaching a curve on a rainy day, may intuitively realize that he is driving too fast. He then consciously decides whether to apply the brakes, remove his foot from the accelerator, or merely reduce pressure.

If you want a child to be a good reader, a good speller, and a creative writer, then you first goal is to create efficient and automatic subroutines in the sensorimotor skills that should not require overt attention, such as encoding and decoding. An efficient reader looks at text and does not see letters, nor does she see words; she experiences *meaning* directly (McGuinness, 1997: 155).

Stage 5: Expertise

We usually don't make conscious deliberative decisions when we walk, talk, drive, or carry on most social activities. An expert's skill has become so much a part of him that he need be no more aware of it than he is of his own body.

The expert driver becomes one with his car, and he experiences himself simply as driving, rather than as driving a car, just as, at other times, he certainly experiences himself as walking and not, as a small child might, as consciously and deliberately

propelling his body forward. Ichikawa (1975, cited in Nomura, 1989) calls it "Kumikomi," or assimilation, in which learners put an external object like tools and a language into their body or mind as if they are one of their body parts or assimilated.

5. Conclusion

Foreign language learning research has been done on the basis of input-output paradigm. However, this kind of research approach needs to control unnecessary factors in the environment surrounding the learner. Bernstein's dexterity approach will show a new type of research.

Basically learning itself is done in a specific domain in everyday life (Nomura, 2002: 110). Foreign language learning does not occur in a laboratory, either. It is quite difficult to control the learning environment if you want to know the longitudinal effects of learning and teaching. Bernstein's approach to dexterity will pioneer a new way to research. The approach tries to explain the structure of skills to be acquired and set up stages to acquire those skills. The researchers can identify the progress of learning based on the stages the learners reach. Bernstein's Level D, Dreyfus and Dreyfus's Stage 5, and Nomura's Mastery Level seem to have something in common. They all focus on performers' skills and their actions in the environment surrounding them. The concept of affordance and microslip may help guide us in the quest of finding more similarities among those concepts and setting up a new paradigm of language skill acquisition research.

As for an educational implication, you may be able to manipulate the learning environment. Burton, Brown, and Fischer (1984) say that learning environments can be examined in terms of a paradigm called "increasingly complex microworlds." In this paradigm, the student is exposed to a sequence of environments (microworlds) in which his tasks become increasingly complex. The purpose of the sequence is to evolve the simplified skills toward the goal skill.

References

Araki, Keisuke. (2002) Shinkasuru-gakushu. (Intensifying of Learning.) Ch. 6 of *Koui-no-shinrigaku. (Psychology of Action.)* Edited by Nomura, Yukimasa. Kansai University Press. 109–131.

Bernstein, N. A. (1996) On Dexterity and Its Development: *Dexterity and its Development.* Translated from Russian by Mark L. Latash. Edited by Mark L. Latash and Michael T. Turvey. Lawrence Erlbaum Associates, Inc.New Jersey. 3–246.

Burton, Richard R., Brown, John Seely, Fischer, Gerhard. (1984) Skiing as a Model of Instruction. Ch. 6 of *Everyday Cognition.* Edited by Rogoff, Barbara and Lave, Jean. 139–150.

DeKeyser, Robert M. (2001) Automaticity and automatization. Ch. 5 of *Cognition and Second Language Instruction.* Edited by Robinson, Peter. Cambridge. UK. 132.

Dreyfus, L. Hubert and Dreyfus, E. Stuart. (1986) Five Steps to Novice to Expert. Ch. 1 of *Mind Over Machine–The Power*

of Human Intuition and Expertise in the Era of the Computer. The Free Press. 16–51.

Feigenberg, I.M. and Latash, L.P. (1996) N.A. Bernstein: The reformer of Neuroscience: *Dexterity and its Development.* edited by Mark L. Latash and Michael T. Turvey. Lawrence Erlbaum Associates, Inc.New Jersey. 247–276.

Gardner, Howard. (1985) *The Mind's New Science—A History of the Cognitive Revolution.* Basic Books. 28.

Ichikawa, Hiroshi. (1975) "*Seishin-toshiteno-shintai.*" (*A Body as a Mind.*) Keiso-shobo. Cited in Nomura, Yukimasa. (1989) "*Chi-no-taitoku — Ninchikagaku-heno-teigen —.*" (*Acquisition of Intelligence — Propositions for Cognitive Science —.*)

McGuinness, Diane. (1997) *Why Our Children Can't Read And What We Can Do About It.* Touchstone. 155.

Nomura, Yukimasa. (2002) Jukutatsuka-to-jiko. (Master of Skills and Self.) Ch. 6 of *Koui-no-shinrigaku.* (*Psychology of Behavior.*) Edited by Nomura, Yukimasa. Kansai University Press. 157–179.

Yamamoto, Akio (2003) A Quarter Century after the Monitor Model. *The Gakushuin Boys' Senior High School Bulletin 1.* 19–31.

Yamamoto, Akio. (2004) Microslips in EFL. *The Gakushuin Boys' Senior High School Bulletin 2.* 1–12.