

Skill Acquisition Theory

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ABSTRACT

Skill Acquisition Theory accounts for how people progress in learning a variety of skills, from initial learning to advanced proficiency. The scientific roots of Skill Acquisition Theory are to be found in various branches of psychology, but this research area has proven to be remarkably resilient through various developments in psychology, from behaviorism to cognitivism to connectionism. The same can be said about other directions in which skill acquisition research has expanded in recent years: the study of the forgetting of skills and the role of distributed versus massed practice in learning and forgetting. The acquisition of declarative knowledge of a kind that can be proceduralized requires the judicious use of rules and examples. Furthermore, research on skill acquisition, whether carried out with behavioral data or through neuroimaging or computer modeling, is tremendously explicit in its procedures and claims.

Chapter 5 Skill Acquisition Theory

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Skill Acquisition Theory accounts for how people progress from initial learning to advanced proficiency in a variety of skills. Skills studied include both cognitive and psychomotor skills, in domains that range from classroom learning to applications in sports and industry. Research in this area ranges from quite theoretical (computational modeling of skill acquisition, the place of skills in an architecture of the mind) to quite applied (how to sequence activities for maximal learning efficiency in areas as diverse as teaching high school algebra, tutoring college physics, coaching professional basketball, or training airplane pilots).

The scientific roots of Skill Acquisition Theory are to be found in various branches of psychology, and this research area has proven to be remarkably resilient through various developments in psychology, from behaviorism to cognitivism to connectionism. After all, the practical needs as well as the fundamental theoretical questions and the basic empirical facts remain, regardless of the continuous developments in psychological theory, methodology, and terminology.

The Theory and Its Constructs

The basic claim of Skill Acquisition Theory is that the learning of a wide variety of skills shows a remarkable similarity in development from initial representation of knowledge through initial changes in behavior to eventual fluent, spontaneous, largely effortless, and highly skilled behavior, and that this set of phenomena can be accounted for by a set of basic principles common to the acquisition of all skills. The terminology in the previous sentence was deliberately chosen to be nontechnical and theory-neutral; it will come as no surprise that a theory that has been applied to so many domains over such a long period of time has seen its share of technical terms, which have varied with the area of psychology researchers have worked in and the types of skills they have studied. Generally speaking, however, researchers have posited three stages of development, whether they called them cognitive, associative, and autonomous, as Fitts and Posner

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(1967); or declarative, procedural, and automatic, as Anderson (e.g., Anderson, 1982, 1993, 2007; Anderson et al., 2004; Taatgen, Huss, Dickison, & Anderson, 2008).

These three stages are characterized by large differences in the nature of knowledge and its use, as reflected in various ways through introspection, verbalization, and most importantly various aspects of behavior especially under demanding conditions. Initially, a student, learner, apprentice, or trainee may acquire quite a bit of knowledge ABOUT a skill without ever even trying to use it. That knowledge may be acquired through perceptive observation and analysis of others engaged in skilled behavior (e.g., learning a new dance move), but most often is transmitted in verbal form from one who knows to one who does not (as in a parent or driving instructor teaching a teenager how to drive a car), and often through a combination of the two, when the “expert” demonstrates the behavior slowly while commenting on the relevant aspects (e.g., teaching a child how to swim or how to play tennis).

Next comes the stage of “acting on” this knowledge to facilitate a behavior, using “knowledge that” to create “knowledge how,” or in more technical terms, using **declarative knowledge** to build **procedural knowledge**. This **proceduralization** of knowledge is not particularly arduous or time consuming. Provided that the relevant declarative knowledge is available and drawn on in the execution of the target behavior, proceduralization can be complete after just a few trials/instances. For example, Anderson et al. (2004, p. 1046) point out that, in a typical psychology experiment, participants shift from a declarative understanding and a slow interpretation of the task (as outlined in the experimenter's instructions) to a fluid, swift procedural performance of the task. Similarly, in second language (L2) learning, DeKeyser (1997) demonstrated that proceduralization was essentially complete after the first 16-item block of practice items. Proceduralized knowledge has a big advantage over declarative knowledge: It no longer requires the individual to retrieve bits and pieces of information from memory to assemble them into a “program” for a specific behavior; instead, that “program” is now available as a ready-made chunk (as a result of production compilation, i.e., the combination of several production rules; see Anderson, 2007; Taatgen & Lee, 2003) to be called up in its entirety each time the conditions for that behavior are met.

Once procedural knowledge has been acquired, there is still a long way to go before the relevant behavior can be consistently displayed with complete fluency or

spontaneity, rarely showing any errors. In other words, the knowledge is not yet robust and fine-tuned. A large amount of practice is needed to decrease the time required to execute the task (“reaction time”), the percentage of errors (“error rate”), and the amount of attention required (and hence interference with/from other tasks, or more generally “robustness”; cf. Taatgen et al., 2008). This practice leads to gradual **automatization** of knowledge. **Automaticity** is not an all-or-nothing affair; even highly automatized behaviors are not 100% automatic, as becomes clear when we stumble walking down the stairs, when we realize we are driving too fast when engaged in an exciting conversation with a passenger, or when we stumble over our words while uttering a simple sentence in our native language.

It should be stressed that this intensive practice (sometimes called overlearning) *after* mastery over the task has been achieved is only useful if it takes learners from the proceduralization stage (where declarative and procedural knowledge are used) to the automatization stage (where knowledge is completely procedural already). In such cases, however, its impact is great, not only because of the obvious immediate advantages of reaching high levels of automaticity but also because (automatized) procedural knowledge is known to decay less with time. On the other hand, while some tasks can be carried out completely on the basis of procedural knowledge (esp. motor skills), others keep requiring access to at least some declarative information, and hence benefit less from overlearning (Kim, Ritter, & Koubek, 2013).

A central concept in the study of skill acquisition is the **power law of learning** (named this way because its mathematical formalization is a power function: an equation with an exponent, which in this case represents the amount of practice). This equation formalizes mathematically what has been observed many times, for skills as different as making cigars out of tobacco leaves or writing computer programs: that both reaction time and error rate decrease systematically as a consequence of practice. If the learning curves for reaction time and error rate for such a variety of skills share the very specific shape of a power function (and not even a quite similar one like that of an exponential function), then this shape must contain the key to some fundamental learning mechanisms. Since Newell and Rosenbloom’s (1981) seminal article on the power law, a variety of hypotheses have been formulated to explain this robust empirical phenomenon. This chapter is not the place to discuss the relative merit of these hypotheses (for more

discussion, see DeKeyser, 2001; Segalowitz, 2010), but what they all have in common is that they posit a qualitative change over time, as a result of practice, in the basic cognitive mechanisms used to execute the same task. What superficially seems like a set of smooth quantitative changes (reaction time and error rate declining following a power function) in fact reflects a qualitative change in mechanisms of knowledge retrieval, quite radical for a while, and then gradually stabilizing without ever reaching an absolute endpoint (hence the learning curve in the specific shape of a power function illustrated in Figure 5.1).

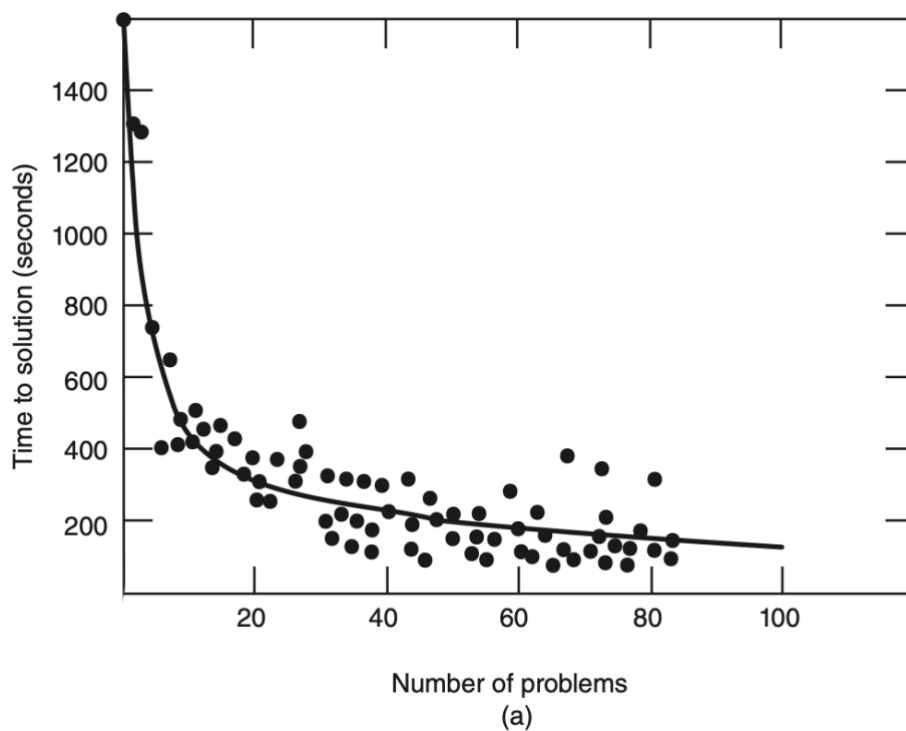


Figure 5.1 A sample graph of the power curve of learning.

Probably the most widely accepted interpretation of this change is that it represents first a shift from declarative to procedural knowledge (achieved rather quickly, hence the rather steep initial section of the curve) followed by a much slower process of automatization of procedural knowledge. The term automatization itself can be interpreted in various ways, ranging from a mere speed-up of the same basic mechanisms to a speed-up of a broader task through a qualitative change in its components. Again, we are not taking a position here on this point either (for more discussion, see DeKeyser,

2007a; Segalowitz, 2010), but we *are* using automatization in a more specific sense than just “improvement through practice,” because we are reserving the term for the latter, flatter part of the learning curve, after the steep decline due to rapid proceduralization has taken place (see Figure 5.1).

Another point on which there is widespread agreement is that, regardless of the exact nature of the knowledge drawn on in the later stages of development, this knowledge is much more specific than at the beginning, and in fact, so highly specific that it does not **transfer** well, even to what may seem quite similar tasks. A well-known example from the skill acquisition literature is reading versus writing computer programs (see Singley & Anderson, 1989), and an obvious parallel in the domain of language learning is perception/comprehension versus production (see Sakai & Moorman, 2018; Shintani, Li, & Ellis, 2013 for their meta-analysis in speech and grammar learning, respectively). Other examples, of course, would be transfer from speaking to writing, or from one situation to another (such as from an orderly dialogue to an argument with multiple interlocutors, or from the kitchen table to the boardroom). The implication for training is that two kinds of knowledge need to be fostered: highly specific (automatized) procedural knowledge for efficient use in the situations that the learner is most likely to confront in the immediate future and solid abstract declarative knowledge that can be called upon to be integrated into much broader, more abstract procedural rules, which are indispensable when confronting new contexts of use.

Skill Acquisition Theory stresses the importance of the distinction between declarative and procedural knowledge and sees the transition from mostly declarative to mostly procedural as the norm in skill development (cf. Anderson, 2007). What is often overlooked is that this whole sequence of proceduralization and automatization cannot get started if the right conditions for proceduralization are not present. Proceduralization is likely to occur with the declarative knowledge required by the task at hand, and a task set-up that allows for use of that declarative knowledge. Anderson, Fincham, and Douglass (1997), in particular, show convincingly that the combination of abstract rules and concrete examples is necessary to get learners past the declarative threshold into proceduralization.

The declarative/procedural distinction does not completely coincide with the explicit/implicit distinction often made in discussions of L2 learning and knowledge, but

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for our purposes here, they are equivalent (for further discussion, see DeKeyser, 2009, 2017). It is important to realize that Skill Acquisition Theory by no means denies a role for implicit learning. There can even be “synergy” between the two types of learning for a particular rule or a distribution of roles between the two when a variety of different rules, patterns, or regularities need to be learned.

Research on skill acquisition inside and outside of the language domain is increasingly concerned with such synergies and complimentary roles of implicit and explicit learning processes. Ferman, Olshtain, Schechtman, and Karni (2009) showed that there may be a differential role in the sense that the simpler rules tend to be learned explicitly and the complex or probabilistic ones—being hard to induce, comprehend, or proceduralize—tend to fare very poorly in explicit learning, to the extent that implicit learning, slow and probabilistic as it may be, yields better results. From psycholinguistic perspectives, several in-depth reviews of the implicit–explicit learning issue are presented in the SLA literature (see DeKeyser, 2003; Williams & Rebuschat, 2023; for a discussion of the potential interactions in L2 acquisition, see Ellis, 2005; Godfroid, 2023).

Skill Acquisition Theory, then, does not reject the possibility or usefulness of implicit learning, but focuses on how explicit learning (which is often the only realistic possibility for specific learning problems because of time constraints or logistic issues) can, via proceduralization and automatization of explicitly learned knowledge, lead to knowledge that is functionally equivalent to implicit knowledge. This does not mean explicit knowledge “turning into” implicit knowledge. No mysterious transformation happens in the brain (Ullman, this volume; for a recent fMRI study on the declarative-procedural distinction, see Suzuki, Jeong et al., 2023), not even that the more procedural knowledge there is, the less declarative knowledge. The phrase “turning into” is a bit misleading on that point; all that is claimed is that existing declarative knowledge, via practice, plays a causal role in the development of procedural knowledge (e.g., DeKeyser, 2009, 2017). This is supported by the tentative evidence that explicit knowledge, through a long process of proceduralization and automatization, can be instrumental in the development of implicit knowledge (Suzuki & DeKeyser, 2017).

From a purely psycholinguistic point of view, it is important to stress, as does Paradis (2009), that explicit knowledge never “becomes” implicit through practice; from an applied point of view, however, it is equally important to stress that what matters is

fast, accurate, and robust use—the hallmark of automatized procedural knowledge. Given how difficult it is to determine whether knowledge is implicit or explicit (and even more whether learning was implicit or explicit), even under controlled laboratory conditions, it stands to reason that the implicit/explicit distinction in this narrow sense should be of little concern to L2 learners and teachers. Proceduralization, however, as well as a certain degree of automatization of explicitly acquired knowledge is a necessary condition for practically useful levels of proficiency. How exactly to get to that point is what Skill Acquisition Theory is all about.

What Counts as Evidence?

The oldest form of evidence in this area is behavioral in nature: reaction times, error rates, and differences in performance from one condition to another such as interference from a secondary task. Any overview of the behavioral data should start with Newell and Rosenbloom (1981), not because it was the first study in this area but because it was seminal in that it brought together empirical data from so many different studies about so many different forms of skill acquisition, and it proposed both a quantitative model (the power law) and a qualitative interpretation for this mountain of data. Some of the domains of learning included motor behavior, reading, decision making, and problem solving. For information on the individual studies included, see Newell and Rosenbloom's article. Major empirical studies since then include Anderson et al. (1997) on the role of rules and examples in the proceduralization of a simple reasoning task, Logan (1988, 1992, 2002) on the learning of a new form of arithmetic (with letters), and Taatgen et al. (2008) on robustness and flexibility of procedural knowledge as a function of the form of the production rules (with or without explicit statement of pre- and postconditions in the environment).

In the last 25 years, less direct evidence in the form of computational modeling has become very important in the study of skill acquisition, even more so than in other subfields of psychology. This line of evidence includes large amounts of work with a variety of computer models such as the various consecutive incarnations of ACT (Adaptive Control of Thought) (see especially Anderson, 1993, 2007; Anderson & Lebiere, 1998; Anderson et al., 2004; Taatgen & Anderson, 2010), EPIC (Executive

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Process-Interactive Control) (Meyer & Kieras, 1997), Soar (State Operator And Result) (Newell, 1990; Laird, 2012), and 4CAPS (Cortical Capacity-Constrained Concurrent Activation-based Production System) (Just & Varma, 2007). In all such models, the aim is to show how a cognitive mechanism can work and with which implications for reaction time and error rate, but of course the model never proves that the processes taking place in the human mind are the same.

During this same period, skill acquisition researchers have begun to draw on what some would see as data that are even more direct than the behavioral data themselves, that is, neuroimaging and measures of electrophysiological activity in specific areas of the brain linked to specific cognitive tasks. There is an ongoing research agenda to develop neurological explanations of skill acquisition models such as ACT-R (see Anderson, 2007, Chapter 2 and pp. 169–181).

With the combination of computational modeling and neuroimaging data, Tenison and Anderson (2016) successfully verified a three-stage model of skill acquisition, consistent with a key tenet of ACT-R. Based on Tenison and Anderson's (2016) work, Maie (2022) applied the same computational modeling to behavioral data of intentional (explicit) grammar learning by novice learners. The analyses of reaction time data over 1,056 trials supported the three-stage development in L2 comprehension skills. Furthermore, Stocco et al. (2023) propose to map the neurobiological substrate of long-term memory (e.g., hippocampus underlying declarative memory) onto key modules in the ACT-R architecture. The putative localization of brain regions for memory processes including encoding, consolidation, retrieval, and forgetting may allow for more precise prediction of the relationship between amount of practice and learning.

In sum, the behavioral data show the similarity in skill development across different cognitive domains; the neurological data show how different areas of the brain are involved to a different extent after different amounts of practice; and the computational models show the hypothetical inner workings of the mechanisms that cannot be observed directly through behavioral or neurological data.

As should be clear from the literature cited earlier, evidence for central constructs such as the power law, procedural knowledge, or automatization abounds in the psychological literature. What is harder to come by is empirical data that unambiguously point to a specific interpretation of these phenomena in terms of learning mechanisms.

More importantly for our purposes here, not much research in the field of L2 learning has explicitly set out to gather data from L2 learners to test (a specific variant of) Skill Acquisition Theory.

The studies that have tested the predictions of skill acquisition most directly are DeKeyser (1997) and Robinson (1997). They test one of two competing theories of skill acquisition with L2 data: DeKeyser (1997) found that the concepts of proceduralization, automatization, and specificity of procedural rules accounted well for the learning curves for reaction time and error rate during a semester of practice of a small number of grammar rules. Robinson (1997), on the other hand, found that his data on the learning of an ESL grammar rule did not fit the predictions of Logan's competing theory of automatization through retrieval of specific instances from memory instead of rules.

Findings for **skill specificity** was evidenced by a series of empirical studies focusing on different linguistic domains. De Jong (2005) corroborated the initial evidence by DeKeyser (1997) for skill specific development of comprehension and production skills in learners of Spanish as a L2. Her study revealed that while extensive aural comprehension training increased processing speed, it did not significantly reduce errors in production. Conversely, while engaging in oral output training led to more accurate production, it did not hinder the acquisition of comprehension skills. Rodgers (2011) worked with learners of Italian L2 to show that automatization of verbal morphology developed as a function of practice but that it was less advanced in production than in comprehension, further documenting the specificity of procedural knowledge. With intermediate learners of Chinese, S. Li and Taguchi (2014) showed that accurate comprehension and production of speech acts was achieved by both input and output practice, but improvement on performance speed was dependent on practice modality. M. Li and DeKeyser (2017), in a study on Chinese L2, once more provided strong evidence for skill specificity, in this case for the learning of tone in Chinese L2. They compared learners who had been trained either in productive or in receptive skills, and the results showed that performance was far worse when participants were tested on the reverse skill than when they were tested on the practiced skill in terms of both error rates and reaction times. Taken together, the evidence clearly shows how different forms of skill-specific procedural knowledge develop from the same declarative knowledge.

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Alongside the growing body of research testing the key tenets of Skill Acquisition Theory, skill acquisition research has extended in other directions in recent years: the role of **practice** in SLA and language teaching. Here, practice is a technical term and more specific than merely receiving input and producing output in communication and broader than mechanical drills and pattern practice (DeKeyser, 2007a; Suzuki, 2023). It refers to “specific activities in the second language, engaged in systematically, deliberately, with the goal of developing knowledge of and skills in the second language.” (DeKeyser, 2007a, p. 1) This new conceptualization of practice is rooted in cognitive/educational psychology research, and Skill Acquisition Theory lays the foundation for interpreting L2 learning mechanisms from an explicit learning perspective. This new line of investigations addresses both theoretical and practical concerns to inform how L2 learning can be optimized in instructed SLA research (see Suzuki, Nakata & DeKeyser, 2019 and Jones, 2018 for thematic collections of empirical work).

A comprehensive review of practice research found a steady increase in empirical work in the last decade (Maie & Godfroid, 2023). More than 85% of practice activities in the synthesized research were categorized as meaningful and communicative in nature. A majority of research has focused on speaking, listening, and reading; little research focused on writing skill development through practice. Nonetheless, drawing on Skill Acquisition Theory, L2 researchers have started exploring “what kind of practice, including how much, for whom, for which language structure and skill, and in what context, is essential and facilitative for L2 learning.” (Suzuki, 2023, p. 2)

The optimal conditions for automatization have been subjected to empirical research from multiple angles. Automatization is typically evidenced by changes in reaction time (RT) and coefficient of variation (CV) in experimental tasks (see Suzuki & Elgort, 2023 for a review). Although there is a debate over its utility for capturing automatization (Hulstijn, Van Gelderen, & Schoonen, 2009), CV may differentiate automatization from mere speed-up of language processing (faster RT) and indicate genuine automatization involving higher processing stability or possibly restructuring especially in immersive contexts where L2 is practiced extensively. McManus and Marsden (2019) demonstrated that combining L1 and L2 explicit information enhances automatization in French L2 learners' imparfait verbal morphology, particularly in later

practice sessions, as evidenced by both RT and CV measures (see “Exemplary Study” section). Sato and McDonough (2019) found that declarative knowledge enables initial proceduralization of *wh*-questions in EFL learners, leading to improved accuracy and RT measures (i.e., speech rate, mean length of pauses, and self-repair) in communicative interactive tasks. These findings lend credence to a key aspect of Skill Acquisition Theory, positing that declarative knowledge is instrumental in the eventual attainment of automatized knowledge.

A notable advancement has been made in one area of L2 practice research: **distributed (spaced) versus massed practice** in learning and forgetting. The longstanding topic of what constitutes ideal distribution of practice has been revived in the cognitive and educational psychology literature in the 21st century, and a provisional conclusion is drawn from this literature as a whole (see the meta-analyses in Cepeda, Pashler, Vul, Wixted, & Rohrer, 2006). A large-scale experiment by Cepeda et al. (2009) revealed that the ideal spacing of practice is determined by the ratio of inter-session interval (the amount of time between different encounters with the same item) and retention interval (the amount of time between the end of practice and the beginning of testing).

On this point, since early 1990s, the L2 acquisition literature has revealed the potential advantage for intensive foreign language programs, where instructional hours are concentrated in several hours per *day* for several *months*, over regular programs where instructional hours are thinly distributed 2-3 hours per *week* for several *years* (e.g., Collins, Halter, Lightbown, & Spada, 1999; Lightbown & Spada, 1994; Serrano, 2011; Serrano & Muñoz, 2007; White & Turner, 2005).

More narrowly focused studies have yielded more nuanced patterns of optimal practice distribution for different aspects of L2 learning (Kim & Webb, 2022). Consistent patterns are found in the majority of the psychology literature, particularly for L2 vocabulary practice: spaced practice is superior to massed practice, and longer-spaced practice is more effective than shorter-spaced practice (Nakata, 2015). Yet, the scheduling of practice can be optimized for different types of linguistic knowledge, linguistic domains, skills (see Serrano, 2022; Rogers, 2023 for in-depth review). While Bird (2010) found longer-spaced practice (14-day interval) to be superior for learning the English tense system through error-correction activities to shorter-spaced practice (3-day interval),

Suzuki (2017) showed shorter-spaced practice (3-day interval) was superior to longer-spaced practice (7-day interval) for the acquisition of oral grammatical skills. M. Li and DeKeyser (2019), in a study on the learning of tone in Chinese L2, found the same advantage of shorter-spaced practice for procedural skill, but an advantage of longer-spaced practice for declarative knowledge. It appears then that the optimal practice distribution not only depend on the length of the treatment and the scope of the knowledge involved but also—and perhaps most importantly—on the extent to which declarative and procedural learning is involved (see Servant et al., 2018 for intriguing findings from neural experiments that suggest the potential superiority of massed practice over spaced practice for the development of automaticity in a visual search task).

A recent development in the area of Skill Acquisition Theory in SLA has been research on the declarative/procedural distinction in the area of individual differences in declarative and procedural memory—the aptitudes for declarative and procedural learning (see Ullman, this volume). Morgan-Short, Faretta-Stutenberg, Bill-Schuetz, Carpenter, and Wong (2014) used a test battery of declarative memory (aptitude for acquiring declarative knowledge) and procedural memory (aptitude for acquiring procedural knowledge). They found that declarative learning ability was highly predictive of language development at early stages, while procedural learning ability was highly predictive of later development (see also Pili-Moss et al., 2020, who analyzed RT and CV during practice sessions).

Capitalizing on individual difference factors resonates with the concept of **aptitude-treatment interaction** proposed in educational psychology (Cronbach & Snow, 1977), which has made significant inroads into L2 research in recent years. ATI research has revealed how learners' abilities and instructional/learning contexts converge to shape learning outcomes (see DeKeyser, 2019 for a review). Ruiz et al. (2019) investigated the roles of declarative and working memory in L2 vocabulary acquisition through intelligent computer assisted language learning (ICALL). L2 English learners read news texts on the Internet for two weeks under form-focused or meaning-focused instruction. They found that while declarative memory was essential to vocabulary learning regardless of the learning conditions, working memory predicted learning only in the form-focused condition. Procedural memory is also found to be implicated in the kind of L2 grammar practice that is conducive for automatization. In his re-analysis of Suzuki (2017) on the

data from computerized training under the shorter-spaced practice (3-day interval) and the longer-spaced practice (7-day interval), Suzuki (2018) found that procedural learning ability was significantly associated with RT in the shorter spacing group only. This probably explains the advantage of shorter-spaced practice in automatization, as measured by the higher processing stability indexed by CV.

The relevance of declarative and procedural memory may change depending on a broader learning context: classroom versus study abroad. Faretta-Stutenberg and Morgan-Short's (2018) study of event-related potentials (ERP) in a grammaticality judgment task revealed a potential shift from declarative to procedural learning. In a classroom setting, learners demonstrated behavioral improvement over the course of a semester, but this progress did not significantly relate to individual differences in memory. Conversely, in a study abroad context, notable correlations were found between the learners' behavioral and neural processing changes and their procedural learning ability and working memory.

One of the reasons why research from a skill acquisition perspective in SLA has increased in the last decade is the technological advancement required for the research methodology in this area. Experiments on skill acquisition typically involve rather large numbers of participants over rather long periods of time, yielding very large amounts of data for statistical analysis (Maie & Godfroid, 2023). Researchers do not need to be trained in computational modeling or neuroscience at all to contribute to research on skill acquisition; with a sophisticated approach to design, data collection, and data analysis, using technology that is fairly easily available at research institutions, behavioral data still have much to contribute to this area (see three methodological syntheses, including Maie & Godfroid, 2023, in the edited volume by Suzuki, 2023).

Given the increasing sophistication of the technology as well as the research methodology at the disposal of L2 researchers, along with a return to focus on form and explicit learning in recent years (see, e.g., DeKeyser, 2009, 2017; Doughty, 2001; Ellis, 2012; Goo, Granena, Yilmaz, & Novella, 2015; Norris & Ortega, 2000; Spada & Tomita, 2010), one can expect this area of research to pick up, especially as many researchers have begun to at least interpret existing findings from the L2 literature within the framework of Skill Acquisition Theory and highlight the crucial role of explicit knowledge: pronunciation skills (Saito & Plonsky, 2019), vocabulary and listening skills

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(Saito, Uchihara, Takizawa, & Suzukida, 2023), the output hypothesis (de Bot, 1996), writing development (Williams, 2012), speech fluency and self-monitoring (Albarqi & Tavakoli, 2023; Towell, Hawkins, & Bazergui, 1996), oral and written corrective feedback (Sato & Lyster, 2012; Shintani & Aubrey, 2016), form-focused instruction (Ranta & Lyster, 2018), immersion and content-based language teaching (Lyster, 2007), foreign language/L2 pedagogy (Macaro, 2003; Polat, Gregersen, & MacIntyre, 2020), and study abroad (McManus, Mitchell, & Tracy-Ventura, 2021; Pérez-Vidal, 2014).

Common Misunderstandings

Two kinds of misunderstanding about the contribution of Skill Acquisition Theory to SLA research are very common: the idea that skill acquisition either explains everything about L2 learning or nothing, in other words, that it competes with other theories to be the one and only valid explanation of the set of phenomena we call “SLA,” and the idea that it is incompatible with a variety of empirical findings in the field. These two misunderstandings are, of course, related, as we will see later.

Because of its emphasis on the importance of explicit/declarative knowledge in initial stages of learning, Skill Acquisition Theory is most easily applicable to what happens in (a) adolescent/adult learners with (b) high explicit language aptitude engaged in (c) the learning of simple structures at (d) fairly early stages of learning in (e) instructional contexts. That does *not* mean these five conditions all have to be fulfilled for Skill Acquisition Theory to be applicable, but it does mean that the more the learning situation deviates from this prototypical situation in one of these five respects, the less likely it is that concepts from Skill Acquisition Theory will account well for the data. If adults have below-average explicit language aptitude (e.g., language analytic ability, rote memory), they may find it hard to form declarative representations of grammar rules especially without the help of a teacher and textbooks. By the same token, children will not be able to conceptualize many of grammar rules, which are of course inherently abstract. This problem is even worse when the rules are very complex: In that case even adults of above-average aptitude will find it hard to understand, and especially to proceduralize and automatize, the rule. Finally, as learners enter more advanced stages of learning (where they interact constantly and fluently with native speakers and are exposed

to a large amount of oral and written input), the likelihood of implicit learning of frequent and relatively concrete patterns in the input increases substantially. That in turn does *not* mean that skill acquisition theory is of marginal relevance: a substantial amount of second/foreign language learning is done by adolescents and adults with certain levels of explicit language aptitude going through the initial stages of learning in a school context. Moreover, if the potential for learning in these initial stages is not maximized (because everything we know about cognitive skill acquisition is ignored), this will have repercussions, of course, for all learning thereafter.

Related to overgeneralization of Skill Acquisition Theory to the situations where it does not apply well is the tendency to see the theory as incompatible with a number of empirical findings as well as theoretical positions in the field. Some will overinterpret the theory as predicting that any kind of construction can be learned, practiced, and automatized by anybody in any order and that therefore it is incompatible with the literature on the natural order of acquisition (summarized, e.g., in Dulay, Burt, & Krashen, 1982; Goldschneider & DeKeyser, 2001; Luk & Shirai, 2009). This reasoning actually combines a misreading of both Skill Acquisition Theory and research on the natural order of acquisition, because the latter never found an ordering for all or even most structures in the language, only for a few morphemes in some studies or for a few closely related syntactic patterns in others, and because most studies of order of acquisition were carried out with learners who had massive exposure to the language and/or were young learners, which means that they were largely implicit learners and that the skill acquisition model (going from declarative/explicit to procedural/implicit knowledge) did not apply to them.

Skill Acquisition Theory should not be seen as being in competition with other contemporary tendencies in the way focus on form is implemented, such as task-based learning (e.g., Bygate, 2020; Ellis, 2003; Long, 2015; Van den Branden, 2006), because engaging in carefully sequenced tasks (from a psycholinguistic perspective) will lead to proceduralization and potentially some degree of automatization, provided that the requisite declarative knowledge is at the disposal of the learner during the task (DeKeyser, 2018; Lambert, 2023). Nor does Skill Acquisition Theory contradict the notion that implicit learning and usage are important (leading directly to implicit knowledge, that is, knowledge that one is not aware of, which is stressed both in the universal grammar approach [see White, this volume] and the usage-based approach to learning [see Ellis &

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Wulff, this volume]). While stressing the importance of implicit learning and statistical tallying through rich input and usage, Ellis (see esp. Ellis, 2002, 2005; see also Ellis & Wulff, this volume) makes it very clear that “many aspects of a second language are unlearnable—or at best acquired very slowly—from implicit processes alone” (Ellis, 2005, p. 307), and that “slot-and-frame patterns, drills, mnemonics, and declarative statements of pedagogical grammar ... all contribute to the conscious creation of utterances that then partake in subsequent implicit learning and proceduralization” (p. 308).

In language pedagogy literature, Skill Acquisition Theory is often associated with the Presentation-Practice-Production (PPP) procedure originally proposed during the early days of communicative language teaching (Byrne, 1986). However, its application extends beyond the traditional PPP, which has been subject to varied interpretations and criticisms for its non-authentic “presentation” and decontextualized “practice” stages. We do not advocate this impoverished version of PPP from a Skill Acquisition Theory perspective; rather, we emphasize the importance of guided practice where learners understand rules with examples, then have a minimal amount of controlled practice, and then have lots of communicative practice to automatize their knowledge and skills. Skill Acquisition Theory explains a crucial factor that is not often addressed in the more linguistically oriented literature, but that is of tremendous importance in the more applied literature: the types of practice activities *and* their sequencing with timely linguistic support and spacing. No amount of any activity means much if it does not fit into the right point of development of skill for a given individual.

[An Exemplary Study: McManus and Marsden \(2019\)](#)

McManus and Marsden (2019) provide an interesting angle on L2 skill acquisition, because they emphasize a crucial yet often overlooked aspect of skill development: how the specific nature of explicitly taught declarative knowledge determines the subsequent processes of proceduralization and automatization. Their research investigated the role of explicit information (EI) and practice in learning the French “*imparfait*,” which requires cross-linguistically complex form-meaning mapping for English-speaking learners. The study involved three groups of English-speaking learners of French. Each group differed in the combination of L1 and L2 explicit information (EI) about the target structures and

practice they received: 1) L2 EI and L2 practice; 2) the same L2 EI/L2 practice as in Group 1, but with L1 EI and practice; 3) the same L2 EI/L2 practice as in Group 1, with L1 practice but no L1 EI. Each group's training consisted of four sessions where they engaged in L2 receptive, listening-and-reading practice activities with a total of 552 items.

Posttest results showed that Group 2, the only one that received EI about L1, not only did better than the other groups, but also showed a different learning process during practice. McManus and Marsden not only looked at change through practice spread over four sessions but also at the learning curves (for accuracy and reaction times) within each session. Within each session they found Group x Item interactions, which means that progress from practice item to item differed depending on which treatment group the participants were in; this was the case for both accuracy and reaction time. This interaction was strong enough to bring the group with the slowest start, i.e. Group 2, the only one with L1 EI, to the strongest level at the end of each session (for both accuracy and reaction time). The effect of practice was the strongest in the last session, which had the more difficult items (contrasting three tenses instead of one); this too was the case for both accuracy and reaction time. The last session was also the only one in which another variable, regular vs. irregular verbs, played a role (but only for the groups that had not received L1 EI).

In addition to analyzing the averages for accuracy and reaction time, the authors also inspected the change of the coefficient of variance (standard deviation divided by average reaction time) over time within each practice section. This coefficient reliably decreased in the last two sessions, which the authors interpret as increasing stability and efficiency setting in, indicative of automatization, no longer just proceduralization.

This is, then, a study with various interesting findings in terms of skill acquisition theory. They suggest that mere L2 practice is sometimes insufficient for learning complex L2 structures. For such L2 features with large crosslinguistic influence, L1 EI is facilitative in establishing a solid declarative base for successful proceduralization and eventual automatization. As the authors acknowledge, however, future research should seek generalizability of this finding by investigating L1 English speakers learning other structures such as *ser-estar* distinction in Spanish, where a single form be is expressed by multiple

forms and *zai* in L2 Chinese, where multiple forms progressive *ing* and prepositional *in* are expressed by the single form *zai*.

Explanation of Observed Findings in L2 Acquisition

Observation 7: There are limits on the effects of frequency on L2 acquisition; Observation 9: There are limits on the effects of instruction on L2 acquisition; Observation 10: There are limits on the effects of output (learner production) on language acquisition. The findings that there are limits on the effects of frequency, on the effects of instruction, and on the effects of output are very easily explained in this framework: factors such as whether students receive instruction, produce output, and are exposed to certain structures frequently play little role if (explicit) instruction and practice with input and output are not integrated in a way that makes sense according to this theory. Automatization requires procedural knowledge. Proceduralization requires declarative knowledge and slow deliberate practice. The acquisition of declarative knowledge of a kind that can be proceduralized requires the judicious use of rules and examples. These stages cannot be skipped, reversed, or rushed. Unfortunately, however, just about any kind of existing teaching methodology tends to do at least one of the latter three.

Observation 5: Second language acquisition is characterized by variation among and within individuals; Observation 6: Second language learning is variable across linguistic subsystems. The findings that L2 learning is variable in its outcome and variable across linguistic subsystems are equally easy to explain in this framework. Different learners achieve very different levels of proficiency in a given area because of their different levels of ability to grasp the declarative knowledge, the widely differing amounts of practice of specific kinds that individual learners receive for specific structures, and most importantly, the different sequencing of various kinds of explicit information, implicit input, and practice with input and output that different learners receive or create for themselves (which are influenced in turn by motivation, personality, and social context). Learners also show a large amount of intraindividual variation between the different linguistic domains because of differential aptitude, instruction, and practice. Even more importantly, Skill Acquisition Theory easily explains the differences in performance from task to task that are so often observed for the same subcomponent

of language in the same individual learner. Performance draws on procedural knowledge, which we saw is very specific, and unevenly developed depending on the amount of practice of various elements of the language under various task conditions.

Observation 4: Learners' output (speech) often follows predictable paths with predictable stages in the acquisition of a given structure. The fact that learners follow a predictable path in their development for a given structure also fits well with Skill Acquisition Theory, especially if it is understood somewhat more broadly than in merely linguistic terms. Learners who are exposed to little or no instruction may learn different variants of a structure in a certain order through implicit mechanisms, and show little task variation at a given point in time, but learners who are carefully guided through the stages of skill acquisition for a given structure may show less developmental variation in declarative knowledge of that kind of structure, but more developmental variation in speed and systematicity of use of this structure, including variation due to (even small variations in) task conditions. When such learners are forced to perform beyond the level of skill they have reached, they may fall back on the same variants of structures used by implicit learners, depending on factors such as how much exposure they have received along with their systematic instruction and what age they are (these two factors influence their opportunity for and their relative susceptibility to implicit and explicit learning).

Conclusion

In this chapter, we have presented both major findings and methodological aspects of skill acquisition research, illustrated them with a study from the L2 domain, and explained how Skill Acquisition Theory is quite compatible with many of the major findings from SLA research and even explains some phenomena better than other theories. In closing, however, it is only fitting to take a somewhat broader view of how well explanations of L2 learning phenomena based on Skill Acquisition Theory fit into the larger enterprise of cognitive science; in our case, that means trying to understand how the same mind that learns how to recognize the neighbors, play chess, appreciate music, ride a bicycle, program a computer, or use a L1 also learns to understand and produce a L2.

An advantage of the approach illustrated in this chapter is definitely that it fits in very well with other aspects of cognitive science. The same mechanisms, whether

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couched in psychological or neurological terms, are invoked to explain L2 learning and a wide variety of other skills. Studying the acquisition of complex cognitive skills such as L2 learning from Skill Acquisition Theory perspectives, in turn, has the potential to contribute to the body of cognitive science and better understanding of human mind.

The approach to skill learning has itself proven to be quite robust over the decades, despite the obvious changes in emphases, methodology, and terminology. Research on skill acquisition, whether carried out with behavioral data or through neuroimaging or computer modeling, is tremendously explicit in its procedures and claims. Power curves, computer programs, and brain scanners give precise answers to precise questions (even though interpreting the answers can still leave a lot of room for discussion). Most important of all, perhaps, research in this area is truly developmental. It does not take snapshots of learners at two or three points between initial learning and near-native proficiency and speculate on how learners got from point A to point B. It can document learning day after day and show how rapid acquisition of declarative knowledge about some structures, rapid proceduralization of knowledge about others, and automatization of some elements of knowledge for specific uses all happen in parallel, while other elements never get automatized, or maybe not even proceduralized, or perhaps not even learned at all. It may have less to say about which elements of language are going to be learned in what order than other, more (psycho-)linguistically oriented approaches, but it is painstakingly precise and explicit about the big and small steps a learner takes in acquiring a specific use of a specific structure.

Discussion Questions

- 1 Central to Skill Acquisition Theory are the constructs of declarative knowledge, proceduralization, and automatization. Discuss each, paying particular attention to the difference between proceduralization and automatization as well as the context(s) in which automatization may occur.
- 2 Both DeKeyser and Ellis and Wulff offer approaches that are cognitive in nature, that is, built on models/theories from psychology rather than, say, linguistics. How are the two approaches similar or different?

- 3 It is clear that Skill Acquisition Theory is concerned with language behavior. Do you think that such an approach is incompatible with an approach that focuses on competence (e.g., White, this volume)?
- 4 One interpretation of Skill Acquisition Theory is that it is better suited to explain tutored language acquisition as compared to nontutored language acquisition. Another is that it is better suited to explain adult L2 acquisition but not child L1 acquisition or child L2 acquisition. Do you agree?
- 5 Read the exemplary study presented in this chapter and prepare a discussion for class in which you describe how you would conduct a replication study. Be sure to explain any changes you would make and what motivates such changes.

Suggested Further Reading

Anderson, J. R. (2007). *How can the human mind occur in the physical universe?* New York, NY: Oxford University Press.

This book provides a more thorough and at the same time more readable account of what was covered in the 2004 article, with ample discussion of how modeling skill acquisition fits into the broader psychological currents of the last three decades.

Anderson, J. R. , Bothell, D. , Byrne, M. D. , Douglass, S. , Lebiere, C. , & Qin, Y. (2004). An integrated theory of the mind. *Psychological Review*, *111*, 1036–1060.

An overview of ACT-R theory, with new emphases on neuro-imaging data and the issue of modularity of the mind. Parts are very technical; others are very readable.

DeKeyser, R. (Ed.). (2007). *Practice in a second language: Perspectives from applied linguistics and cognitive psychology*. New York, NY: Cambridge University Press.

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A book that takes a broad view of practice, with many chapters drawing on Skill Acquisition Theory, applying it to issues from error correction in the classroom to interaction with native speakers during study abroad.

DeKeyser, R. (2018). Task repetition for language learning: A perspective from skill acquisition theory. In M. Bygate (Ed.), *Learning language through task repetition* (pp. 27–41). Amsterdam, Netherlands: Benjamins.

This chapter provides detailed discussion of issues such as distribution of practice, skill specificity, and transfer from the point of view of Skill Acquisition Theory.

DeKeyser, R. M. , & Criado-Sánchez, R. (2012). Automatization, skill acquisition, and practice in second language acquisition. In C. A. Chapelle (Ed.), *The encyclopedia of applied linguistics* (pp. 323–331). Oxford, England: Wiley-Blackwell.

A discussion of what Skill Acquisition Theory means for practice activities in a second language.

Lyster, R. , & Sato, M. (2013). Skill acquisition theory and the role of practice in L2 development. In M. García Mayo , J. Gutierrez-Mangado , & M. Martínez Adrián (Eds.), *Contemporary approaches to second language acquisition* (pp. 71–91). Amsterdam, Netherlands: John Benjamins.

A thorough discussion of Skill Acquisition Theory and practice in L2, with some emphasis on the role of feedback. Very useful to read in conjunction with this chapter.

Segalowitz, N. (2010). *Cognitive bases of second language fluency*. London, England: Routledge.

The most thorough discussion to date of automaticity and the process of automatization as they apply to second language learning and bilingualism.

Suzuki, Y. (Ed.) (2023). *Practice and automatization in second language research: Perspectives from skill acquisition theory and cognitive psychology*. New York: Routledge.

This book extends the edited volume by DeKeyser (2007) with up-to-date reviews on advancement in SLA research drawing on Skill Acquisition Theory and cognitive psychology.

Suzuki, Y. (2024). Skill acquisition theory: Learning-to-use and usage-for-learning in SLA. In K. McManus (Ed.), *Usage in second language acquisition: Critical reflections and future directions* (pp. 147-168). New York: Routledge.

From a Skill Acquisition Theory perspective, this chapter discusses the potential complimentary roles of “practice” and “usage” in SLA by addressing the dilemma between learning-to-use and usage-for-learning.

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