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Implicit AND explicit language learning

Their dynamic interface and complexity

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Learning symbols and their arrangement in language involves learning associations across and within modalities. Research on implicit learning and chunking within modalities (e.g. N. C. Ellis, 2002) has identified how language users are sensitive to the frequency of language forms and their sequential probabilities at all levels of granularity from phoneme to phrase. This knowledge allows efficient language processing and underpins acquisition by syntactic bootstrapping. Research on explicit learning (e.g. N. C. Ellis, 2005) has shown how conscious processing promotes the acquisition of novel explicit cross-modal form-meaning associations. These breathe meaning into the processing of language form and they underpin acquisition by semantic bootstrapping. This is particularly important in establishing novel processing routines in L2 acquisition. These representations are also then available as units of implicit learning in subsequent processing. Language systems emerge, both diachronically and ontogenetically, from the statistical abstraction of patterns latent within and across form and function in language usage. The complex adaptive system (N. C. Ellis & Larsen-Freeman, 2009b) of interactions within AND across form and function is far richer than that emergent from implicit or explicit learning alone.

Introduction

"Implicit learning is acquisition of knowledge about the underlying structure of a complex stimulus environment by a process which takes place naturally, simply and without conscious operations. Explicit learning is a more conscious operation where the individual makes and tests hypotheses in a search for structure. Knowledge attainment can thus take place implicitly (a nonconscious and automatic abstraction of the structural nature of the material arrived at from experience of instances), explicitly through selective learning (the learner searching for information and building then testing hypotheses), or, because we can communicate using language, explicitly via given rules (assimilation of a rule following explicit instruction). Two research

questions naturally follow from these distinctions. What are the processes and resultant mental representations of implicit and explicit learning? Which of human cognitive capabilities are acquired implicitly and which learned explicitly? This second question is of both theoretical and practical pedagogic importance since teaching interventions are less relevant to implicitly learned skills but essential to explicitly learned ones" (pp. 1–2).

"There is need for a detailed theoretical analysis of the processes of explicit and implicit learning. What can be learned implicitly? If implicit learning is simply associationist learning and the induction of statistical regularities, what aspects of language can be so acquired? Just how modular and inaccessible are the implicit learning processes for language acquisition? What are the various mechanisms of explicit learning that are available to the language learner? If the provision of explicit rules facilitates, or is necessary for, the acquisition of certain forms, what are the appropriate nature of these rules? What are the developmental paths of implicit and explicit learning abilities? Are there sensitive periods for implicit language acquisition? What are the neural substrates of these processes?" (pp. 3–4).

This was the research agenda I outlined in the introduction to *Implicit and Explicit Learning of Languages* (N. C. Ellis, 1994). The subsequent two decades have seen much research addressing these questions, as this volume attests. In what follows here I describe the development of my own thinking over these years. After briefly specifying what I believe are the units of language acquisition, I outline the contributions of implicit learning, the limits of implicit learning, and the consequent necessity for explicit learning in L2 acquisition. I emphasize how an emergentist perspective is necessary in order to investigate the complex system of language that arises from the dynamic interactions of implicit *and* explicit language learning and usage.

The units of language acquisition

Usage-based approaches to language view the basic units of representation as 'constructions': form-function mappings, conventionalized in the speech community, and entrenched as language knowledge in the learner's mind (Bybee, 2010; Robinson & Ellis, 2008; Tomasello, 2003). Constructions are symbolic: they specify the defining properties of morphological, syntactic, and lexical form, and the semantic, pragmatic, and discourse functions that are associated with these. Usage-based theories of language acquisition hold that we learn constructions while engaging in communication, and that an individual's linguistic competence emerges from the memories of the utterances in their history of language use and the abstraction of regularities within them.

These assumptions are fundamentally de Saussurian:

1. Linguistic signs arise from the dynamic interactions of thought and sound – from patterns of usage: "Everything depends on relations. … [1] Words as used in discourse, strung together one after another, enter into relations based on the linear character of languages… Combinations based on sequentiality may be called *syntagmas*…. [2] Outside of the context of discourse, words having something [meaningful] in common are associated together in memory. This kind of connection between words is of quite a different order. It is not based on linear sequence. It is a connection in the brain. Such connections are part of that accumulated store which is the form the language takes in an individual's brain. We shall call these *associative relations*." (de Saussure, 1916, pp. 120–121).

2. Linguistic structure emerges from patterns of usage that are automatically memorized by individual speakers, and these representations and associations collaborate in subsequent language processing: "The whole set of phonetic and conceptual differences which constitute a language are thus the product of two kinds of comparison, associative and syntagmatic. Groups of both kinds are in large part established by the language. This set of habitual relations is what constitutes linguistic structure and determines how the language functions…" (p. 126). "Any [linguistic] creation must be preceded by an unconscious comparison of the material deposited in the storehouse of language, where productive forms are arranged according to their relations." (de Saussure, 1916, p. 164).

3. Regular schematic structures are frequency-weighted abstractions across concrete patterns of like-types. "To the language and not to speech, must be attributed all types of syntagmas constructed on regular patterns,… such types will not exist unless sufficiently numerous examples do indeed occur" (p. 120–121). "Abstract entities are based ultimately upon concrete entities. No grammatical abstraction is possible unless it has a foundation in the form of some series of material elements, and these are the elements one must come back to finally" (de Saussure, 1916, p. 137).

Note his emphasis on association and association-strength, the emergence of structure from statistical collaborations, and the importance of unconscious cognition in language processing. Note the date of this work, nigh 100 years ago.

Implicit language learning

The importance of these factors has been amply confirmed over a subsequent century of research in psycholinguistics which has shown that language processing is exquisitely sensitive to usage frequency. Language knowledge involves statistical knowledge,

so humans learn more easily and process more fluently high frequency forms and 'regular' patterns which are exemplified by many types and which have few competitors (see e.g. Bybee & Hopper, 2001; N. C. Ellis, 2002; Gries & Divjak, 2012b). I believe that these phenomena of language processing provide definitive evidence concerning language acquisition and the implicit/explicit learning distinction:

Firstly, with regard usage-based language acquisition: if language processing is sensitive to occurrence frequency in the language, then there must be some cognitive mechanism that tallies the frequencies of occurrence of the units of language during language usage. "These psycholinguistic demonstrations that frequency-sensitivity pervades all aspects of language <u>processing</u> have profound implications for theories of language <u>acquisition</u>: <u>Language learning is exemplar based</u>. The evidence reviewed here suggests that the knowledge underlying fluent use of language is not grammar in the sense of abstract rules or structure, but it is rather a huge collection of memories of previously experienced utterances. These exemplars are linked, with like-kinds being related in such a way that they resonate as abstract linguistic categories, schema and prototypes. Linguistic regularities emerge as central-tendencies in the conspiracy of the data-base of memories for utterances" (N. C. Ellis, 2002, p. 166).

Secondly, with regard the role of consciousness: when we use language, we are conscious of communicating rather than of counting, yet in the course of conversation we naturally acquire knowledge of the frequencies of the elements of language, their transitional dependencies, and their mappings. The phenomenon is clear-cut. When you read, you never consciously count bigram frequencies. You never have done. When you listen, you never consciously tally phonotactic sequences. When you speak, you never consciously update collocation frequencies, and you never, ever have. We never consciously compute the relative frequencies of units of language, their transitional probabilities, the mutual information between units, ΔP, T, log likelihood or any other association statistic. Nevertheless, since our processing systems are sensitive to these statistics across the whole gamut of language, we must have naturally acquired this knowledge of the frequencies of the elements of language, their transitional dependencies, and their mappings in the course of language usage. These aspects of language learning therefore must reflect implicit learning. "The mechanism underlying such <u>unconscious</u> counting is to be found in the plasticity of synaptic connections rather than abacuses or registers, but it's counting nevertheless" (Ellis, 2002, p. 146). This 2002 review went on to review the evidence to that date demonstrating that these factors applied across all levels of language representation: phonology and phonotactics, reading, spelling, lexis, morphosyntax, formulaic language, language comprehension, grammaticality, sentence production, and syntax.

Thanks to the pioneering research of Arthur Reber (Reber, 1976; for an overview, see 1993; Reber, Kassin, Lewis, & Cantor, 1980), much of the foundational experimental psychological work on implicit learning concerned the learning of artificial

grammars, proxying the syntagmas of Saussure, along with other perceptual and motor sequences. These experiments show that from repeated experience of sequential behavior, learners automatically acquire knowledge of the underlying patterns of sequential dependencies. This research, together with emerging constructionist accounts of child language acquisition (Tomasello, 2003, 1998), prompted the article "Sequencing in SLA" (N. C. Ellis, 1996) which contended that language acquisition is essentially sequence learning and that learners' long-term knowledge of lexical sequences in formulaic phrases serves as the database for the acquisition of language grammar. Following (Newell, 1990), it proposed "chunking" as a general process of second language acquisition (L2 acquisition).

There has been substantial recent work investigating learners' sensitivity to sequential statistics and chunks, both in comprehension and production, and in fluency therein. The summary is worth updating here. Again, I will sample experiments across levels of language representation and across first and second language.

Phonetic processing and lexical perception are affected by sequential or formulaic knowledge. Hilpert (2008) demonstrated that syntactic context in the form of constructions and collocations affects both phonemic categorization and low-level phonetic processing in native speakers. One experiment used the English *make*-causative construction which has a strong bias towards verbs of emotion and psycho-physiological reaction: the verb *cry* occurs 73 times in the *make*-causative construction, the verb *try* just 11; in discourse as a whole, *try* is ten times more frequent than *cry*; thus *make me cry* is more formulaic than *make me try*. The carrier phrase was *They made me*, followed by a signal that ranged on an eight-step continuum from /trai/ to /krai/. Over many trials, participants had to say whether they heard /t/ or /k/. The resulting categorization curve was half a step towards the right side of the continuum, i.e. more instances of ambiguous sounds were identified as *cry*, when they were presented in the *make*-causative constructional carrier phrase rather than alone. Kapatsinski and Radicke (2008, p. 137) provide data that similarly point to a competition between larger units and their parts when the whole-form is of sufficient frequency. Participants had to respond whenever they detected the particle *up* in a verb–particle combination (e.g. *give up*). Reaction times were faster the more frequent the collocation up to a point (a priming effect correlated with transition probability), but then for collocations in the highest frequency bin, there was a slowdown in reaction times (showing that the phrase was now so bound that it was difficult to recognize *up* as a component part.

Reading time is affected by collocational and sequential probabilities. Bod (2001), using a lexical-decision task, showed that high-frequency three-word sentences such as "I like it" were reacted to faster than low-frequency sentences such as "I keep it" by native speakers. Ellis, Frey and Jalkanen (2008) used lexical decision to demonstrate that native speakers preferentially process frequent verb-argument and booster/maximizer-adjective two-word collocations. Durrant and Doherty (2010) used lexical decision to

assess the degree to which the first word of low- (e.g. *famous saying*), middle- (*recent figures*), high- frequency (*foreign debt*) and high frequency and psychologically-associated (*estate agent*) collocations primed the processing of the second word in native speakers. The highly frequent and high-frequency associated collocations evidenced significant priming. Arnon and Snider (2010) used a phrasal decision task (is this phrase possible in English or not?) to show that comprehenders are also sensitive to the frequencies of compositional four-word phrases: more frequent phrases (e.g. *don't have to worry*) were processed faster than less-frequent phrases (*don't have to wait*) even though these were matched for the frequency of the individual words or substrings. Tremblay, Derwing, Libben and Westbury (2011) examined the extent to which lexical bundles (LBs, defined as frequently recurring strings of words that often span traditional syntactic boundaries) are stored and processed holistically. Three self-paced reading experiments compared sentences containing LBs (e.g. *in the middle of the*) and matched control sentence fragments (*in the front of the*) such as *I sat in the middle/front of the bullet train*. LBs and sentences containing LBs were read faster than the control sentence fragments in all three experiments.

There is a very substantial literature demonstrating sensitivity to such sequential information in sentence processing (see MacDonald & Seidenberg, 2006 for review). Eye-movement research shows that the fixation time on each word in reading is a function of the frequency of that word (frequent words have shorter fixations) and of the forward transitional probability (the conditional probability of a word given the previous word $P(w_k|w_{k-1})$: for example, the probability of the word *in* given that the previous word was *interested* is higher than the probability of *in* if the last word was *dog*) (McDonald & Shillcock, 2003, 2004). Parsing time reflects the more frequent uses of a word (e.g. the garden-path effect caused by *The old man the bridge*, in which *man* is used as a verb). Phrase-frequency affects parsing in a similar way. For example, ambiguity resolution is driven not only by how often a verb appears as a past participle and how likely a noun is to be an agent, but also by the exact frequencies of the noun–verb combination. Reali and Christiansen (2007) demonstrate such effects of chunk frequency in the processing of object relative clauses. Sentences such as *The person who I met distrusted the lawyer*, are easier to process when the embedded clause is formed by frequent pronoun–verb combinations (*I liked* or *I met*) than when it is formed by less frequent combinations (*I distrusted* or *I phoned*).

Generally, analyses of large corpora of eye-movements recorded when people read text demonstrate that measures of *surprisal* account for the costs in reading time that result when the current word is not predicted by the preceding context. Measuring surprisal requires a probabilistic notion of linguistic structure (utilizing transitional probabilities or probabilistic grammars). The surprisal of a word in a sentential context corresponds to the probability mass of the analyses that are not consistent with the new word (Demberg & Keller, 2008).

Maintenance of material in short-term memory and its accurate subsequent production is also affected by knowledge of formulaic sequences. Bannard and Matthews (2008) identified frequently occurring chunks in child-directed speech (e.g. *sit in your chair*) and matched them to infrequent sequences (e.g. *sit in your truck*). They tested young children's ability to produce these sequences in a sentence-repetition test. Three-year-olds and 2-year-olds were significantly more likely to repeat frequent sequences correctly than to repeat infrequent sequences correctly. Moreover, the 3-year-olds were significantly faster to repeat the first three words of an item if they formed part of a chunk (e.g. they were quicker to say *sit in your* when the following word was *chair* than when it was *truck*). Tremblay, Derwing, Libben and Westbury (2011) similarly used word and sentence recall experiments to demonstrate that more sentences containing LBs (the same ones as in their earlier mentioned comprehension experiments) were correctly remembered by adults in short-term memory experiments.

Priming effects are another standard paradigm for investigating implicit learning effects in psychological research. Language processing also shows priming effects across phonology, conceptual representations, lexical choice, and syntax where a construction recently experienced in discourse is picked up and reused productively. Syntactic priming refers to the phenomenon of using a particular syntactic structure given prior exposure to the same structure. This behavior has been observed when people hear, speak, read or write sentences (Bock, 1986; McDonough & Trofimovich, 2008; Pickering & Ferreira, 2008; Pickering & Garrod, 2006).

People have longer-term memory as well for the particular wording used to express something (as any parent who misreads a favorite bed-time story can readily attest). Some learning takes place after just one incidental exposure. Gurevich, Johnson, & Goldberg (2010) showed that adult native speakers recognize at above chance rates full sentences that they have been exposed to only once (Experiments 1 and 3) in texts of 300 words long that were presented non-interactively with no advanced warning of a memory test. Verbatim memory occurred even when lexical content and memory for gist was controlled for (Experiments 2 and 4). Even after a six-day delay, participants reliably reproduced sentences they have heard before when asked to describe scenes, even though they were not asked to recall what they had heard (Experiment 5).

These effects cumulate: "All lexical items are primed for grammatical and collocational use, i.e. every time we encounter a lexical item it becomes loaded with the cumulative effects of these encounters, such that it is part of our knowledge of the word that it regularly co-occurs with particular other words or with particular grammatical functions" (Hoey, 2004, p. 21; 2005).

The evidence I have gathered here concerns native speakers. What about L2 learners? Jiang and Nekrasova (2007) examined the representation and processing of formulaic sequences using online grammaticality judgment tasks. English as a second language speakers and native English speakers were tested with formulaic and

non-formulaic phrases matched for word length and frequency (e.g. *to tell the truth* vs. *to tell the price*). Both native and nonnative speakers responded to the formulaic sequences significantly faster and with fewer errors than they did to nonformulaic sequences. Similarly, Conklin and Schmitt (2007) measured reading times for formulaic sequences versus matched nonformulaic phrases in native and nonnative speakers. The formulaic sequences were read more quickly than the non-formulaic phrases by both groups of participants.

Ellis and Simpson-Vlach (2009) and Ellis, Simpson-Vlach and Maynard (2008) used four experimental procedures to determine how the corpus linguistic metrics of frequency and mutual information (MI, a statistical measure of the coherence of strings) are represented implicitly in native and non-native speakers, thus to affect their accuracy and fluency of processing of the formulas of the Academic Formulas List (AFL, Simpson-Vlach & Ellis, 2010). The language processing tasks in these experiments were selected to sample an ecologically valid range of language processing skills: spoken and written, production and comprehension, form-focused and meaning-focused. They were: (1) speed of reading and acceptance in a grammaticality judgment task where half of the items were real phrases in English and half were not, (2) rate of reading and rate of spoken articulation, (3) binding and primed pronunciation – the degree to which reading the beginning of the formula primed recognition of its final word, (4) speed of comprehension and acceptance of the formula as being appropriate in a meaningful context. Processing in all experiments was affected by various corpus-derived metrics: length, frequency, and mutual information (MI). Frequency was the major determinant for non-native speakers, but for native speakers it was predominantly the MI of the formula which determined processability.

Priming has also been extensively researched and observed in L2 acquisition (Gries & Wulff, 2005, 2009; McDonough & De Vleeschauwer, in press; McDonough & Kim, 2009; McDonough & Mackey, 2008; McDonough & Trofimovich, 2008).

Broadly, these findings demonstrate that language users are sophisticated in their knowledge of the sequential probabilities of the units of language, and that it is their usage experience that has cultivated this knowledge. As before, I argue that if the tallying involved is not part of the user's conscious experience, then this knowledge is implicitly won. Krashen (1985) likewise championed the importance of unconscious acquisition from natural usage. This recognition has been there from the beginnings of modern linguistics. I repeat: "Any [linguistic] creation must be preceded by an unconscious comparison of the material deposited in the storehouse of language, where productive forms are arranged according to their relations." (de Saussure, 1916, p. 164). The fact that at least L1 acquisition proceeds largely implicitly (without intention to learn and resulting in a tacit knowledge base) is one thing that contemporary generative and emergentist accounts agree upon.

Grammatical and lexical knowledge form a continuum from heavily entrenched and conventionalized formulaic units (unique patterns of high token frequency) to loosely connected but collaborative elements (patterns of high type frequency) (Bybee, 2010; N. C. Ellis, 2008b, 2012; N. C. Ellis & Larsen-Freeman, 2009a; Robinson & Ellis, 2008). "The linguist's task is in fact to study the whole range of repetition in discourse, and in doing so to seek out those regularities which promise interest as incipient subsystems. Structure, then, in this view is not an overarching set of abstract principles, but more a question of a spreading of systematicity from individual words, phrases, and small sets." (Hopper, 1987, p. 143).

Language users (L1 and L2 both) are sensitive to the sequential statistics of these dependencies large and small. "Words used together fuse together" (Bybee, 2005) (after Hebb's (1949) research often summarized by the phrase "Cells that fire together, wire together"). These collaborations, conspiracies, and competitions occur at all levels of granularity and points in a sequence – remember, for example, the demonstration of Bannard and Matthews (2008) that the three words beginning a chunk of a four word sequence are said more quickly when they precede a more highly related collocation. The phenomenon is entirely graded.

These usage-based/input-based/cognitive/statistical learning views of language acquisition are now current and widespread. See readings in Bybee and Hopper (2001), Bod, Hay, and Jannedy (2003), and Diessel (2007) for reviews of frequency effects in language processing, Corrigan, Moravcsik, Ouali and Wheatley (2009) for reviews of processing formulaic language, Trousdale and Hoffman (2013) for a handbook of construction grammar, Robinson and Ellis (2008) for a handful of usage-based theories of SLA, Gries and Divjak (2012a) for theoretical analyses which bridge corpus, cognitive, and psycholinguistic evidence, and Rebuschat and Williams (2012) for the state-of-the-art on statistical language learning.

The results consolidate the view that learners are sensitive to the frequencies of occurrence of constructions and their transitional probabilities, and that they have learned these statistics from usage, tallying them implicitly during each processing episode. "Learners FIGURE language out: their task is, in essence, to learn the probability distribution P(*interpretation|cue, context*), the probability of an interpretation given a formal cue in a particular context, a mapping from form to meaning conditioned by context" (N. C. Ellis, 2006a, p. 8). Again, all very de Saussurian: de Saussure (1916) said, "To speak of a 'linguistic law' in general is like trying to lay hands on a ghost… Synchronic laws are general, but not imperative…[they] are imposed upon speakers by the constraints of common usage… In short, when one speaks of a synchronic law, one is speaking of an arrangement, or a principle of regularity" (pp. 90–91). The frequencies of common usage count in the emergence of regularity in L2 acquisition. Usage is rich in latent linguistic structure, and learners apprehend this structure in the large part by means of implicit learning.

The limits of implicit language learning

Nevertheless, a major theme within second language research has been the conclusion, convincingly won over the last thirty years of research building on the foundations laid by Schmidt (1990), Long (1991), and Lightbown, Spada, and White (1993) that L2 acquisition by implicit means alone is limited in its success. Although L2 learners are surrounded by language, not all of it 'goes in'. This is Corder's distinction between input, the available target language, and intake, that subset of input that actually gets in and which the learner utilizes in some way (Corder, 1967). Naturalistic L2 acquisition is typically much less successful than L1 acquisition. The crosslinguistic, longitudinal ESF research project (Perdue, 1993) examined how 40 adult learners picked up the language of their social environment by everyday communication. Analysis of the interlanguage of these L2 learners resulted in its being described as the 'Basic Variety'. All learners, independent of source language and target language, developed and used it, with about one-third of them fossilizing at this level in that although they learned more words, they did not further complexify their utterances in respects of morphology or syntax. In this Basic Variety, most lexical items stem from the target language, but they are uninflected. "There is no functional morphology. By far most lexical items correspond to nouns, verbs and adverbs; closed-class items, in particular determiners, subordinating elements, and prepositions, are rare, if present at all." "Note that there is no functional inflection whatsoever: no tense, no aspect, no mood, no agreement, no casemarking, no gender assignment; nor are there, for example, any expletive elements" (Klein, 1998, pp. 544–545). These grammatical functors abound in the input, but they are simply not picked up by many naturalistic L2 learners.

The L2 learning literature, rife with such demonstrations of how years of input can fail to become intake, shows that implicit tallying does not take place for low salient cues for which pattern recognition units have never been consolidated. N. C. Ellis (2006b) analyzed these cases where input fails to become L2 intake and describes how 'learned attention,' a key concept in contemporary associative and connectionist theories of animal and human learning, explains these effects. Fluent native language processing is automatized and unconscious. Thousands of hours of L1 processing tunes the system to the cues of the L1 and automatizes their production and recognition. It is impressive how rapidly we start tuning into to our ambient language and disregarding cues that are not relevant to them (Kuhl, 2004). High frequency grammatical words and morphemes thus become produced more quickly over time, and they shorten and become less salient in the speech stream. This doesn't matter for L1 hearers, because they are also automatized in their recognition – they know the functors are there and process them by top-down, expectation-driven means. But it makes these low salience cues very difficult for L2 learners to perceive, analyze, and figure, especially in a rich discourse input where there are other more salient and

more reliable cues which make morphology redundant. The successes of L1 acquisition and the limitations of L2 acquisition both derive from the same basic learning principles. The fragile features of L2 acquisition are those which, however available, fall short of intake because of one of the factors of salience, interference, overshadowing, blocking, contingency, cue competition, or perceptual learning, all shaped by the L1 (N. C. Ellis, 2006b).

Blocking, a phenomenon of learned attention, pervades second language acquisition. Cues are present in the input but they are blocked from intake by learned attention. Our recent program of experimental research helps clarify the dynamic learning processes that underpin this phenomenon (N. C. Ellis et al. 2013; N. C. Ellis & Sagarra, 2010a, 2010b, 2011; Sagarra & Ellis, in press). Nevertheless, the importance of transfer has ever been a mainstay in SLA theory: Lado's theory of second language learning, built upon the behaviorist principles of learning (including the fundamental principle of contiguity, the law of exercise, the law of intensity, the law of assimilation, and the law of effect), was that grammatical structure is a system of habits (Lado, 1957, p. 57; 1964, pp. 37–45). In this view, acquisition is the learning of patterns of expression, content, and their association, a concept closely akin to that of constructions as described in Section 1, and because all experiences leave a trace in the memory store, all previous experiences are a factor, either facilitating or inhibiting the learning of a new language. Hence Lado's emphasis on transfer and the later development of Contrastive Analysis (C. James, 1980).

Explicit language learning

Learned attention limits the potential of implicit learning, and that is why explicit learning is necessary in L2 acquisition. "To the extent that language processing is based on frequency and probabilistic knowledge, language learning is implicit learning. This does NOT deny the importance of noticing (Schmidt, 1990) in the initial registration of a pattern recognition unit, NOR does it deny a role for explicit instruction. Language acquisition can be speeded by explicit instruction. The last 20 years of empirical investigations into the effectiveness of L2 instruction demonstrate that focused L2 instruction results in large target-oriented gains, that explicit types of instruction are more effective than implicit types, and that the effectiveness of L2 instruction is durable". (Ellis, 2002, p. 145).

In cases where linguistic form lacks perceptual salience and so goes unnoticed (Schmidt, 1990, 2001) by learners, or where the L2 semantic/pragmatic concepts to be mapped onto the L2 forms are unfamiliar, additional attention is necessary in order for the relevant associations to be learned. In order to counteract the L1 attentional biases to allow implicit estimation procedures to optimize induction, all of the L2

input needs to be made to count (as it does in L1 acquisition), not just the restricted sample typical of the biased intake of L2 acquisition. Reviews of the experimental and quasi-experimental investigations into the effectiveness of instruction and feedback on error (Doughty & Williams, 1998; N. C. Ellis & Laporte, 1997; R. Ellis, 2001, 2008, this volume; Hulstijn & DeKeyser, 1997; Li, 2010; Lightbown et al. 1993; Long, 2006, Chapter 5; Norris & Ortega, 2000, 2006; Spada, 1997, 2011; Spada & Tomita, 2010) demonstrate that form-focused L2 instruction results in substantial target-oriented gains, that explicit types of instruction are more effective than implicit types, and that the effectiveness of L2 instruction is durable.

Form-focused instruction can help to achieve this by recruiting learners' explicit, conscious processing to allow them to consolidate unitized form-function bindings of novel L2 constructions (N. C. Ellis, 2005). Once a construction has been represented in this way, its use in subsequent implicit processing can update the statistical tallying of its frequency of usage and probabilities of form-function mapping.

Ellis (2005) reviews the instructional, psychological, epistemological, social, and neurological dynamics of the interface by which explicit knowledge of form-meaning associations impacts upon implicit language learning. "The interface is dynamic: It happens transiently during conscious processing, but the influence upon implicit cognition endures thereafter. The primary conscious involvement in L2 acquisition is the explicit learning involved in the initial registration of pattern recognizers for constructions that are then tuned and integrated into the system by implicit learning during subsequent input processing. Neural systems in the prefrontal cortex involved in working memory provide attentional selection, perceptual integration, and the unification of consciousness. Neural systems in the hippocampus then bind these disparate cortical representations into unitary episodic representations. These are the mechanisms by which Schmidt's (1990) *noticing* helps solve Quine's (1960) problem of referential indeterminacy. Explicit memories can also guide the conscious building of novel linguistic utterances through processes of analogy. Formulas, slot-and-frame patterns, drills, and declarative pedagogical grammar rules all contribute to the conscious creation of utterances whose subsequent usage promotes implicit learning and proceduralization. Flawed output can prompt focused feedback by way of recasts that present learners with psycholinguistic data ready for explicit analysis" (Ellis, 2005, p. 305).

Implicit AND explicit language learning

So I believe that learners' language systematicity emerges from their history of interactions of implicit and explicit language learning, from the statistical abstraction of patterns latent within and across form and function in language usage. The complex

adaptive system (N. C. Ellis & Larsen-Freeman, 2009b) of interactions within AND across form and function is far richer than that emergent from implicit *or* explicit learning alone. This is true too in neurobiology, and it also applies both in synchronic usage and in diachronic language change. Interactions of conscious and unconscious learning processes play roles at all of these emergent levels:

The neurobiology of language learning

Global Workspace Theory (Baars, 1988) and parallel research into the neural correlates of consciousness (NCC) (Koch, 2004), illuminates the mechanisms by which the brain interfaces functionally and anatomically independent implicit and explicit memory systems involved variously in motoric, auditory, emotive, or visual processing, and in declarative, analogue, perceptual or procedural memories, despite their different modes of processing which bear upon representations and entities of very different natures (Berntson & Cacioppo, 2009; Voss & Paller, 2008). Biological adaptations tend to be accretive (Gould, 1982). The speech system, for example, is overlaid on a set of organs that in earlier mammals supports breathing, eating, and simple vocalization. Language is overlaid upon systems for the visual representation of the world. Yet however different are the symbolic representations of language and the analogue representations of vision, they do interact so that through language we create mental images in our listeners that might normally be produced only by the memory of events as recorded and integrated by the sensory and perceptual systems of the brain (Jerison, 1976). Likewise, it may be that the global broadcasting property of the consciousness system is overlaid on earlier functions that are primarily sensori-motor. In his major review culminating a lifetime's pioneering work in human neuropsychology, Luria (1973), having separately analyzed the workings of the three principal functional units of the brain (the unit for regulating tone or waking, the unit for obtaining, processing, and storing information, and the unit for programming, regulating and verifying mental activity), emphasized that it would be a mistake to imagine that each of these units carry out their activity independently: "Each form of conscious activity is always a *complex functional system* and takes place through the *combined working of all three brain units*, each of which makes its own contribution… *all three principal functional brain units work concertedly*, and it is only by studying their interactions when each unit makes its own specific contribution, that an insight can be obtained into the nature of the cerebral mechanisms of mental activity" (pp. 99–101, italics in original).

Language representation in the brain involves specialized localized modules, largely implicit in their operation, collaborating via long-range associations in dynamic coalitions of cell assemblies representing, among others, the phonological forms of words and constructions and their sensory and motor groundings (Barsalou, 1999;

Pulvermüller, 1999, 2003). The interactions of these networks underlie implicit and explicit language use, and the dynamics of implicit and explicit language use in turn affects the development, consolidation, and connectivity of these neurological systems (Paradis, 2004).

Synchronic language usage

Conscious and unconscious processes similarly affect the dance of dialogue in the way in which native conversation partners align perspectives and means of linguistic expression (Garrod & Pickering, 2004; Pickering & Garrod, 2004). "The cognitive processes which compute symbolic constructions are embodied, attentionally- and socially-gated, conscious, dialogic, interactive, situated, and cultured." (N. C. Ellis, 2008c, p. 36). Language is a distributed emergent phenomenon. People and language create each other, grow from each other, and change and act under the influence of the other. Language and cognition are mutually inextricable; they determine each other. Language has come to represent the world as we know it; it is grounded in our perceptual experience. Language is used to organize, process, and convey information, from one person to another, from one embodied mind to another. Learning language involves determining structure from usage and this, like learning about all other aspects of the world, involves the full scope of cognition: the remembering of utterances and episodes, the categorization of experience, the determination of patterns among and between stimuli, the generalization of conceptual schema and prototypes from exemplars, and the use of cognitive models, metaphors, analogies, and images in thinking. Language is used to focus the listener's attention to the world; it can foreground different elements in the theatre of consciousness to potentially relate many different stories and perspectives about the same scene. What is attended focuses learning, and so attention controls the acquisition of language itself. The functions of language in discourse determine its usage and learning. Language use, language change, language acquisition, and language structure are similarly inseparable. There is nothing that so well characterizes human social action as language.

Understanding these interactions is at the heart of usage-based approaches to language acquisition (Barlow & Kemmer, 2000; Behrens, 2009; Bybee, 2010; N. C. Ellis & Cadierno, 2009; Langacker, 2000; Robinson & Ellis, 2008).

Diachronic language change

These factors play out into the structure of language and how it changes too. Ellis (2008a) outlines an emergentist account whereby "the limited end-state typical of adult second language learners results from dynamic cycles of language use, language change, language perception, and language learning in the interactions of members of language communities. In summary, the major processes are:

1. *Usage leads to change*: High frequency use of grammatical functors causes their phonological erosion and homonymy.
2. *Change affects perception:* Phonologically reduced cues are hard to perceive.
3. *Perception affects learning*: Low salience cues are difficult to learn, as are homonymous/polysemous constructions because of the low contingency of their form-function association.
4. *Learning affects usage:* (i) Where language is predominantly learned naturalistically by adults without any form-focus, a typical result is a Basic Variety of interlanguage, low in grammatical complexity but reasonably communicatively effective. Because *usage leads to change*, maximum contact languages learned naturalistically can thus simplify and lose grammatical intricacies. Alternatively, (ii) where there are efforts promoting formal accuracy, the attractor state of the Basic Variety can be escaped by means of dialectic forces, socially recruited, involving the dynamics of learner consciousness, form-focused attention, and explicit learning. Such influences promote language maintenance." (N. C. Ellis, 2008a, p. 232).

Language as a complex dynamic system

These interactions make it clear that implicit and explicit language learning and usage are constant currents in the dynamics of language, and why therefore it is necessary to study language as a complex adaptive system (Beckner et al. 2009; N. C. Ellis, 2007; N. C. Ellis & Larsen-Freeman, 2006, 2009b; Larsen-Freeman, 1997). Understanding the dynamic interactions of implicit and explicit knowledge and their synergy in development are major priorities for future research. We traditionally divide linguistic structure up into units at different levels – into phonemes, syllables, morphemes, words, syntactic rules, sentences, etc. Construction grammar blurs these boundaries and sees no hard-fast distinction between these levels or between the mechanisms of their acquisition or processing (Goldberg, 2003, 2008; Trousdale & Hoffmann, 2013). Nevertheless, emergent and dynamic systems approaches emphasize that we should focus our attention as much on process as on structure, on linguistic construction as much as linguistic constructions (N. C. Ellis, 1998, 2007, 2011; Elman, 2004). This has a noble tradition as well. William James emphasized the stream of thought: "The traditional psychology talks like one who should say a river consists of nothing but pailsful, spoonsful, quartpotsful, barrelsful, and other moulded forms of water. Even were the pails and the pots all actually standing in the stream, still between them the free water would continue to flow. It is just this free water of consciousness that psychologists resolutely overlook. Every definite image in the mind is steeped and dyed in the free water that flows round it. With it goes the sense of its relations, near and remote, the dying echo of whence it came to us, the dawning sense of whither it is to lead." (W. James, 1890, p. 255).

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