

# COGNITIVE UNDERPINNINGS OF FOCUS ON FORM<sup>1</sup>

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## INTRODUCTION

The purpose of this paper is to examine focus on form in cognitive processing terms by postulating plausible, psychologically real, cognitive correlates for a range of L2 learning processes that have become prevalent in the instructed second language acquisition (SLA) literature. Progress in adult SLA is thought often to depend crucially upon cognitive processes such as paying attention to features of target input, noticing interlocutor reactions to interlanguage output, and making insightful comparisons involving differences between input and output utterance details. To be effective, these cognitive comparisons must be carried out under certain conditions of processing meaning, forms, and function, i.e., conditions which promote *processing for language learning*. Whereas pedagogically oriented discussions of issues—such as noticing the gap and L2 processing—abound, psycholinguistically motivated rationales for pedagogical recommendations are still rare.

Focus on form is proposed as an instructional expedient for addressing pervasive, systematic, remediable or persistent L2 learning problems (Long, 1991); for instance, pervasiveness and systematicity as evidenced in emerged L2 developmental errors, persistence as evidenced in the less-than-targetlike production of advanced immersion learners (Doughty & Williams, 1998b; Long, 1991; Long & Robinson, 1998), and remediability in the sense of not already fundamentally determined by immutable acquisition processes (Long, 1991; Pienemann, 1989). Such pedagogical intervention is claimed to be more effective and efficient than would be leaving learners to their own devices to solve these L2 problems (Doughty & Williams, 1998c). Although, in general, these focus-on-form recommendations make pedagogical sense and are consistent overall with findings of second language acquisition research, I believe that particular focus-on-form constructs, as expressed in pedagogical terms, are in need of greater scrutiny in cognitive processing terms in order to ascertain the validity of the intuitive

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recommendations and to inform more specific decisions, such as determining when best to “intrude” into the ordinary language processing by the L2 learner.

The organization of the paper is as follows. First, four definitions of focus on form are examined with a view to identifying the likely-to-be integral cognitive constructs, for instance, cognitive *microprocesses*, such as working memory and noticing; cognitive *macroprocesses*, such as input processing, output production; and cognitive *resources* such as the long-term memory mental representation of the learner’s developing interlanguage (IL) knowledge. Next, a consideration of two schematic models (Figures 1 & 2)—one of memory and one of speech processing—is undertaken to facilitate discussion of determining the optimal points of intervention for focus on form. Throughout the examination of definitions and models, the cognitive correlates of focus on form are identified—see underlined terms—and then cumulatively represented in Figure 3. The discussion then turns briefly to a set of specific pedagogical recommendations before finally taking up, in cognitive terms, three fundamental issues concerning the feasibility and timing of recommended focus-on-form interventions: *the noticing issue*, *the interruption issue*, and *the timing issue*.

1. *The noticing issue*: Do learners have the cognitive resources to notice the gap between their IL utterances and the TL utterances around them?
2. *The interruption issue*: Is a pedagogical intervention that does not interrupt the learner’s own processing for language learning even possible?
3. *The timing issue*: If so, then precisely “when,” in cognitive terms, should the pedagogical intervention occur?

### ***Pedagogical Definitions of Focus on Form***

Of the four definitions of focus on form cited below, the first is the original theoretical construct, and the second is an operational definition derived from that construct:

1. “...focus on form...overtly draws students’ attention to linguistic elements as they arise incidentally in lessons whose overriding focus is on meaning or communication.” (Long, 1991, pp. 45-46)
2. “focus on form involves...an occasional shift in attention to linguistic code features—by the teacher and/or one or more students—triggered by perceived problems with comprehension or production” (Long & Robinson, 1998, p. 23).

From both the theoretical and the operational definition, it is clear that the key cognitive construct in focus on form is focus, or more specifically, selective attention (for further discussion, see Long & Robinson, 1998). In the second pedagogical definition, Long and

Robinson (1998) suggest that any shift of attention from meaning processing to forms processing should be a brief response to problems in on-line communication. Similarly, Lightbown (1998) and Doughty and Williams (1998c) recommend further that the pedagogical intervention should not interrupt language use, or, stated in cognitive terms, that the teaching intervention should not interfere with the larger macroprocessing involved in speech comprehension or production (Doughty & Williams, 1998b; Lightbown, 1998).

The third and fourth definitions cited below have recently been proposed in order to clarify the crucial difference between the more cognitively integrated microprocess, focus on form, in comparison both with the more circumscribed microprocess known as focus on forms, involving explicit learning (often, in practice, time-consuming metalinguistic learning), and the more global macroprocess, focus on meaning, involving experiential learning. (See also Long, 1998) The phrase *form-focused instruction* (see definition 3), ever problematic in the literature, encompasses *both* focus on forms and focus on form (Doughty & Williams, 1998b). As shown in definition 4, however, whereas focus on form entails focus on forms, the reverse cannot be true.

3. *form-focused instruction* is "any pedagogical effort which is used to draw the learners' attention to language form either implicitly or explicitly. This can include the direct teaching of language (e.g., through grammatical rules) and/or reactions to learners' errors (e.g., corrective feedback)...The essential difference [between form-focused instruction and focus on form]...is that Long's definition of *focus on form* is restricted to meaning-based pedagogical events in which attention is drawn to language as a perceived need arises rather than in predetermined ways." (Spada, 1997, p. 73)
4. "focus on forms and focus on form are *not* polar opposites in the way that 'form' and 'meaning' have often been considered to be. Rather, a focus on form *entails* a focus on formal elements of language, whereas focus on forms is *limited to* such a focus, and focus on meaning *excludes* it. Most important, it should be kept in mind that the fundamental assumption of focus-on-form instruction is that meaning and use must already be evident to the learner at the time that attention is drawn to the linguistic apparatus needed to get the meaning across." (Doughty & Williams, 1998a, p. 4).

Taken together, these four definitional proposals point to the importance of what happens uniquely in working memory during focus on form. In other words, the factor that consistently distinguishes focus on form from the other pedagogical approaches is the requirement that focus on form involves learners' briefly and perhaps simultaneously

attending to form, meaning, and use during one cognitive event. This kind of joint processing is claimed to facilitate the cognitive mapping among forms, meaning and use that is fundamental to language learning. It is the overall purpose of this paper to try to examine the nature of joint processing in working memory and to specify the kinds of pedagogical interventions that potentially can facilitate it.

### *Cognitive Correlates of the Components of Focus on Form*

**Memory and speech processing.** It goes almost without saying that, to be comprehended, produced and/or acquired, language must be cognitively processed. However, the details of this are little understood and enormously complex, involving automatic, invariant processes as well as processes that are attuned to the conditions (both cognitive and social) under which the language input is being processed. Focus-on-form procedures potentially *can* influence any of these processes, but probably *will* do so only if the intervention conforms sufficiently with the nature of the language encoding underway (where encoding refers to the transformation of linguistic information at one stage of processing for use in the next) and *will* do so only if the intervention manages not to disrupt or halt the fundamental and ongoing cognitive macroprocessing that comprises comprehension and production.<sup>2</sup>

To understand these issues further, it will be useful to examine two essential cognitive constructs—memory and speech processing—though an exhaustive consideration of these is well beyond the scope of this paper. Nevertheless, some explication of the constructs as represented in the two models shown in Figures 1 and 2, taken in conjunction, is needed to enable the identification of potentially optimal intervention points for focus on form during particular cognitive processes or events. In different ways, both of these models depict the manner in which language input is encoded when going either from thought to speech, as in production, or from speech to understanding, as in comprehension. Together, the models schematize the cognitive resources that are utilized along the way. Figure 1 emphasizes the contribution of memory to language processing (Cowan, 1996), and Figure 2 provides considerable detail regarding the nature of the language encoding that is carried out at each stage of processing (Levelt, 1993).

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<sup>2</sup> For example, when the learner is encoding a message for production, if the teacher were to interrupt the learner's utterance with a correction, the utterance encoding would likely breakdown completely at that point of intervention. On the other hand, if the teacher were to provide an unobtrusive backchannel, any new linguistic information could potentially be integrated to the speech plan in progress.

Figure 1

*Memory in Language Processing (adapted from Cowan, 1997)*

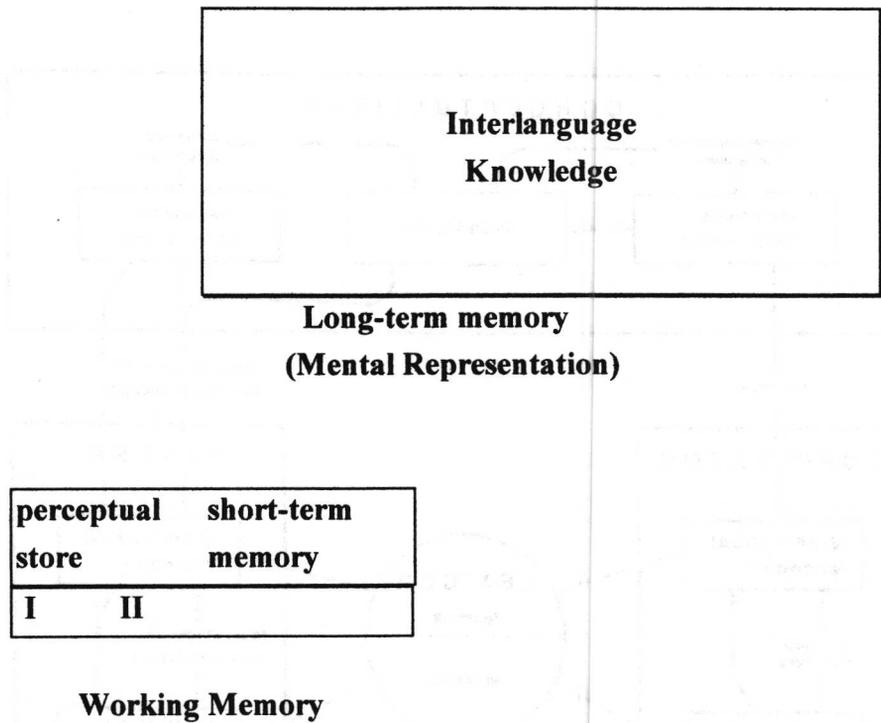
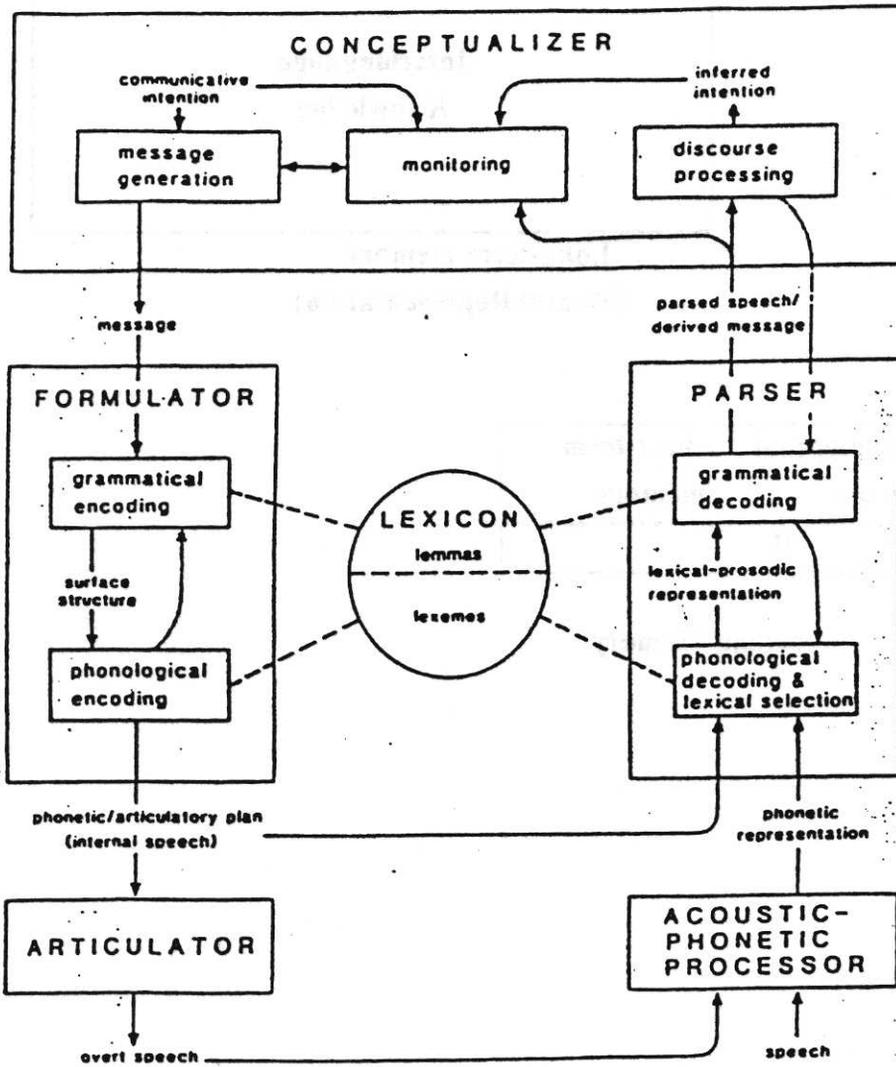


Figure 2

*Levelt's (1993) Production Model*

As can be seen in Figure 1, working memory consists of a perceptual store for initial and rather automatic acoustic processing. Once the input is encoded acoustically, it then passes to the short-term memory store for further encoding. Rather than being in linear alignment as in earlier models of memory and processing (e.g., Baddeley, 1986; Broadbent, 1984), the current psycholinguistic conceptualization of working memory is one of a presently activated segment of long-term memory (Cowan, 1988, 1993, 1997). In this conceptualization, the contribution to processing for language learning of already stored knowledge can be accounted for, since new information encoding processes have continual access to (activated) IL mental representations from long-term memory.

Figure 2, which is Levelt's well known and generally accepted speech processing model (Dell & O'Seaghda, 1992; Levelt, 1989, 1992), shows that language can be processed on an incoming basis (as in the cognitive macroprocesses involved in comprehension, for instance during listening and reading); and/or on an outgoing basis (as in the cognitive macroprocesses in production, for instance during speaking and writing). Applying and modifying the two models to handle the case of processing for language learning, first on the incoming, comprehension basis, it can be seen that language input is encoded roughly in the following ways (and see the right side of Figure 2, working up from the bottom):

1. Input moves from the environment into the perceptual store of working memory via acoustic phonetic encoding.
2. Acoustically processed input moves into the short-term store via a little understood process of analysis. The input in the short-term store is available for use by comprehension and/or learning processes.
3. During comprehension, input is parsed via phonological decoding (where decoding refers essentially to encoding on an incoming basis), lexical selection, and grammatical decoding. During interlanguage development, internalization of new input and mapping processes are continually underway. In Levelt's terms, new lemmas<sup>3</sup> are being constructed in the IL lexicon.
4. Parsed speech is understood via processes that utilize discourse knowledge and encyclopedic knowledge as resources and speech plan monitoring to check for success of processing at earlier stages.
5. During IL development, offline restructuring of the mental representation of IL knowledge is continually underway. New forms-meaning-function mappings are made, and existing ones are fine-tuned in accordance with the linguistic evidence in

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<sup>3</sup> Lemmas are similar to subcategorization frames for constituents in generative grammars and to lexical entries in lexical-functional grammars.

the input. As for processing for language learning, on a moment-to-moment basis, cognitive comparisons of input, internal representations, and output can be made.

Sometimes these comparisons can result in new insights.

On the outgoing, production basis, speech is processed roughly in the following ways (see the left side of Figure 2, moving from the top down, this time):

1. The conceptual content of a speech act is planned. Concepts (ideas) are then moved to the utterance formulator via message generation involving encoding into propositions.
2. Propositional messages are moved to the articulator via formulation, which involves grammatical and then phonological encoding, resulting in an internal, partially encoded speech plan.
3. Internally formulated utterances are moved to the environment (i.e., "produced") via phonetic encoding and articulatory processes.
4. Simultaneously, the internal speech plans are returned to the conceptualizer for monitoring of the degree of success of the conceptualization, formulation and articulation of the message intent, in light of the relevant discourse and encyclopedic knowledge of the speaker.
5. In processing for language learning, a special kind of monitoring involving cognitive comparisons of the intention, the input, and the output is sometimes engaged in. Such comparisons are made in the short-term memory store.

It is important to note that, while these models of memory and speech processing are represented separately, any and all of these cognitive forces are or can be simultaneous in operation during speech processing. Crucially, the extent to which they interact becomes an important issue to consider in planning any pedagogical intervention.

The processes and memory resources that are involved in processing language for comprehension, for production, and for learning are grouped together in Figure 3 in columns opposite their focus-on-form pedagogical counterparts. Some of these cognitive processes are the continual, more or less automatic macroprocesses of interlanguage development, such as internalization of input, mapping, analysis, and restructuring. Others are shorter-term, sometimes momentary, cognitive microprocesses, such as selective attention, cognitive comparison, and focus on form. The key question for focus-on-form pedagogical intervention is whether the latter can have any significant effect on the former.

Figure 3  
*The Cognitive Correlates of Focus on Form*

Focus-on-form concepts	Cognitive correlates
<b>1. Micro-processes</b>	
Focus	Selective attention, expectation, orientation
Focus on form (by learner)	Simultaneous processing of forms, meaning, and use in working memory
Focus on forms	Explicit learning (often metalinguistic in practice)
Noticing the gap	Detection, cognitive comparison
Focus-on-form, pedagogical intervention (by teacher or another learner)	Cognitive "intrusion," directing or attracting attention
<b>2. Macroprocesses</b>	
Focus on meaning	Implicit (experiential) learning
Processing for language learning (Intake)	Segmentation, acoustic, lexico-semantic, syntactic encoding; abstraction; monitoring; planning; rehearsal; memory search
Language use	Speech processing, i.e., production, comprehension
Language learning	Mapping among forms, meaning, and use
Interlanguage development	Internalization of input, analysis, restructuring
<b>3. Resources</b>	
Interlanguage knowledge	Mental representation in long-term memory
World knowledge	Discourse and encyclopedic knowledge

**Macroprocessing and focus on form.** Taking the case of cognitive macroprocessing first, it is generally agreed among applied linguists that the default mode is processing for meaning.<sup>4</sup> Insofar as the meaning is clear to the learner, and the language forms that encode the meaning have already been acquired, then, typically, it is hypothesized, no other processing mode is necessary<sup>5</sup> (VanPatten, 1989, 1990). When the language being processed is beyond the learner's L2 ability, then processing for language learning is possible. Processing for language learning has been discussed in a number of, by now, familiar ways in the SLA literature. Three well-known examples are found in discussions of the notions of intake for acquisition (Corder, 1967), processing instruction (VanPatten, 1995), and *i + 1* input comprehension (Krashen, 1982).

In cognitive processing models of SLA, intake is defined as that portion of the available input that is selectively attended to and extracted from the stream of speech for further processing (Corder, 1967; Leow, 1993, Sharwood-Smith, 1985; VanPatten, 1995). Specifically, this extraction requires the segmentation and selection from the stream of speech of those "bits" of language that are morpho-phonologically and/or semantically salient. Among other cognitive operating principles proposed for first language acquisition, Slobin (1985) defines an extraction operating principle called OP (Attention) Sounds: Store any perceptually salient stretches of speech. To accomplish this, learners extract chunks that are larger than words at first (i.e., chunking), but eventually component words and morphemes also become perceptually salient. At the word level, morphemes located in word-final position are perceptually most salient to learners, followed by stressed morphemes, and finally, preposed morphemes (Slobin, 1985). Hardest to perceive and, therefore, not likely to readily become intake are bound, contracted, unstressed, asyllabic, and allophonic morphemes (Slobin, 1985). An example of semantic transparency during interlanguage development may be found in Zobl's (1982) discussion of the acquisition of English articles by an L1 Chinese speaker, a case of zero contrast, i.e., in which the L1 does not have a structure analogous to the target. The L1 Chinese speaker is forced by the zero contrast to employ a basic developmental form. The data reveal that the learner selects a deictic form to be used in the context of the definite article. Zobl (1982, p. 178) argues that

[t]he use of deictic forms as an initial approximation to the definite article represents an extension of the developmental continuum.... One can say that zero contrast obliges the Chinese child to begin the continuum with a more basic developmental structure. This means that the semantic motivation on the form is more transparent.

<sup>4</sup> It should be noted, however, that, on the basis of findings of brain imaging studies, some cognitive scientists assume the opposite. That is, the default language processing mode is considered to be primarily syntactic in nature.





1984). Furthermore, no cognitive mechanisms for the conversion of comprehended *i + 1* input into IL mental representation are proposed. And finally, the overemphasis on meaningful and extralinguistic contexts overstates the value of simplified input in solving the problem of the acquisition of formal features of language (White, 1987).

Inherent in all three of the above notions of processing for language learning is an assumption that the learner is somehow utilizing the input such that the input details which are processible become integrated into the IL system. To make any progress in our understanding of SLA, however, any cognitive theory of such processes is in need of far greater specification. For instance, whereas intake processes are dependent upon the quality of the input vis à vis the learner's IL ability, other integrative cognitive macroprocesses, such as analysis, mapping, and restructuring (see 2 in Figure 3), are thought to be automatic in the sense that they are continually in operation regardless of the fluctuations of the quality of the input in the linguistic environment.

Little is known about these invisible, mysterious cognitive macroprocesses. Nonetheless, there are a number of important theoretical proposals concerning the nature of analysis, mapping, and restructuring. According to Bialystok (1994, p. 561) who has been developing her theoretical model of SLA for two decades,

Analysis is the process by which linguistic and conceptual representations become more explicit, more structured, and more accessible to inspection.

Analysis proceeds on implicit unstructured representations and converts them to an increasingly explicit form. This process uncovers the basic categories of knowledge and is similar to what Bowerman (1987) calls "off-line" change. It is the means by which cognitive processes are responsible for altering mental concepts of grammar in the absence of any ongoing input or correction.

Mapping is a key component of analysis. For L1 learning, Slobin (1985) has hypothesized that children engage in mapping basic cognitive notions onto a fixed set of phonological forms, which they extract from the input. For instance, children consistently interpret the highlights of scenes around them as prototypically involving agents, actions, objects, patients, figures, ground, etc. Three examples of this are (a) the manipulative activity scene (Agent/Object), (b) the object transfer scene (Figure/Ground), and (c) the object placement scene (Figure/Ground) (Slobin, 1985). In the prototypical manipulative activity scene through which the child acquires the grammatical notions of transitivity and causality, the Agent (usually the child using his own hands) and the Object (the physical object manipulated by the child) are cognitively salient. The object-salient scenes both involve Figure and Ground and enable the child to acquire semantic notions like location,

path, direction, etc. The basic figure-ground scene has been described as follows:

- The Figure is a MOVING or conceptually MOVEABLE object whose site, path, or orientation is conceived as a variable the particular value of which is the salient issue.
- The Ground is a reference object (itself having a stationary setting within a reference frame) with respect to which the Figure's site, path, or orientation receives characterization. (Talmy, 1983, as cited in Slobin, 1985, p. 1178)

Slobin assumes that the scene information that is stored during input processing has to be stored in such a way that permits mapping of extracted phonological forms and salient scene highlights. What ensures the mapping of forms to meaning and grammatical functions is the support of the physical context, as can be seen in the following examples:

1. That's good. Give the ball to Mommy. (Agent/Object; transitivity)
2. Look, the ball is rolling away! (Object placement; location)
3. Look, the ball is rolling to Mommy! (Object transfer; location)

In support of this proposal, a study comparing the processing of event representations during interaction in familiar vs. unfamiliar events demonstrated via lexical and grammatical measures that language acquisition is facilitated only by familiar events (Farrar, Friend, & Forbes, 1993). Similarly, Barton and Tomasello (1991) have shown that actions that are jointly attended to by mother and child, as measured by eye gaze, influence the order of acquisition of the verb types involved.

Although Slobin's proposals for mapping and storage cognitive operating principles are complex (and not without their critics; see Bowerman, 1987), several are shown in Figure 5 to illustrate the (as yet theoretical) mapping construct. Whether these particular formulations of the mapping macroprocess can be considered valid need not concern us excessively here. Underlying this account of mapping is an assumption that language learners are predisposed to systematization. This systematization involves an expectation for meaning and function and that these should be mapped in some organized fashion onto forms. This view is generally held by cognitive SLA researchers, with the caveat, of course, that adults are not developing the bulk of the cognitive notions contemporaneously with forms-function-meaning mapping as are children.

Figure 5

*Cognitive Mapping Principles (based on Slobin, 1985, appendix)*

**OP(MAPPING): CONTENT WORDS AND ROUTINES**

Look for prototypical activities and interactions (predisposition). Assume that all words are content words, holophrases, or interactional routines. Continually try to assign new strings to content words.

**OP(MAPPING): DICTIONARY**

Store the meaning in conjunction with some representation of the context in which the item was encountered.

**OP(MAPPING): FUNCTIONS**

Map the leftover bit to an accessible grammaticizable notion that is related to the nearest referential words.

**OP(MAPPING): EXTENSION**

When you figure something out, try to map it to all members of that word class.

**OP(MAPPING): AFFIX-CHECKING**

Do not add an affix to a word that already appears to have one.

**OP(MAPPING)**

If you discover that a form expresses two closely related but distinguishable notions, use available means in your language to mark the two notions distinctly.

**OP(MAPPING): ANALYTIC FORM**

If you discover that a complex notion can be expressed by a single, unitary form (synthetic) or by a combination of several separate forms (Analysis), prefer the analytic form.

**OP(MAPPING): VARIABLE WORD ORDER**

If you find more than one word order for a clause type, attempt to find a distinct function for each order.

Perhaps the most cogent discussion of operating principles for SLA is found in Andersen's (1989) cognitive-interactionist theory of SLA, in which he discusses the processes of mapping (as one of the composite of processes involved in "nativization") and restructuring (which he calls "denativization") in an attempt to explain variation in SLA. Andersen divides a set of 12 cognitive operating principles for SLA into two groups: "Basic psycholinguistic processes of perception and storage," and "Additional principles," which have the first set as prerequisites (see Figure 6).

Figure 6

*12 Cognitive Operating Principles in SLA (adapted from Andersen, 1989, pp. 50-56)*

*Basic psycholinguistic processes of perception and storage*

1. Attention (sounds): Store any perceptually salient stretches of speech (Slobin 1985, p.1165).
2. Attention (stress): Pay attention to stressed syllables in extracted speech units. Store such syllables separately and also in relation to the units with which they occur. (Slobin 1985, p. 1166).
3. Storage (frequency): Keep track of the frequency of occurrence of every unit and pattern that you store (Slobin 1985, p. 1166).
4. Storage (units): Determine whether a newly extracted stretch of speech seems to be the same as or different from anything you have already stored. If it is different, store it separately; if it is the same, take note of this sameness by increasing its frequency count by one.

*Additional principles*

5. The one-to-one principle: An interlanguage system should be constructed in such a way that an intended underlying meaning is expressed with one clear invariant surface form (or construction). (Andersen, 1984, p. 79).
6. The multifunctionality principle: 9a) Where there is clear evidence in the input that more than one form marks the meaning conveyed by only one form in the interlanguage, try to discover the distribution and additional meaning (if any) of the new form. (b) Where there is evidence in the input that an interlanguage form conveys only one of the meanings that the same form has in the input, try to discover the additional meanings of the form in the input.
7. Formal determinism: When the form:meaning relationship is clearly and uniformly encoded in the input, the learner will discover it earlier than other form:meaning relationships and will incorporate it more consistently within his interlanguage system.
8. Distributional bias: If both X and Y can occur in the same environments A and B, but a bias in the distribution of X and Y makes it appear that X only occurs in environment A and Y only occurs in environment B, when you acquire X and Y, restrict X to environment A and Y to environment B.
9. Relevance: OP (Position): relevance. If two or more functors apply to a content word, try to place them so that the more relevant the meaning of a functor is to the meaning of the content work, the closer it is placed to the content word. If you find that a Notion is marked in several places, at first mark it only in the position closest to the relevant content word. (Slobin 1985, p. 1255).
10. Constituent structure: (a) When a new form is incorporated into your interlanguage system, place it within the existing constituent structure of that system.
11. Transfer to somewhere: A grammatical form of structure will occur consistently and to a significant extent in the interlanguage as a result of transfer if and only if (1) natural acquisitional principles are consistent with the L1 structure or (2) there already exists within the L2 input the potential for (mis)generalization from the input to produce the same form or structure. furthermore in such transfer preference is given in the resulting interlanguage to free, invariant, functionally simple morphemes which are congruent with the L1 and L2 (or there is

congruence between the L1 and natural acquisitional processes) and [to] morphemes [which] occur frequently in the L1 and/or the L2. (Andersen, 1983, p. 182).

12. Relexification: When you cannot perceive the structural pattern used by the language you are trying to acquire, use your native language structure with lexical items for the second language.

Andersen's approach was to adopt those of Slobin's operating principles which clearly provided insight into problems of SLA and then to postulate additional principles based on his own analysis of L2 data.<sup>7</sup> The case for the explanatory value of these twelve principles is made through examination of the well-documented developmental sequence for L2 negation, in which learners progress from sentence external negation, through pre-verbal negation, finally arriving at the targetlike, analyzed system for negation of main and auxiliary verbs (Cazden, Cancino, Rosansky, & Schumann, 1975; Schumann, 1978). Andersen demonstrates clearly how the details of the sequence can be explained on the basis of cognitive processing and mapping (see Andersen, 1989 for an extended discussion).

In their discussion of the complexity of mapping that is inherent in focus on form, Doughty and Williams recognize that the term *meaning*, which is often equated only with its lexical component, in fact, subsumes lexical, semantic and pragmatic meaning (see also Celce-Murcia, 1992; Larsen-Freeman, 1995). To be more precise, Doughty and Williams note that focus on form includes *forms*, *meaning* and *function* (or *use*), and, following Larsen-Freeman (1995), they illustrate the mapping involved in acquiring the form, meaning and function of the passive (see Figure 7), noting in particular that both meaning and function mapping elements are often overlooked in instruction.

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<sup>7</sup> Andersen explicitly rejects the criticisms leveled by a number of researchers against Slobin's operating principles as being a case of throwing the baby out with the bath water: "My position on this criticism is that rather than rejecting the OPs (with nothing comparable to replace them), we should work with them as they are and improve on them with further research. More important, however, it is quite possible—I would say probable—that the difficulties faced in testing some of the operating principles as well as the interrelatedness of certain of the principles with each other are the result of the complexity of language and human cognition, not necessarily a weakness in the operating principles themselves of the theoretical framework" (p. 61).

Figure 7

*Forms-Meaning-Function Mapping for English (Doughty & Williams, 1998c, pp. 244-245).*

*Examples*

- A. The bill was paid by the company.
- B. The wallet was stolen.
- C. The data were collected and analyzed.
- D. Spare toilet paper is stored here.
- E. A mistake was made.

*Forms*

[NP-theme] [Aux + Past Participle of Transitive Verb ([by + NP-Agent])]

*Meaning*

The events (the action expressed in the verb); the entities (the lexical meaning of nouns); and the semantic relations (Agent; Theme)

*Function*

Use when: theme is the topic (A, B); agent is unknown (D), agent is unimportant (C); want to conceal the agent (E).

Doughty and Williams suggest that the degree of effectiveness (especially over the long term) of focus on form, as measured by successful mapping leading to analysis, ultimately depends on the level of integration of the learner's attention to all three aspects of form, meaning, and function in the target language, although this dependence may be mediated in some ways by individual differences (see Sawyer & Ranta, in press)

Whereas the mapping component of analysis is continual and cumulative, the cognitive macroprocess of restructuring is a more insightful phase in analysis in which some aspect of knowledge suddenly becomes more efficient in mental representation. Abstract examples of restructuring in the psycholinguistic literature tend to be more mathematical than linguistic, but nonetheless serve to illustrate the construct (see Cheng, 1986). For instance, given current knowledge of the operation of addition, when faced with the problem of determining the total of a pair of twos, it is perfectly adequate to add the two numbers together. However, when faced with a pile of pennies, one might discover the principle of counting by even numbers, which subsumes increases of two (2, 4, 6, 8), thereby restructuring the totaling procedure according to this new knowledge of the principle of even numbers. Finally, when times tables are committed to memory, and the principle of multiplication is understood, the most efficient way to total a large number of pairs of things would be to retrieve the memorized formula ( $2 \times 10 = 20$ ).

In his most recent version of ACT theory (ACT-\*), Anderson discusses the difference between declarative rules and procedural rules—or what are now called production rules—providing another example, this time more language-based, of the process of restructuring. In this work, subjects are given examples of regular relationships and then are asked to solve problems involving this relationship (Anderson, Fincham, & Douglass, 1997). Each time a problem occurs, a subject has an opportunity to codify abstractly the relationship in the form of an initial coding which, according to Anderson et al., is declarative knowledge. An example (based on Anderson et al., 1997, p. 933) of such a *declarative encoding* would be:

Example: *Skydiving was practiced on Saturday at 5 p.m. and Monday at 4 p.m.*

Declarative

Rule: “The second day is 2 days later and 1 hour earlier than the first.”

After about fifty such examples, reaction times in problem solving show a directional asymmetry, which Anderson, et al. interpret as evidence of proceduralization (or what Anderson, 1982 called compilation), a process that results in a more efficient production rule<sup>8</sup> as follows:

Production

Rule: IF the question is about skydiving,  
and the second day is D2 and the second hour is H2,  
and D1 is two days before D2,  
and H1 is one hour after H2,  
THEN the first day is D1 and the first hour is H1

Inspired by Anderson’s ACT theory of learning, DeKeyser (1997) designed a computer-mediated investigation of the learning of an artificial language, Autopractan, (developed to instantiate testable language rules), in which it was demonstrated that “learning of second language grammar rules can proceed in very much the same way that learning in other cognitive domains from geometry to computer programming, has been shown to take place.” The evidence for this is found in examining the learning curves (as measured by reaction times at each experimental session) of subjects who participated in 15 sessions of instruction on four grammar rules and 32 vocabulary items. Results showed a dramatic decrease in reaction times between sessions one and two, followed by a continuing, very gradual reduction in reaction time. DeKeyser argues that this reflects, in the first instance, qualitative restructuring in which declarative knowledge becomes procedural knowledge and then, in the second instance, gradual automatization of the now restructured, procedural knowledge as a consequence of repeated practice. The latter

<sup>8</sup> Although the production rule appears to be more complex, it is more readily and automatically accessible during problem solving, as evidenced by faster reaction times and emerging asymmetry of the rule.

change is a quantitative one within the same knowledge components. (See also, DeKeyser, in press).

Leaving aside the proceduralization model for learning, another example of what is meant by the mysterious process of restructuring can be found by taking up, once again, Zobl's (1982) discussion of the effects of zero contrast on language transfer. To this, we can add the concept of congruence between the L1 and L2 and inspect the stages of the development of L2 English definite articles:

1. All learners go through a stage of absence of articles.
2. When the L1 matches the L2 (congruence), the category of article emerges quickly, but the competence is usually variable. When the L1 does not match the L2 (zero contrast), there will be a delay in the emergence of the category (and sometimes there is emergence of a more basic form, as discussed earlier in the case of Chinese L1 learners of English L2). Once emerged, competence is also variable for the zero contrast learners.
3. After the category has emerged, if there is congruence, it is not usual for a delay in restructuring to occur at this point, where restructuring refers to the sorting out of the variable competence in the category to match the details of L2 rather than the hypothesis of the L1. For example, Spanish L1 learners of English L2 quickly overgeneralize the definite article to all prenominal contexts, even to the nontargetlike abstract and generic contexts: this seems to delay restructuring. No such restructuring delay is experienced by learners whose L1 does not match the L2. Once they have noticed the category, albeit late, they may be in a better position to notice the distributional details and, hence, restructure and move to targetlike use faster than learners with L1-L2 congruence.
4. After restructuring, competence is less variable and more targetlike for both congruent and zero contrast learners.

Although fascinating, further discussion of the "off-line" changes that occur in mental representation—for present purposes, in interlanguage development—is beyond the scope of this paper, particularly given the still more or less theoretical status of this aspect of cognitive development (but see Karmillof-Smith, 1992 for detailed proposals). For present purposes, it should be sufficient to note that mapping, analysis, and restructuring appear to be both continually in operation and not subject to conscious reflection, although once the insight has occurred, the knowledge itself may become increasingly available for metalinguistic comment (Bialystok, 1994). Both of these observations, however tentative, may need to be taken account of in pedagogical considerations.

***Microprocesses and focus on form.*** Still other processes, such as selective attention, cognitive comparison, and focus on form, occur on a moment-to-moment basis, are dependent upon current processing conditions, and may be more accessible to conscious awareness, though obtaining reports thereof is notoriously difficult (see Jourdenais, 1998; in press). Whereas the cognitive macroprocesses discussed in the previous section are relatively automatic and inaccessible, moment-to-moment microprocessing, on the other hand, may be open to influence, for instance by a pedagogical intervention such as focus on form. Focus on form, (in this case, but not necessarily, a pedagogical intervention by the L2 teacher), appears in the box at the center of Figure 3 with the cognitive correlate of "cognitive intrusion" (Harley 1984). This term emphasizes that directing or attracting learner attention to formal features of language is potentially an intrusion on ordinary cognitive processing, which may or may not be advantageous, depending upon degree of intrusiveness or congruence with the processing underway (Doughty & Williams, 1998c). We will return to this issue later in a discussion of how to determine optimal language processing intervention points.

As noted briefly earlier, from the four definitions of focus on form that were examined at the outset of this paper, it is quite evident that the cognitive microprocess of selective attention is the key cognitive correlate in learner focus on form. A clear understanding of attention and its relationship to language encoding is fundamental to any discussion of the cognitive underpinnings of focus on form (see Schmidt, in press). The centrality of attention is also claimed by some for all aspects of second language acquisition (SLA). Schmidt, for example, holds the strongest version of the claim that attention is central (Schmidt, 1992, 1993, 1994, 1995, in press). Schmidt's Noticing Hypothesis states essentially that "learners need to pay attention to (and notice) details and differences in order to learn" (Schmidt, in press). For some fifteen years now, this crucial process of noticing details and differences has been referred to as *noticing the gap* (Schmidt & Frota, 1986; Swain, 1995), and by this is meant that learners must notice the difference between what they themselves can or have said (or even what they know they cannot say) and what it is that more competent speakers of the target language say instead to convey the same intention under the same social conditions.

For it to be cognitively possible for learners to notice gaps, they must have sufficient and coordinated working and long-term memory resources to enable the cognitive comparison of, on the one hand, their own interlanguage utterance or, on the other, a propositional message that could not be formulated into a speech plan for an utterance due to insufficient interlanguage knowledge, with the relevant data available from the contingent utterances of their more competent interlocutors. In other words, in the case

of a nontargetlike utterance, the learner would have to compare TL and IL differences (i.e., noticing mismatches), and in the case of an incomplete utterance, the learner would have to notice the additional linguistic material in the TL utterance which might have been relevant to the speech plan (i.e., noticing holes). The ability to make such a comparison suggests (a) that there is some continual relationship or connection between short term-memory and long-term memory as we have already seen in Figure 1 and (b) that working memory can hold more than the notorious seven bits of information (Miller, 1956).

In fact, as already noted in the discussion of Figure 2, recent studies of memory suggest that working memory is far more complex and integrated than held by earlier conceptualizations (see Broadbent, 1984 for the earlier view, and Cowan, 1992, 1993 for the updated view; see also Shiffrin, 1993 for a short commentary). Whereas earlier views depicted short-term memory as "either (1) the set of representations from long-term memory currently in a state of heightened activation OR (2) the focus of attention or the content of awareness," a more coherent view, according to Cowan (1993) would be to say that working memory involves both currently activated portions of long-term memory and attentional focus, arranged in a hierarchical fashion, with the focus of attention being a subset of the activated portion of long-term memory (Cowan, 1993, p. 162). In sum, Cowan (1988) suggests that working memory is the sum of all activated information.

Another definition that Cowan offers is "the temporary state of memory representation that would allow these representations to have a priming effect on subsequent stimuli" (Cowan, 1988, p. 165). Numerous psycholinguistic experiments demonstrating priming effects are evidence of the relationship between long-term memory and its activation in the short-term store. For example, in lexical priming studies, the mean time to recognize two items that have appeared in an experiment is positively related to how many times either of the pair has earlier appeared in another. These studies show that, at the very least, previously attended items stay active in short term memory in some capacity for a while after they leave awareness. A stronger claim made by Cowan on the basis of the lexical priming studies is that recently attended items may even be reactivatable from long-term memory. For present purposes, this kind of heightened activation of previously attended input items suggests an important cognitive resource for focus on form and task sequencing. If learners have just been attending to input that has already been identified as relevant to their language learning needs, the L2 teacher may take advantage of the fact that these items may be especially amenable to pedagogical intervention in this heightened state of activation, particularly if the learner microprocessing involved is cognitive comparison.

Another important and potentially relevant psycholinguistic finding concerning the nature of working memory is that the length of retention of encoded input in both the perceptual store and the short-term memory store may be longer than originally thought. Whereas it had previously been held that a subject can recall (i.e., hold in short term memory) about as many items of a particular type as can be pronounced in two seconds (known as the speech rate effect; see Baddeley et al. 1975), more recent studies have shown that subjects can retain material in memory up to 20 seconds in each phase (see Figure 2, phases I and II) by utilizing cognitive processes of rehearsal and rapid searching through activated long-term memory resources (Cowan, 1993). Evidence for the latter is found in studies showing that the length of memory span and speech-rate effect are greatly affected if the items used in the experiment are already known words. Taken together, findings such as these are suggestive of the length of duration of what Doughty and Williams (1998c) have called the cognitive window for provision of focus on form. This may be as long as 40 seconds, if the learner is able to rehearse material in the perceptual store and if already-stored interlanguage knowledge is engaged. In sum, this brief review of studies has shown that the earlier conceptualization of short-term memory involved an unfortunate separation between mechanisms of storage and mechanisms of processing. Theoretically, as Cowan (1992) claims, "short-term memory serves as the interface between everything we know and everything we perceive or do." Making connections between the known and the unknown eventually leads to knowledge restructuring. Consequently, the aim of focus on form should be facilitating the making of such connections.

## **DETERMINING OPTIMAL LANGUAGE PROCESSING INTERVENTION POINTS**

### ***The Pedagogical Recommendations***

Ideally, focus on form should come at cognitively opportune times, i.e., when the intervention can somehow be seamless with processing for language learning, rather than at overtly intrusive moments. This notion has been expressed in general ways in pedagogical discussions of focus on form (Long & Robinson, 1998, pp. 21-26). Drawing upon this work, Doughty (1997) cites three criteria which must be met if a pedagogical intervention is to be considered unobtrusive: (a) the primary focus is on meaning; (b) the focus-on-form targets arise incidentally; and (c) learner attention is drawn to forms briefly (and perhaps overtly). An overarching pedagogical recommendation in all the above proposals is that focus on form should be carried out in response to learners' needs. This

is a two-fold proposition involving curricular learner needs assessment (for instance, to facilitate the identification of target tasks in task-based language teaching—see Long, 1998) and a contemporaneous, classroom discourse-based or other diagnostic analysis of L2 learning problems. The latter learner-needs-as-a-starting-point recommendation is meant to contrast with more formal and/or synthetic approaches to language teaching that are based upon notions of linguistic complexity (Long, 1991, 1998). Instead, learners' needs are defined globally in terms of long-term developmental needs, often referred to as the "learner's internal syllabus" (Corder, 1967; Lightbown, 1992, 1998) and/or in terms of short-term task-related or communicative needs (Long, 1998). The overall recommendation stresses the futility of attempting a pedagogical intervention for which the learner is not ready or for which the learner has no purpose. Beyond this, however, it remains for cognitive SLA theory and research to determine the cognitively optimal intervention points for focus on form.

Assuming the efficiency of addressing developmental and communicatively relevant L2 learners' needs, cognitively opportune moments can be identified somewhat more precisely by examining four somewhat more specific focus-on-form recommendations that have been proposed (Long & Robinson, 1998, pp. 22-25):

1. Focus on form "draws learners' attention to mismatches between input and output."
2. Focus on form should take place at "a crucial site for language development," for example during "interaction between learners and more proficient speakers or certain types of texts."
3. Focus on form should use "pedagogical devices" that are appropriate for learners.
4. Focus on form must be "timed appropriately."

With the exception of much useful consideration of the role of attention in focus on form (Schmidt, 1992; in press; Tomlin & Villa, 1994), the remaining pedagogical recommendations have not been elaborated sufficiently in cognitive SLA terms.

Accordingly, in the following section, building upon the foregoing discussion of memory, mapping, analysis, and restructuring, we will examine focus on form during processing for language learning in considerably more detail.

### ***Cognitive Processing Concerns***

Taken together, the focus-on-form pedagogical recommendations seem to raise at least the following three cognitive processing concerns:

1. *The noticing issue*: Do learners have the cognitive resources to notice the gap?

2. *The interruption issue:* Is a pedagogical intervention that does not interrupt the learner's own processing for language learning even possible?
3. *The timing issue:* If so, then precisely "when," in cognitive terms, should the pedagogical intervention occur?

The discussion will now turn to a psycholinguistic research-based consideration of each of these issues, using the cognitive correlates to focus on form established in Figure 3 as the point of departure.

*The noticing issue.* *Do learners have the cognitive resources to notice the gap?* To address the noticing issue, it is necessary to draw upon the cognitive constructs of attention, selective attention (noticing), short-term memory, cognitive comparison, and mapping. Focus-on-form pedagogy recommends drawing learners' attention to mismatches. From the learner's perspective, this implies that such mismatches are noticeable (Swain, 1995; Schmidt, 1990, 1992, in press; Schmidt & Frota, 1986), which implies, in turn, that the learner can hold a representation of the output utterance (learner's own or interlocutor's), as well as keep the relevant input utterance in memory. This begs the question of whether learners simultaneously (or at least within a specified cognitive window) can pay attention to input and output during speech processing. Based on current conceptualization of L2 learner short-term memory capacity, there are at least three possibilities for how this kind of cognitive comparison could work:

1. Representations of the input and output utterances are held in short term memory and compared there;
2. Only a deeper (semantic) representation of the already-processed utterance is held in long-term memory, but it leaves useable traces in the short term memory against which new utterances may be compared; and
3. The memory of the utterance passes to the long-term memory but readily can be reactivated if there is any suspicion by the language processor that there is a mismatch between stored knowledge and incoming linguistic evidence.

All three of these proposals involve the language processor accordng special status to speech input that has recently occurred in the discourse. Therefore, evidence for a cognitive preference for re-utilizing recent speech would provide a strong underpinning for focus-on-form pedagogy aimed at helping learners notice the gap. Such evidence is found in three different kinds of research: conversational analysis of adult-adult and child-adult discourse, examination of naturally occurring speech errors, and controlled psycholinguistic experimentation.

*Conversational evidence for the preference for recent speech.* At the discourse level, a detailed formal conversational analysis by Schenkein (1980, p. 46) has led to the claim that "the systematic use of resources from prior talk in current talk apparently organizes the conversation." Schenkein terms these *repeating resources* and documents through analyses of ten different kinds of conversation that topical, inflectional, structural, and thematic resources that occur in the prior turn are used to organize ensuing conversation. The most fascinating examples of these are to be found in a taped conversation between two bank robbers:

A band of thieves had burrowed through the basements of a handbag shop and fast food outlet into the vault of a Lloyds Bank [to get at private safe deposit boxes]... All this was especially remarkable since police had been notified of the crime while it was in progress. A ham radio operator was dialing through his megacycles just before retiring on Saturday night when he happened to hear a suspicious remark about 'sitting on 300 grand.' He had intercepted a walkie-talkie communiqué between a man already in the bank vault and another man acting as a lookout on a nearby rooftop. When he reported this suspicious conversation to police he was regarded as a 'nut case,' and by the time the authenticity of his report had been verified with tape recordings of the intercepted conversations, it was too late. With an excellent sense of good timing, the thieves finished their work before the authorities located the site of their deed.

(Schenkein, 1980, p. 21)

According to Schenkein's analysis, many of the repeating resources carry a theme over from one turn to the next, using the same discourse speech act (i.e., a complaint followed by complaint). This occurs either within the same speaker's clause, across turns, or even minutes later. Furthermore, many of the repeats "conduct inflectional and structural features down through the interaction," such that the previous turn provides an automatic format for the following turns, as can be seen in this example, where each interlocutor is complaining about his respective "working conditions" (A is drilling into safe deposit boxes and B is the roof-top lookout) (from Schenkein 1980, p. 27):

A: Cor, the noise downstairs, *you've got to hear and witness it to realise how bad it is.*

B: *You have got to experience exactly the same position as me, mate, to understand how I feel.*

Here, the speech act that is reiterated is the complaint, and the sentence format (i.e., roughly the italics part in the examples) that is carried forward is something like:

You've got to do X terrible thing to understand how Y my situation is.

*Evidence from child-directed discourse.* Further evidence for preference for utilizing earlier topics and language in conversation is found in studies of child-directed discourse, this time with the advantage of supporting a language development model, whereas the previous prior-utterance preference data have come from the speech of already competent speakers. A central issue in L1 developmental research is whether children can make use of negative evidence (defined as information indicating what is not possible in the adult language) provided to them during interaction. To determine this, it must be ascertained whether negative evidence is provided at all and, if it is, whether it is supplied in a reliable fashion, whether children notice this consistent evidence, and whether child language development is affected in any way by provision and noticing of negative evidence. These questions, well known in current controversy concerning the role of negative evidence in language learning, are presented in Figure 8, together with relevant empirical evidence (adapted from Doughty, 1994):

Figure 8

*Child Preference for Linguistic Data in Recent Speech (Doughty, 1994)**Do parents provide negative evidence?*

Adults are more likely to:

- recast or request clarification of children's illformed utterances than of the well formed ones (Demetras, Post, & Snow, 1986).
- recast illformed utterances with one error than those with many (Bohannon & Stanowitz, 1988).
- provide "specific contrastive evidence" by giving exemplars (in their recasts) of the correct syntactic form or pronunciation immediately after the child error has been uttered (Bohannon & Stanowicz, 1988).
- repeat well- than illformed utterances (Demetras, Post, & Snow, 1986).

*Do children differentiate feedback types (i.e., notice negative evidence)?*

Children show their sensitivity to parental feedback by being more likely to:

- repeat recasts than to repeat adult repetitions (Bohannon & Stanowicz, 1988; Farrar, 1992)
- imitate the grammatical morphemes contained in corrective recasts than to imitate the identical information contained in other discourse categories (all constituting positive evidence) (Farrar, 1992).

*Does negative evidence contribute to child language acquisition?*

Parental discourse types provide reliable information to the child insofar as:

- 90% of adult exact repetitions follow well formed utterances (Demetras, Post, K., & Snow, 1986).
- 100% of corrective recasts (those that supply contrastive evidence) follow illformed child utterances (note that this is by definition)

Effects on language acquisition:

- children whose parents repeat after them more often learn faster (Nelson, Delinger, Bonvillian, Kaplan, & Baker, 1984)
- parental feedback has been shown to be correlated with child language acquisition of specific morphemes and syntax (Baker & Nelson, 1984; Farrar, 1990)

This cumulative evidence points to a conclusion that parents differentially fine-tune their feedback to the accuracy of child utterances, that negative evidence in the form of corrective recasts is reliably associated with ungrammatical utterances, and that children notice and use the information during L1 development. Thus, it may be the case that child-adult discourse, like adult-adult discourse, is psycholinguistically organized by a cognitive preference for using repeating resources from recent speech.

*Evidence from naturally occurring speech errors.* In study which analyzed naturally occurring speech errors, Harley (1984) has also demonstrated that material early in

conversations (e.g., speech or concepts) influences subsequent utterances. Concurring with Schenkein, Harley claims that speech errors reveal that “speakers must hold fairly concrete representations of prior discourse throughout conversation which either can be incorporated into or used to influence the form of new productions” (p. 199). In psycholinguistic terms, this is known as the cognitive process of *perseveration*. While Schenkein’s conversational data primarily shows perseveration of speech act forms and syntactic and prosodic features, Harley’s data further reveal perseveration at the lexical level, typically as an associate to an earlier concept. These speech errors are categorized as topic-based, as exemplified in Figure 9:

Figure 9

Topic-Based Errors: Intrusion of Material from Earlier in the Conversation (but not in the utterance being planned) into the Intended Utterance (Harley, 1984)

*C: Helping to load books into small boxes.*

T: At least they’ll be good for books.

U: At least they’ll be good for boxes.

*C: After a spectacular miscue during a game of pool.*

T: I haven’t a clue what went wrong there.

U: I haven’t a cue what went wrong there.

*C: The interlocutor’s previous utterance: “I don’t fancy anything fried for breakfast.” He said that as he spoke he was not aware of thinking about fried food.*

T: I just fancy some tea and muesli.

U: I just fancy some bacon and muesli.

*C: Had just been discussing literature, but the word read had not been used.*

T: I’m going to eat a yoghurt.

U: I’m going to read a yoghurt.

Interestingly, topic-based errors show that propositional content from the prior discourse can influence the production of subsequent utterances, even if the speakers are not explicitly attending to those items in focal attention. This suggests that message propositions, in addition to actually uttered prior speech, are available for reactivation and use in speech planning. Further examples appearing in the category of content-addressable errors (see Figure 10) show whole word substitution when the target and the substitution are in strict or loose semantic association. Clearly, both already-encoded

language and unformulated concepts that are current in thought are activated such that they affect encoding processes.

Figure 10

*Cognitive intrusions (Harley, 1984)*

(1) Environmental contaminants: intrusion of a lexical representation of something in the speaker's environment into the intended utterance (e.g., word substitution):

C = context; T = target utterance; U = actual utterance

(a) from another channel

C: *Glancing up at "Clark's" shop while getting out of car.*

T: Get out of the car.

U: Get out of the clark.

(b) from another speech event

C: *Talking about dress making while interlocutor is switching of TV. Announcer is saying: "The next program is 'Bee in my Bonnet.'"*

T: Why not a plain white dress?

U: Why not a bee?

(2) Content-addressable errors (i.e., intruding thoughts): whole word substitution when the target and the substitution are in strict or loose semantic association.

C: *Talking about swifts*

T: They even sleep on the wing

U: They even fly on the wing.

C: *Talking about moving to a place where the incidence of skin cancer due to sunshine was very high.*

T: Head for the west coast and die of skin cancer.

U: Head for the west coast and die of sun cancer.

C: *Talking about a lodger living in a tent in the yard. Reported no reason. After-thought association - both are made of canvas.*

T: You could have a tent up.

U: You could have a flag up.

C: *Speaker reported having two crafts, but was thinking of the quilts.*

T: I tried making some parchment last night.

U: I tried making some patchwork last night.

*C: Speaking to a friend who was soon due to have a cartilage removed from his knee, which meant that his knee was not in good shape. Said while offering to help carry heavy object. No mention of the surgery in earlier discourse. No mention of thinking of the word "carting."*

T: You'll need some portage help.

U: You'll need some cartilage help.

*C: Talking while looking at a picture of a woman in the newspaper. Subject said he was thinking about what he was saying and not about the photograph.*

T: They're doing ...

U: She's doing ...

### (3) Errors made because of competing speech plans

#### (a) Word blends

fire/flames → flire

shut/locked → shlocked

hypothesis/syndrome → hydrome

heard/knew → /h - schwa - nju

#### (b) Syntactic blends

T1: It depends where they place their limits.

T2: It does depend where they place their limits

U: It depends where it does place their limits.

T1: The disease will run its course.

T2: The disease must run its course.

U: The disease will rust its course.

T1: What are they?

T2: What are those?

U: What are they those?

T1: You feel ever so good when you do work.

T2: One feels ever so good when one does work.

U: You feel ever so good when one does work.

### (4) Errors due to alternative plans

T1: I got up at 8:52

T2: I felt fine at 8:52

T3: I woke up feeling fine at 8:52

U: I felt up fine at 8:52

T1: The sky is blue.

T2: The sun is shining.

U: The sky is shining.

*C: Speaker reported that the primary target in T1 was money, but he also thought of profits, which caused the hesitation*

T1: They're really losing money/profits

T2: They've really got problems

U: They're really losing // problems.

*Evidence from psycholinguistic experiments.* The third source of evidence for speakers' preference for previous utterances is found in a series of psycholinguistic experiments conducted by Levelt and his colleagues which constitute a detailed, controlled examination of this preference for words or sentence frames used by a speaker and/or the interlocutor. Levelt has termed this the *correspondence effect*, and describes it as follows: "It is as if previous talk sets up a more or less abstract frame in the mind of an interlocutor, which is then used in the formulation of the next turn (Levelt & Kelter, 1982, p. 79).

A psycholinguistically plausible use for the correspondence effect that Levelt and Kelter propose is that of keeping track of co-reference for the correct production and interpretation of anaphora. Moreover, if speech formats somehow remain activated in memory, they reason that this generally is more cognitively economical than perpetually generating speech anew. However, acknowledging that other explanations for the correspondence effect could include rhetorical style, politeness, and theme maintenance, Levelt and Kelter have, through a carefully designed series of experiments, ruled out any pragmatic explanation and established the roles in sentence production of short-term and long-term memory in the correspondence effect. This convincing reasoning is demonstrated in their analyses of results of six experiments, which we will consider in some detail here.

In the first experiment, the correspondence effect was simply established under minimal conditions, as in the case of asking questions in two formats (QFs) incorporating verbs that can be used with or without prepositions (from the original Dutch, preserving

Dutch word order):

Semantically and pragmatically equivalent questions:

QF1 (+preposition)	To whom lets Paul his violin see?
QF2 (-preposition)	Whom lets Paul his violin see?

Plausible answers:

Elaborated	To Toos lets he see his violin.
	Toos lets he see his violin.
Elliptical	To Toos.
	Toos.

In this experiment, subjects look at a picture and are directed to answer the question. There were four preposition types (to, of, for, on), and for each picture, questions with and without prepositions are equally natural. The study investigated whether or not subjects would show a bias for answering questions with the form corresponding to the question format. Results showed that, for all four preposition types, there was a 73% chance of a prepositional response over a non-prepositional response when the question was in the prepositional format. This effect is significant because such a correspondence is not obligatory. To determine whether subjects were using a strategy of matching the degree-of-elaboration of the question (rather than the correspondence effect), Levelt and Kelter checked to see whether longer questions (i.e., those in the prepositional format) were more likely to elicit answers with main verbs rather than their elliptical counterparts, which are also conversationally appropriate. According to this measure, there was no general tendency on the part of subjects to match the degree of elaboration of the question. Rather, it seemed that subjects preferred to match question and answer formats exactly.

In the second experiment, Levelt and Kelter distinguished between a possible politeness strategy (i.e., matching the interlocutor's format merely to show attentiveness to the question) versus their hypothesized preference for speech in recent memory activation. The aim of this study was to determine whether respondents show a greater tendency to match the preposition format of the question when the questions occur amidst distracting information. (The conversational analog to this would be the case of answering a question when more than one question had been asked). The hypothesis was that the distracting information could cause a decrease in the correspondence effect because the answerer would lose the relevant trace of the surface form from short-term memory. Distracting information, therefore, was incorporated into a second version of the

picture-based, question-answer experiment under two conditions—slight, proactive interference and strong, retroactive interference—as shown here:

Irrelevant Question	Relevant Question	Picture	Answer
Relevant Question	Irrelevant Question	Picture	Answer

The findings showed that, in the slight proactive interference condition, the correspondence effect was significantly higher than in the strong retroactive interference condition; however, under both slight and strong interference conditions, the subjects still gave corresponding answers to questions at a level higher than would be expected by chance. Two alternative politeness strategies were ruled out on the basis of examining the format of the answers. First a *when in doubt, be explicit* strategy (where explicitness is taken to be more polite) was ruled out because there was no tendency for subjects to answer more often in the more explicit prepositional format regardless of the format of the question. And, as was the case in the first experiment, a *degree of elaboration matching* strategy was not in use since subjects, once again, were not more likely to use main verbs in answers to prepositional format questions. Levelt and Kelter's interpretation of the findings thus far are that:

This 'baseline' correspondence so far does not seem to serve any conversational function [e.g., politeness]. It is more like an autonomic process of copying on the part of the answerer, a process which can be [somewhat] interfered with by adding distracting information to the question. (p. 87)

The third experiment simply attempted to establish the correspondence effect *in vivo* by asking questions over the telephone. In Nijmegen, where the research was carried out, there is considerable uncertainty regarding shop closing times on Saturdays; consequently, ringing up to ask when shops will close is a very natural speech act. The telephone questions were asked in the two formats, and each with and without strong, retroactive interfering material (i.e., the "since" clause):

Context: *Shops close at all different times on Saturday afternoon.*

QF1: What time does your shop close, (+/-) since I have to come into town especially, you see?

QF2: At what time does your shop close, (+/-) since I have to come into town especially, you see?

In this naturalistic experiment, as before, shopkeepers did not use the *when in doubt, be explicit* strategy in their answers, nor were they more likely to give elaborate (non-elliptical) answers to the longer, prepositional format questions. And, also as before, the correspondence effect was replicated in the non-interference condition. However, *in vivo*, the correspondence effect disappeared under the distraction of the since-clause.

In the fourth and fifth experiments, Levelt and Kelter began to investigate the cognitive mechanism that might be responsible for the correspondence effect. One obvious possibility is that somehow speakers can rehearse the format of the question in an articulatory buffer while formulating the answer. Following a well-established technique (Baddeley & Hitch, 1974), subjects were asked to rehearse an irrelevant six-digit number while preparing an answer to the question. Under both the interference (rehearsal) and noninterference (non-rehearsal) condition, there were strong correspondence effects (73% and 75%, respectively). This finding was unexpected<sup>9</sup> and so a fifth experiment that contained considerably more intervening material than six digits was conducted to rule out the possibility that subjects had retained a verbatim representation of the question format while searching for resources for processing the rest of the answer format. For this, they returned to the design used in Experiment 2. In addition, a measure of the subjects' recall of the question format taken at increasingly delayed time intervals (T1-3) was included to determine whether subjects could store any sort of representation of recent speech in long-term memory:

Question 1			
Question 2	Picture 1	Answer 1	"What was question 1?" (T1)
Question 3	Picture 2	Answer 2	"What was question 1?" (T2)
Question 4	Picture 3	Answer 3	"What was question 1?" (T3)

As was the case in experiment 2, the correspondence between the form of the answer and the form of the question was significant for both the non-interference and the interference groups, and the effect for the noninterference group was significantly stronger than for the interference group. Levelt and Kelter interpret these findings as an indication of the robustness of the correspondence effect: although interleaving successive trials did lower the probability of a corresponding answer, this was not reduced to chance level. Thus, it appears that answerers even tend to give corresponding answers when the question's form has probably been erased from working memory. This suggests the existence of a heightened, reactivatable trace in long-term memory.

For the interference group, at all three time intervals (T1= Q1? after Qs1,2; T2= Q1? after Qs1,2,3; T3=Q1? after Qs1,2,3,4), the recall of the question format matched the answer format. Question-answer format matching (short-term memory correspondence effect, e.g., Q1Q2A1) was not better than the question format recall (long-term memory trace, e.g., "What was Q1 after Q1Q2A1"). In other words, the degree of correspondence effect predicts the format recall. According to Levelt & Kelter, "thus there was no

<sup>9</sup> Although perhaps this finding would not be considered surprising now, given Cowan's arguments about the increased span of working memory.

evidence that the memory trace was any better at the moment of answering than at the moment of recall." For the noninterference (e.g., + "since" clause) group, however, the degree of the correspondence effect does not predict the question format recall. In particular, the question-answer matching is significantly better than the question format recall (except at T1, where they are equal). Thus, it appears from these findings that the interference group established a long-term memory representation to enable a corresponding answer to the question because the short-term memory was dealing with the extensive interference material. The non-interference subjects could simply rely upon the short-term memory trace to answer the question with a corresponding format. What is interesting is that clearly, from a focus-on-form perspective, the presence of extensive interfering material influenced the *type* of memory that was utilized in language processing, but did not interrupt the processing itself. Future work on determining optimal pedagogical intervention points should aim to tap into the cognitive resource of heightened, recently activated portions of long-term memory.

*The interruption issue. Is a pedagogical intervention that does not interrupt the learner's own processing for language learning even possible?* Doughty and Williams' (1998a, p. 4) operational definition of focus on form (definition 4) states that "it should be kept in mind that the fundamental assumption of focus-on-form instruction is that meaning and use must already be evident to the learner at the time that attention is drawn to the linguistic apparatus needed to get the meaning across." As a strong integration position, this could be interpreted to mean that simultaneous processing of meaning, function, and forms is a necessary condition for focus on form (Leeman, et al. 1995) and, hence, that the attention to form should not interrupt the ongoing and parallel meaning and function processing. However, since it is known that attentional capacity is limited, this necessitates asking whether simultaneous processing of forms, meaning, and function is cognitively plausible. In SLA research, VanPatten (1989) has claimed that learners cannot attend to forms and meaning simultaneously, however, the operationalization of attention in that study—making a hash mark with pencil—may have itself competed for attentional capacity. For greater insight into the plausibility of simultaneous processing, it is useful to turn psycholinguistic speech error analysis and experimentation.

The first source of insight is the analysis of naturally occurring speech errors. Speech errors reflect an alteration to an intended speech plan that results from some external or internal interference on processing. From the point of view of focus on form as a pedagogical intervention, I suggest that such alterations could be beneficial if they are made in the direction of the target language. In this case, of course, the changed element

would be different from the element in the learner's speech plan but obviously would not be considered a speech error. Furthermore, if the impetus for the speech-plan alteration can be identified in native-speaker naturally occurring speech errors, and an understanding of its cognitive nature ascertained, this could form the basis for developing particular focus-on-form intervention techniques to be examined experimentally in SLA.

In analyzing the systematicity of naturally occurring speech errors, such as the topic-based errors already discussed (i.e., in terms of how the speech of previous discourse shapes subsequent speech plans), Harley (1984) developed the notion of "cognitive intrusions." Cognitive intrusions surface as speech errors, which arise from various discourse, environmental, and processing sources. The method of analysis is as follows: Naturally occurring speech errors are recorded as soon as they are heard. Notes about the context are made, and the speaker is then consulted concerning (a) intended meaning, (b) whether or not the slip was noticed during production, and (c) any awareness of thought processes that could have been responsible for the cognitive intrusion on the intended speech plan. An example of an environmental cognitive intrusion, taken from Harley (1984, p. 196) is the following:

Context: Moving boxes. A is moving a box labeled "SLO-cooker"

A → B: Is that box heavy or slow?

target: *Is that box heavy or light?*

Cognitive intrusions become elements now incorporated into the utterance that were not originally in the specification of the intended speech. In the case of the SLO-cooker example, information read while formulating the spoken utterance intruded into the speech plan, resulting in the substitution of the planned adjective 'light' by the read adjective 'slow.' The range and variety of such cognitive intrusions are shown above in Figure 10. In addition to the speech-plan organizing influence of previous discourse in which the interlocutor participated (already shown in Figure 9), there appear to be at least four additional sources for cognitive intrusions:

1. What Harley calls "environmental contaminants," which reflect the intrusion of input from another channel, such the intrusion of the read word in the example above or from another speech event as seen in the example in Figure 10, in which in which the words of a television announcer are incorporated into the utterance
2. Intruding thoughts or images at the conceptual stage<sup>10</sup> such as the (Figure 10) example in which the speaker said 'sun cancer' instead of 'skin cancer' or the one in which the speaker, looking at a picture of a woman, said 'she' instead of the pronoun 'they' which was required by the speech plan

<sup>10</sup> Harley terms these *content-addressable errors*.

3. Competing speech plans, for instance saying 'schlocked' as a consequence of retrieving both lexical items, 'shut' and 'locked'; and
4. Alternative speech plans, for instance when a speaker says 'The sky is shining' (Figure 10).

These analyses suggest that humans can, and sometimes do, attend to, internalize, and use speech, environmental input, or conceptual information that was not originally formulated in their own speech plan in their utterance. Naturally occurring speech errors also seem to provide evidence that attention can be attracted to something in the environment without interruption of the speech plan. These kinds of intruding elements may or may not be relevant to the conversation at hand and, often, are not something the speaker was fully aware of. A mechanism proposed to explain cognitive intrusion into speech planning is *roving attention* (Garrett, 1980, cited in Harley, 1984; Garrett, 1984). Roving attention is susceptible to influence from stimuli and cognition that are outside of focal attention. Noting that such a mechanism is unsatisfactory on its own because cognitive intrusions, as revealed in naturally occurring speech errors are relatively rare, Harley proposes that environmental contaminants are *only* able to attract roving attention and thus to intrude into speech when there is some sort of conjunction between roving attention and sufficient facilitators, "such that the intrusion can occur in an utterance where there will be a minimum of [processing] disturbance." Furthermore, the ability of roving attention to intrude must decay over time unless there are suitable facilitators available (otherwise there would be a far greater number of speech errors). Thus, the relationship of facilitation of attraction between roving attention and intruding elements is crucial to the ability to process information outside of immediate focal attention.

In examining the data, Harley discusses two cases: that where the intruding stimulus is already in phonological form such as in previous speech and that when the stimulus is a visual concept or a written word. The latter is difficult to explain—the only offering thus far is that there are other cognitive systems responsible for processing environmental input, and they must have access to the lexicon and be able to prime selection from it:

Environmental contamination appears to involve competition between elements, and bears some resemblance to attentional dyslexia and the Stroop effect in that competing representations somehow combine in the speech stream. (Harley, 1984)

In the data shown in Figure 10, the facilitation needed to attract roving attention to the stimulus was either phonological, or semantic, or a combination of the two. To demonstrate that phonological facilitation occurs, Harley shows that the probability of a speech error occurring is greater if the target word and the intrusion or substitution are phonologically similar, as measured by sharing the first consonant in the stressed syllable,

by having an equal number of syllables with identical stress pattern, or by some combination of the two. However, for all three measures in the data, the probability of phonological facilitation, as defined in this way, occurring by chance is still very low. Subsequently, the additive contribution of semantic facilitation was demonstrated by analyzing the distribution of speech errors due to both strict and loose semantic associations between targets and substitutions. Strict semantic similarity, involves any one of three relationships: antonymy (e.g., dry-wet), coordinates (e.g., east-west) and hypernym-hyponym pairs (e.g., dog-poodle). Loose semantic similarity is revealed in synonyms or close associates (e.g., determination-dedication). Overall, the evidence shows that there are more whole-word substitutions in which the target and substitutions are related than could be expected by chance alone. However, it is still not entirely clear what the precise source of facilitation is, since many errors involving both semantically and phonologically related elements also occur. In summary, cognitive intrusions on the current utterance appear to be the result of a combination of one or more among the following environmental and thought 'contaminants,' aided by the attraction of roving attention to phonological and/or semantic facilitation.

1. Irrelevant material from the environment.
2. Especially prominent words in the preceding conversation.
3. Competing goals that blend.
4. Internally verbalized thought.
5. Competing message plans that blend.
6. Loose semantic relations, association, encyclopedic knowledge.

The critical point here is that what appear to be intrusions could also be considered to be momentary expansions of the limitations on attentional capacity. In focus-on-form terms, such cognitive intrusions would be welcome if the "intruding" element were cleverly introduced by the teacher to attract any available learner roving attention. Of course, future investigation of this would have to take into account the integral role of phonological and semantic facilitation in attracting attention.

A second source of insight into the interruption issue concerns the nature of speech plan formulation and the planning units therein. The architecture of the overall production system is generally agreed upon in the field of psycholinguistics. For example, in the case of formulating an utterance, as shown in Figure 11, accessing words in speech to produce words or utterances is generally agreed to involve two stages (this figure represents the formulator portion of Levelt's overall speech processing model shown in its entirety in Figure 2):<sup>11</sup>

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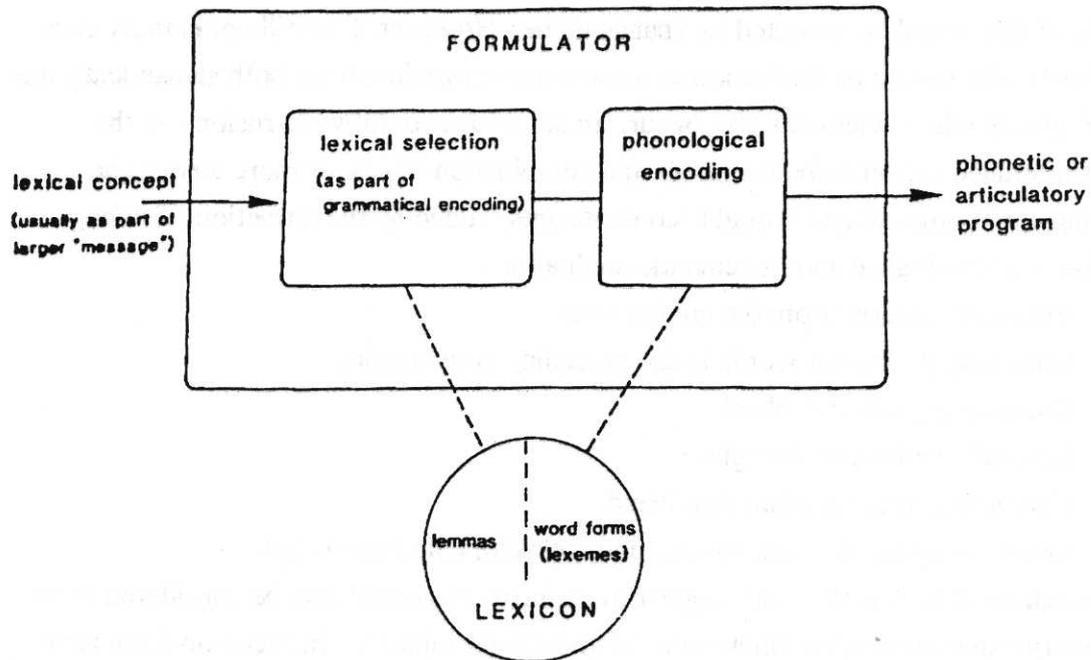
<sup>11</sup> This two-stage access model is common to all modern views of lexical access.

Stage 1 - lemma access: selection of the appropriate lemma from the mental lexicon (Levelt, 1989).

Stage 2 - phonological access: phonological encoding of that item, that is, the computation of the phonetic plan for the item to be used in the context of the utterance, i.e., the lexeme (Kempen & Huijbers, 1983).

Figure 11

*Lexical Access in Speech Production (from Levelt, 1991, p. 4)*



At present, it is undisputed that mapping must take place between a conceptual representation and a word's phonological form and that pragmatic, semantic, syntactic, and phonological information all contribute to this mapping. Nevertheless, difficult questions concerning the time-course of this mapping process remain (Dell & O'Seaghdha, 1991; Meyer, 1991):

- When are the various types of linguistic information used?
- Is their use in each stage organized into temporally distinct phases?
- Or, do the various types of information exert their influence throughout the process of mapping from meaning to sound (i.e., formulation and articulation)?
- What are the planning units?
- How are representations planned and constructed?

At present, there is a debate concerning the extent to which the two stages of cognitive processing are encapsulated (i.e., automatic and modular or discrete). A controversial question is whether phonological encoding can affect lexical selection and vice versa. From a focus-on-form point of view, automatic and encapsulated processes would be impossible to intrude upon, and any attempts to do so perhaps would have the undesirable consequence of interrupting ongoing learner processing or shifting it over to focus on forms.

The encapsulation debate centers on whether semantic information is segregated from phonological information, with semantic information being accessed and used at an earlier stage of lexical access than phonological information. There are two major hypotheses in this debate: the modular two-step hypothesis and the interactive two-step hypothesis (Dell & O'Seaghdha, 1991):

- H1 *The modular, two-step* - Stages 1 & 2 are non-overlapping and operate on different inputs. Semantic (but not phonological) information is active up to point of lemma access, and the reverse is true during phonological access *hypothesis* (Butterworth, 1989; Levelt et al., 1991; Schriefers et al., 1990).
- H2 *The interactive, two-step hypothesis* - Activation is predominantly semantic during lemma access, and activation is predominantly phonological during phonological access, however there is some activation of phonological information during lemma access and some activation of semantic information during phonological access. This interactive view is implemented in a connectionist spreading activation network (Dell 1986; Dell & O'Seaghdha, 1991, 1993).

According to Levelt (1991, p. 5) and the modular hypothesis, lexical selection proceeds as follows:

1. Input to the formulator is a message cast in propositional language of thought representing a speech act.
2. Grammatical encoding retrieves matching lexical items from the mental lexicon and delivers a surface structure as output, which is a hierarchical organization of syntactic phrases made up of lemmas.

Lemmas are semantically and syntactically specified, but as yet unspecified for phonetic form. The syntactic specification involves category and subcategorization information, as well as the way in which grammatical subcategory functions of the lemma are mapped onto the conceptual arguments in the lemma's semantic description (e.g., thematic role assignments). The following is an example of a lemma, e.g., for the French word, *tuer*, meaning *to kill* (de Bot, 1996, p. 539):

*Lemma Tuer*

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Conceptual specification: CAUSE (X ("DIE" Y))

Conceptual arguments: (X,Y)

Syntactic category: V

Grammatical functions: (SUBJ, DO)

Lexical pointer: 245

Diacritic parameters: tense, aspect, mood, person, number, pitch accent

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The semantic (i.e., conceptual) specification is the set of conceptual conditions whose fulfillment in the message is a necessary requirement for lemma retrieval. According to Levelt (1989), lexical selection then drives grammatical encoding and is more or less automatic. The units of planning are the lemmas themselves, which are activated when semantic conditions are met in the message. In their turn, lemmas call syntactic procedures that correspond to their syntactic specifications, for instance, verbs call the VP procedure (e.g., the lemma for *tuer* above) and nouns call the NP procedure. In Levelt's words,

Grammatical encoding is somewhat like solving a set of simultaneous equations, simultaneously realizing the appropriate thematic role assignments for all lemmas retrieved. (Levelt, 1991, p. 5)

Similarly, in step 3,

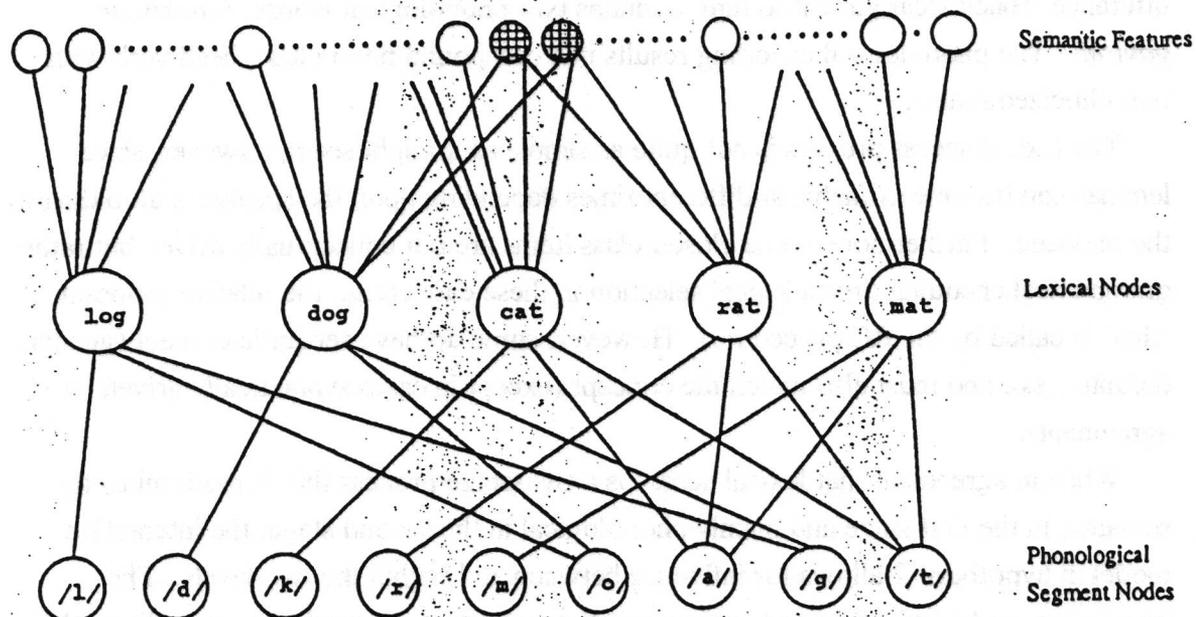
3. phonological encoding, a word's ultimate shape is generated each time it is uttered.

In other words, the phonological information is not stored in the lemma. Although it seems inefficient to pull apart speech in this way, the process is apparently necessary in the production of connected speech (Levelt, 1989). The unit of planning at the phonological level is the phonological word, a unit that is metrical, not lexical, and is based on syllabification and stress (Levelt, 1991). To use Levelt's (1991, pp. 10-11) example, the utterance 'Black Bear gave it to him' contains two phonological words: *BlackBear gavitim*. The phonological encoding results in a compound noun plus a head verb with two cliticized nouns.

The lexical access process is not quite as simple as it might seem, however, since lemmas can become available at different times depending upon the speaker's unfolding of the message. Furthermore, some closed-class items are not conceptually driven but rather grammatical encoding drives lexical selection in these cases (e.g., the relative pronoun 'that' is called by the RC procedure). However, some do have semantic content (gender, definiteness), and must also match the concept (except in cases syntactically driven by agreement).

While in agreement that lexical access is a two-stage process that is predominantly semantic in the first stage and mainly phonological in the second stage, the interaction model in hypothesis 2 allows for influence between and within the two levels. The interactive model is represented in the spreading activation network shown in Figure 12.

Figure 12  
*Spreading Activation During Lexical Access in Speech Production (from Dell & O'Seaghdha, 1991, p. 294)*



The model utilizes the same processing units found in Levelt's production model, but these are organized into a network, which allows for a bi-directional spread of activation between units at adjacent levels. The steps in lexical access in spreading activation account are as follows (Dell & O'Seaghdha, 1991, p. 295):

1. The semantic units of the concept-to-be-lexicalized receive external inputs.
2. Activation spreads in an unconstrained fashion throughout the network.
3. The most highly activated word unit is selected. In the case of sentence production, selection entails the linkage of this unit to the developing syntactic frame for the sentence ... and is followed by post-selection inhibition of other units (activation = 0).
4. When the word is ready for phonological encoding, it is given a triggering jolt of activation. For multi-word utterances, which require advance planning, the timing of this external signal is controlled by the syntactic frame slot (the lemma) that the unit is linked to.
5. Activation continues to spread, but because of the extra activation of the selected word unit the appropriate phonological units at the adjacent level become significantly activated.
6. The most active phonological units are selected and linked to slots in a constructed phonological word-shape frame, a data structure analogous to a syntactic frame.

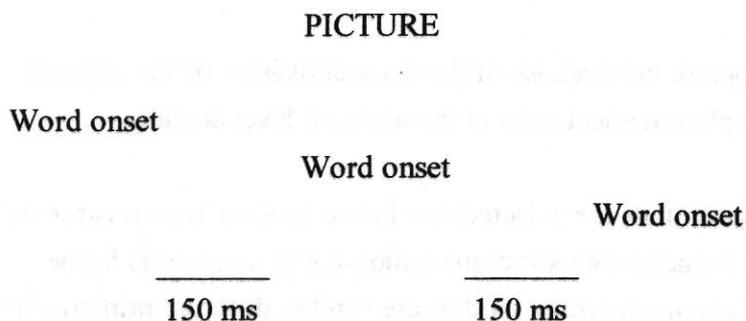
In comparison, the lexical access and modular models are similar, differing primarily in positions taken regarding the interaction or lack thereof between lexical selection and phonological encoding: Levelt envisions the various stages of lexical retrieval and phonological encoding as largely encapsulated or modular, whereas Dell and Reich (1981) claim that speech error work, such as that of Harley (1984) (see Figures 9 & 10) shows that errors of lexical selection and of phonological encoding are not independent. For instance, there is an observed lexical bias effect—that is, errors in phonological encoding more often result in real words than in non-words. According to Dell and Reich, only forward and backward spreading activation can account for this.

Priming and interference techniques are used to study the encapsulation debate (also referred to as the discreteness question or the question of modularity in lexical access). In the standard interference paradigm researchers superimpose an interfering word on a picture to be named, however, a common variation of this procedure involves naming pictures in the presence of an auditorily presented interfering word. Several conditions of interfering words are included in the design to examine all possible (non)interactions of

phonological and semantic encoding processes, as shown here:

semantic	cat-dog	(picture-interfering word)
phonological	fog-dog	
unrelated	roof-dog	
silence	no interference	

Priming studies have employed one of a number of variations of the basic paradigm to investigate the time-course of semantic and phonological encoding during lexical access. In work by Schriefers et al. (1990), subjects named pictures in the presence of semantically or phonologically related spoken words, or in a variety of control conditions. To examine the time-course of semantic and phonological access, the relative onsets of pictures and words were varied such that the word onset preceded the picture by 150 ms, coincided with it, or lagged it by 150 ms:



The findings revealed evidence of semantic interference (relative to unrelated controls) when the words preceded the pictures, but not in the two later word presentation conditions. In contrast, there was evidence of facilitation for phonologically related words relative to the control for the two later word onset conditions, but no effect when the word onset precede the picture. These findings are taken to support convincingly a distinction between phases.<sup>12</sup>

Levelt et al. (1991) further investigated the time-course of semantic and phonological encoding using a different, but related procedure. As before, the primary task was to name pictures of concrete objects. On one-third of the trials, word or non-word targets were interjected between the picture viewing and the naming task. The subjects were required to make a lexical decision. Levelt et al. tested the same conditions as did Schriefers et al.—unrelated, semantically related, phonologically related spoken words—and they added a mediated condition (e.g., target = phonological neighbor: picture =

<sup>12</sup> To explain the finding of facilitation in phonological encoding, it was suggested that related words in this study shared initial segments with the names resulting in little time for the conflicting later segments to interfere.

sheep, decision word = goal: the semantic relative of sheep is goat which is a phonological neighbor of the decision word). This design is shown here:

2/3 trials	View picture	Name picture	
1/3 trials	View picture	See word & (short, medium & long delay 73 / 373 /673 ms)	Name picture
		make lexical decision	

Interactive spreading activation accounts predict that a priming effect should be observed for both the mediated and directly phonologically related targets, whereas finding phonological activation only in the direct condition would be compatible with Levelt et al.'s modular account in which phonological activation is confined to a discrete stage and is restricted to selected lemmas. Levelt et al. report consistent inhibitory effects of both semantic and phonological relatedness at the short stimulus onset asynchronies (delays). At the long delay, they found only evidence of the phonological activation.<sup>13</sup> The absence of a semantic effect is taken as indicative of no semantic activation late in the process of producing single word utterance.

In their discussion of this work, Dell and O'Seaghdha point out that the findings of these studies converge on three phenomena to be explained:

1. Early semantic activation without phonological activation.
2. Absence of mediated semantic -phonological priming.
3. Presence of phonological priming in the absence of late semantic priming.

Schriefers et al. (1990) and Levelt et al. (1991) argue for the discrete, modular, two-step account of lexical access. However, looking at the same data, Dell and O'Seaghdha argue that it is compatible with the interactive spreading activation view, which, for them, is the account to be preferred because it can also handle speech errors, while the modular account cannot do so. To determine the status of semantic-phonological priming, Dell

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<sup>13</sup> These results contrast with those of Schriefers et al in two ways: 1. There is no point in which only a semantic effect was observed (target always lagged pictures); 2. the late phonological effect was inhibitory rather than facilitatory. In a third study, O'Seaghdha & Dell 1991 used a paradigm in which subjects see two words and prepare to say one of them. They press a button when they are ready: on 2/3 trials they name the prepared word, and on 1/3 they name a target. Their findings confirm the same inhibitory effect at the long delay. O'Seaghdha & Dell explain the results by pointing to competition between the discrepant segments of the prepared word and target, a situation which they liken to the repeated phoneme effect in phonological speech errors. Any similarity between the production plans of activated words increases the chance that contrasting segments will move from one word to another. Thus, the contrasting elements tend to slip into the plan.

and O'Seaghdha modeled spreading activation under the following conditions:

<i>Cat</i>	intended word
<i>Dog</i>	semantically related
<i>Mat</i>	phonologically related
<i>Rat</i>	semantically and phonologically related (mixed word)
<i>Log</i>	related only through mediation of the semantic relative (mediated word)

After ten cycles, *cat* received the highest activation, followed by *rat*. *Dog* and *mat* received intermediary activation, whereas *log*, with the smallest number of shared features, was least activated. These results can be shown to be related to distribution of the naturally occurring speech-error types representing the same conditions.

The critical result is that there is approximately a tenfold difference in activation levels between the mixed condition (*rat*) and the mediated condition (*log*). Dell and O'Seaghdha claim that this is because, in the spreading activation model, the mixed condition achieves convergent, additive activation from semantic and phonological sources, whereas the mediated condition receives divergent activation in which the contributions of semantic and phonological relations are diluted. In the mixed case, *rat* receives activation from semantic and phonological nodes shared with *cat*. But in the mediated case, *log* results in only phonological activation from the mediating word *dog*, and this activation is scaled down by the relatively weak activation of the mediator.

Thus, the general answer to the question of the time-course of semantic and phonological encoding seems to be that the production system appears to be globally modular, but locally interactive (Dell & O'Seaghdha, 1991). While, as has been argued by Levelt (1989), linguistic rule systems supply external activation to discrete levels of the lexical network, this does not mean that interaction within the lexical network can be entirely discounted. Speech errors suggest that interaction in the lexical system allows for exchange of activation at adjacent levels. Mingling is most evident when activation sources converge. This account gives the spreading activation model the ability to account for interactive error effects such as mixed errors. This is encouraging for focus on form, given that encapsulation of encoding would represent an insurmountable cognitive obstacle to effective pedagogical intervention seeking to supply information to the forms-function-meaning mapping process.

Another important question concerning the time-course of encoding—one that is also vital for focus-on-form intervention—is that of how far ahead utterances are planned. The time-course matters become more complex when addressed within the context of sentence production (known as the advance planning question). Time-course of utterance planning experiments reveal that speakers plan further ahead semantically than phonologically, but

it is not yet known how far ahead of articulation on either plane the speech plan goes. It has been found, however, that the size and nature of the sentence fragment that speakers encode phonologically before utterance onset do not correspond to syllables or words but rather to sentence structure (Ferriera, 1991). What is not clear is whether this sentence structure encompasses a syntactic unit (e.g., a lemma) or a prosodic unit (e.g., a phonological word).

Accordingly, the focus of interest in studies of utterance planning is the time-course of the construction of "syntactic" and sublexical representations. This concerns the order of accessing lemmas (L) and phonological forms (P). There are three hypotheses concerning this ordering (Dell & O'Seaghdha, 1991):

H1 *The lemma buffering hypothesis* - Several lemmas are selected before the corresponding phonological forms are filled in. (Kempen & Huijbers, 1983)

//L(1) L(2) L(3) / P(1) P(2) P(3)//

H2 *The structurally-determined lemma-buffering hypothesis* - As above, but takes into account major structural boundaries:

// L(1) L(2) / P(1) P(2) // L(3) / P(3)//

H3 *The word-by word hypothesis* - As above, proceeds but word by word:

// L(1) P1 // L(2) P(2) // L(3) P(3)//

Speech error data provide the evidence for lemma buffering and shows that, in general, the extent of advance planning at the syntactic level exceeds the extent of planning at the phonological level. Furthermore, lemmas within a clause may be simultaneously processed, but those in separate clauses typically are not. Most psycholinguists make a distinction between initial activation of lemmas due to conceptual activation and eventual insertion of lemmas into syntactic tree. Whereas the clause is likely the domain of advance planning at the syntactic level, the extent of the domain of phonological planning is not yet known. However, there are three hypotheses concerning phonological planning, although there is not enough evidence to distinguish among these (Dell & O'Seaghdha, 1991, pp. 305-306):

H1 *The word-by-word hypothesis* - Only the word about to be uttered and the following word are prepared, regardless of the structure of the sentence. This view has the advantage of simplicity and it may be all that is need in order to accommodate phonological and phonetic rules. Only forms of adjacent words need be known to get proper phonological form of a word (Levelt, 1989).

H2 *The syntactic-structure hypotheses* - Words are phonologically planned in accordance with syntactic units. Given that phonological advance planning should be less extensive than syntactic, the most common proposal has been that

phonological forms are retrieved in sub-clausal chunks corresponding to major syntactic phrases.

- H3 *The prosodic-structure hypothesis* - Phonological words are concatenated to form phonological phrases which are, prototypically, a content word and any preceding function words. One or more phonological phrases may then constitute an intonational phrase, a level of analysis over which intonational contours are computed. For the most part, however, prosodic units such as phonological phrases correspond to syntactic phrases.

Production priming experiments are employed in the study of the time-course of multi-word utterance planning. First, a subject views a display whose purpose is to induce the preparation of an utterance. Then, the subject prepares the utterance. On most trials, the subject simply produces the prepared utterance, but on critical trials, a target word is displayed. The subject responds to the target and may or may not be required to produce the prepared utterance before the trial ends. Latency and accuracy of response are the dependent measures. The design is shown here:

View	Prepare	2/3 trials:	See * and say utterance
Display	Utterance	1/3 trials:	See & respond to target, then see * and say utterance

The logic is that production plans serve as primes, and the extent to which the primes influence responses to related targets assesses the extent and nature of the utterance plans. The preparation of utterances is varied by utilizing different display and utterance-planning conditions, such as:

1. Reiteration - utterance to be prepared can be completely controlled, but may not be engaging real production process and the display may cause a priming effect.
2. Choice procedure - given two utterances to view, but only prepare one to eliminate effect of display.
3. Construction - given ingredients and are directed to combine them.
4. Pictorial displays - carefully selected and normed pictures get consistent descriptions. Conforms better to natural speech production.

Dell and O'Seaghdha carried out production experiments using the construction and the reiteration versions. In the construction experiment, subjects were to plan active and passive utterances using the basic elements REMOVE (BOXER, COAT) or REMOVE (BY BOXER, COAT). They pressed a button when ready: on 2/3 of trials they were instructed to say the sentence, and on 1/3 of trials to name target as quickly as possible, then to say the utterance. Target words tapped into the representation of the logical direct

object of the prepared utterance, e.g., COAT:

- phonologically related - COAL
- semantically related - SHIRT
- unrelated - APPLE

In passives, the critical word is early; in actives, it is last. The findings pertaining to the phonological priming effects show that when the critical word was early (passives) in the sentence, responses to phonologically related targets were significantly inhibited. In contrast, when the critical word was late in the sentence (actives), there was a significant facilitatory effect for phonologically related primes. Dell and O'Seaghdha take this to mean that there are differences in the phonological plan for early and late words in an utterance. In this study, there were no semantic effects. The inhibitory effects found are indicative of a state in which the access of the phonological form of the prime is complete or nearly complete. As Dell and O'Seaghdha explain, similarity-based competition occurs only when both the initial and the contrasting segment of the prime are present. In the passive condition, the phonological planning of the second word was quite advanced. In contrast, the facilitatory effect in the active condition, in which the critical word is last, reflects a lesser degree of planning of the word. The contrasting segments are not present in sufficient strength, and so there is no inhibition. Rather, there is an opportunity for facilitation by those (similar) segments that are preliminarily activated. In sum, inhibition indicates a great deal of progress toward a word's phonological form, whereas facilitation indicates a much lesser degree of preparation.

In the second, reiteration experiment, results were essentially the same as in the previous construction experiment, but there was a semantic effect this time. The semantic effect differed in nature, however, from the phonological effect in that position had much less influence on the amount and direction of semantic priming than it did with phonological priming. Dell and O'Seaghdha (1991, pp. 310-311) claim that "this is exactly what one would expect if planning at the lemma level exceeds that at the phonological level." The significant semantic and phonological facilitation in the active condition, where the critical word was late, can be taken as evidence of lemma retrieval. Phonological access associated with inhibition lags behind lemma retrieval, giving evidence for some kind of lemma buffering. The scope of these phonological effects is still under investigation.

This utterance-planning model can account for many types of speech errors, especially mixed errors, e.g., start → stop; cat → rat. The important point about mixed errors is that they are much more likely than would be predicted from the independent contributions of phonological and semantic similarity. Therefore, mixed errors also

suggest an interactive influence of semantics and phonology in lexical selection during utterance planning. Dell and O'Seaghdha (1991, pp. 311-312) interpret the findings of the foregoing study as follows:

Our conclusions are, for the most part, in agreement with the standard view of production (e.g., Garrett, 1975; Levelt, 1989) in which the production system distinguishes between form-related and meaning-related processes. The reach of advance planning appears to be different for meaning and form, and meaning and form also appear to be separable over the time-course of the retrieval of individual words. Though this evidence tends to favor the idea of discrete stages in production, we believe that a degree of local interaction in the course of lemma and phonological access is necessary to account for mixed semantic-phonological speech errors. These effects can be accounted for entirely by assuming that the phonological and semantic-syntactic representations of words are connected in a lexical network. That is, the interaction is a product of lexical retrieval processes, not of the way that syntactic and phonological rules are represented and used.

In summary, speech plan processing is largely modular but there do appear to be small cognitive windows of opportunity for "intrusions" and interactions among meaning and forms components during both lexical access and advance planning for utterance production. An intriguing question to raise is the extent to which such opportunities, heretofore discussed in terms of fully mature, native-speaker speech processing, exist and could be exploited in the case of a learner's developing speech processing system. At present, there exists no SLA research in this domain.

*The timing issue.* Precisely "when," in cognitive terms, should the focus-on-form pedagogical intervention occur? The timing issue follows on directly from the noticing and interruption issues. Whereas Doughty and Williams (1998b) imply in their operational definition of focus on form that optimal timing results in simultaneously attention to forms, meaning, and function, there are three other logical (weaker integration position) possibilities, provided they occur within an appropriate cognitive window:

- Attention to form shortly in advance learner need arising (DeKeyser, 1998; Lightbown, 1998).
- Simultaneous attention to forms, meaning, and function (Doughty & Williams, 1998b) at precisely the time when the learner need arises.
- A brief *shift* of attention from meaning and function to forms at precisely the time when the learner need arises (Long & Robinson, 1998).

- Attention to form immediately contingent upon the evident learner need. (Doughty & Varela, 1998; Ortega & Long, 1997).

The pedagogical components of the timing issue have been discussed at length elsewhere and involve such dilemmas as feasibility of lesson planning if attention to form must occur only at moments when a previously unidentified need has arisen, or how the teacher is to assess online whether errors are pervasive and remediable in daily classroom interaction (Doughty & Williams, 1998c). The matters at hand for present purposes are whether the recommended *simultaneous processing*, or *occasional shifts of learners' attention* needed to draw attention to linguistic form briefly during overall processing for meaning are feasible in cognitive processing terms, as well as whether the more logistically practicable advance and contingent focus on form might respectively block or fail to engage important cognitive microprocesses such as cognitive comparison leading to mapping.

*Focus on form in advance.* This view holds that, if attention to form *during* meaning processing is to be brief and unobtrusive, then learners may need some advance organizers to assist them in recognizing what to pay attention to. Two cognitive constructs lend support to this proposal: expectation and orientation. It is well established that expectation affects how selective attention is allocated. This interacts with the observation that, as measured by electrodermal indices of reacting to changes in stimuli, orienting to physical traits (e.g., phonological) is automatic but orienting to semantic traits requires directed attention (Hulstijn, 1979). Thus, it appears entirely plausible that some kind of cognitive preparation for focus on form would facilitate learner noticing of relevant input.

The critical question, however, is what should the learner be prepared to expect? Thus far, the proposals have involved utilizing what amounts to focus on forms as the advance preparation for noticing during focus on form. Lightbown (1998), for instance, recommends brief, explicit grammar lessons that would later be recalled during meaningful processing by extralinguistic means such as hand signals or facial expressions (Schachter, 1981). In other words, the forms needed in the communicative endeavor could be brought into short-term memory as needed, if the learner had been alerted in advance to the possibility that these forms might become useful during the communicative tasks. While it is clear that the advantage of this approach would be the minimization of processing interruption, what is not yet demonstrated is whether learners ever can utilize metalinguistic information during forms-meaning-function mapping. A similar proposal is for the solid establishment of declarative knowledge in advance of its use, a major tenet in the well-known skill acquisition model, ACT-\*, already outlined in the above discussion of

restructuring (see also Anderson, 1982, 1987). In focus-on-form terms, the cognitive window in which forms, meaning, and function can be compared is envisioned to be far greater than is assumed in most models of focus on form (Doughty & Williams, 1998c). DeKeyser (1998) suggests that earlier criticisms of skill-building models were unwarranted because they were based on empirical studies which did not allow for the development of sufficiently elaborated long-term memory representation of declarative knowledge before the learner was expected to be able to begin deploy that knowledge procedurally. Whereas in the small-window models of focus on form (e.g., 2 & 3 above) noticing is claimed to occur on-line and primarily in short-term memory, the effect of established declarative knowledge would have to involve interaction between the long-term memory store and the current processing in short-term memory.

In contrast to these views, it remains entirely possible that the optimal advance preparation for focus on form involves not expectation for and orientation to forms, but rather expectation for and explicit orientation to the event structure of an upcoming task, as is the case in child expectation for and interpretation of event scene highlights. L2 learners could be instructed to pay close attention when they are trying to interpret or express particular meanings. This kind of task orienting has been shown to affect depth of processing (Cowan, 1997). Furthermore, orientation to event representation would be in accordance with Slobin's operating principles. To date, however, both the forms-based and the event-structure-based proposals for focus on form remain completely untested in SLA.

*Simultaneous processing of forms, meaning, and function.* This timing proposal is essentially analogous to the interruption issue and, thus, only one point will be reiterated here. Although this proposal is an entirely new area of consideration, and, hence, somewhat speculative, it appears that, while in the main language processing is highly automatic, there may be some small opportunity for the attraction of attention to forms during message formulation given that speakers have been shown to do so inadvertently. If the cognitive mechanism for this is roving attention, then a key issue for focus-on-form pedagogical intervention is that of providing facilitation factors for the attraction of roving attention to linguistic forms while the remainder of selective attention remains engaged in processing meaning.

*Shifts of attention during processing.* At least one type of study has demonstrated that subjects can temporarily shift a portion of their attention away from a primary processing task to attend to (and notice) other stimuli without compromising ongoing meaningful

macroprocessing. Cross-modal processing studies reveal the complexity of working memory and are indicative of the potential for the kind of simultaneous attention to forms, function, and meaning that would embody non-interruptive processing for language learning. One such study—a study of syllable processing during whispered reading—shows that there is considerable memory for input that is not uniquely attended (Cowan, 1993). During these experiments, subjects whisper-read<sup>14</sup> a novel and occasionally hear syllables through headphones. Periodically, the subjects are interrupted and asked to identify from a list of ten the most recently heard syllable which will have occurred either 1, 5, or 10 seconds prior to the interruption. They then write the sentence most recently read and carry on with reading the novel. At the end of the whole process, they are given a comprehension test, which they expect throughout the study. Subjects are reasonably good at identifying the interrupting syllables, although the ability for identification decays somewhat from 1 to 10 seconds.

The essential finding is that subjects can remember input that was not at the center of selective attention. In other words, the not-uniquely-attended input retained some sort of activated status in short-term memory, which lasted up to 10 seconds. Even more fascinating for present purposes, however, was the discovery of small shifts of subjects' attention and the effect that this had on recall. These shifts of attention were revealed through analyzing the whispered reading in conjunction with the syllable presentation. Frequently, subjects would pause in their whispering within about one second of hearing the target syllable. On such trials, they showed a 20% improvement on recall. This benefit, like the overall recall ability, decayed over the 1 to 10 second interval, nonetheless, the shifts of attention appeared to enhance performance on syllable identification without detriment to comprehension. To follow up on this, Cowan conducted a second experiment in which the subjects were directed to press a button every time they heard a syllable while doing the same whispered reading tasks. The task was somewhat more demanding, but even so there was still a 60% detection rate. Strikingly, of those syllables detected, there was very little forgetting, even after the full 10 seconds. These findings can be interpreted to suggest that the shifts of attention advocated in focus-on-form pedagogy may, indeed, have a cognitive basis in the demonstrated ability of attentional shifting to enhance recall performance.

In her comprehensible output hypothesis, Swain (1995, 1998) claims that learners need to shift globally (not just briefly) from what she calls a more semantically oriented kind of processing that is typical of comprehension to a beneficial mode of syntactic processing that is required for production. Her claim essentially is that learners' own pushed output

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<sup>14</sup> Subjects are asked to whisper to ensure that they are, in fact, engaged in reading.

can serve as an attention-getting device, which brings to their awareness something that they need to know. In other words, the requirements of utterance formulation forces learners to analyze the form of their utterances in ways that would not be necessary during comprehension alone. This kind of noticing the gap, Swain claims, may be prerequisite to learning processes such as extending L1 meanings to L2 contexts, extending L2 meanings to new contexts, and IL system hypothesis formation and testing (Swain & Lapkin, 1995).

*Immediately contingent focus on form.* Perhaps the most compelling proposal for a solution to the timing issue involves tapping the powerful cognitive resources which enable learners to make use of recently occurring utterances. The evidence and arguments for these resources were presented in detail in the discussion of the noticing issues. If the verbatim format of recent speech remains activated in memory and available for use in subsequent utterance formulation, this can be taken to be an important cognitive underpinning for facilitating the opportunity to make cognitive comparisons. With regard to the timing of the information to be compared, the most efficient means to promoting cognitive comparison would seem to be provision immediately contingent recasts.

The fundamental psycholinguistic underpinning of recasting is the hypothesized value of drawing learners' attention to differences in recently produced (especially contingent) speech. From the learner's perspective, this implies simply that mismatches (a) between his or her own intentions and the linguistic resources available to express them or (b) between his/her own IL utterance and a contingent TL utterance in the discourse be made *noticeable*, since the learner presumably can already hold in memory a representation of both the output utterance (his or her own or the interlocutor's) and of the contingent input. Therefore, a key issue to consider is precisely what would make a component of a contingent utterance salient enough to be noticed and subsequently used in a cognitive comparison.

In L1 controversies concerning the contribution of recasts to acquisition, there have been a number of criticisms mainly from the point of view of noticability (cited in Saxton, 1997, p. 144):

1. Unwarranted emphasis on adult response CATEGORY rather than response CONTENT (Saxton, 1993).
2. Adult response categories probably too difficult for the child to identify (Marcus, 1993; Morgan et al., 1995).
3. Adult categories provide only an indeterminate source of information, since they are contingent on both correct and incorrect child utterances (Bowerman, 1988).

4. The child would have to repeat an utterance a great many times, in order to utilize the corrective information available in differential response rates (Marcus, 1993).
5. Computation of a differential response rate is probably beyond the child's processing capacity.
6. Adult response categories such as recasts can never reveal the precise locus of ungrammaticality within a particular child sentence (Pinker, 1989).

Some of these criticisms have also been leveled against recasts in the L2 classroom. Lyster (1998), in discussing the distribution of recasts versus repetitions in immersion classes, claims that the two discourse types occupy the same discourse context and, therefore, are confusing to learners (as evidenced by uptake failure). Doughty (1998) has argued that, whereas this may be the case in immersion classes, it does not follow logically that there is not a way to deliver recasts that would, in fact, be noticeable and useable by learners. Doughty and Varela (1998) have documented the effective use of what they term corrective recasting and have argued that certain features of the recasts enabled ESL learners to notice that material was being presented to them which they were to utilize in their own production. Subjects in the recasting condition, in comparison with no-recast controls, improved both in attempts at the recast target (expression of past) and in advancement toward targetlike use.

Moreover, as Saxton points out, even if differential response categories and response rates are not the explanation for why children seem to notice parental reformulations [or learners the teachers'], two fundamental factors remain which could be explanatory: (a) the specific linguistic content of the individual adult responses and (b) the proximity of the corrective responses to the child errors. Saxton has incorporated these factors into the direct contrast hypothesis:<sup>15</sup>

When the child produces an utterance containing an erroneous form, which is responded to immediately with an utterance containing the correct adult alternative to the erroneous form (i.e., when negative evidence is supplied), then the child may perceive the adult form as being in CONTRAST with the equivalent child form.

Cognizance of a relevant contrast can then form the basis for perceiving the adult form as a correct alternative to the child form.

An example from Saxton's (1997, p. 155) data illustrates the immediately contingent recast (tone = mock argumentation):

Child: Well, I feeled it.

Adult: I felt it.

Child: I felt it.

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<sup>15</sup> Saxton bases the DCH on the work of Nelson (1987) on the rare event theory of cognitive comparison.

Saxton (1997) demonstrated in an experiment which manipulated the input to children acquiring irregular past tense forms that the children were able to recover from overgeneralized hypotheses when given recasts of errors better than when provided positive input models in advance of their errors. This advantage for recasts over models has also been found for L1 English learners of L2 Spanish adjective placement (Ortega & Long, 1997). In other words, these studies suggest that child and adult learners do have the cognitive resources necessary to notice the difference between an old utterance and a new utterance, particularly where the forms of the two utterances are similar and the recast technique of focus on form places them in a contingent relationship, thereby fitting into what may be a tight window of opportunity for making a cognitive comparison.

Doughty (in preparation) also suggests that the information provided to L2 learners in recasts should be targeted in a combination of ways. In particular, the learner needs some guidance as to what the something is when recognizing that the teaching is seeking something. In Lyster's classrooms, the learners seemed, at least, to be wondering whether the teacher is commenting on the length, the meaning or the form of the utterance. This is particularly difficult since the teachers used so many discourse moves, each signaling all of these things. To remedy this, the reformulation needs to be consistent. In my view, what Lyster calls the isolated interrogative recast and what Doughty and Varela call corrective recasting are good candidates for the provision of negative evidence because these contingent recasts often contain the clear signaling factor of rising intonation, follow immediately upon the learner error, and, by not expanding the utterance too much, provide a direct contrast of forms.

In immersion classes, anything and everything seemed to attract teacher reformulation. Faced with this kind of diffuse feedback, it is hardly a wonder that learners become confused. Recasting is most likely to be effective when it is targeted at only one or a few features. Furthermore, on the basis of work by Pienemann and others, the targeted features need to be aspects of language for which the learners are developmentally ready for pedagogical intervention, as evidenced by findings of numerous effect of instruction studies which have shown that any kind of pedagogical intervention that is too far in advance of interlanguage development is ineffective. To target recasts properly, Doughty and Varela (1998) carried out an interlanguage analysis in the classroom to see what kinds of learning problems the students were having. Added to this was a separate concern to be able to test the effect of recasting in classroom tasks in which the need for the targeted form would be very natural and thus likely to occur frequently. Through this preliminary analysis, they settled upon expressing past events—real and hypothesized—in the reporting of science experiments, already a frequent activity in this science class. Finally,

and this departs quite a bit from the kinds of recasts that Lyster examined, Doughty and Varela's recasting technique involved an initial attention getting phase that, in effect, pointed more clearly to the learner error. As can be seen in this example, the teacher sometimes repeated the learner's error with a clear signal of rising intonation that there was a problem with the learner utterance, a kind of intonational focus considered to draw the learner's attention directly to the problem area:

*Context:* Jose is reporting on his experiment

Jose: I think that the worm will go under the soil.

T: I *think* that the worm *will* go under the soil?

Jose: (no response)

T: I *thought* that the worm *would* go under the soil.

Jose: I thought that the worm would go under the soil.

The teacher always gave the student an opportunity to try again, but if he did not repair, then she would consistently provide the targeted reformulation. In this way, if the student is successful after being invited to try again after an error has been put into focus, then the kind of cognitive comparison that he would make would be between his own two attempts at the utterance. If the student was unable to repair, then the material for the comparison would be the learner utterance and the teacher reformulation.

In addition to the targeting of the recasts to a small number of learning problems, in classrooms it seems to be the case that intensive recasting is necessary. The responses to learners in Doughty and Varela's study were consistently provided to learners in one of two ways throughout the treatment phase (i.e., straight recast or repetition plus recast), and the teacher rarely let a learner error of past or past conditional go by without eliciting a successful repair or providing the recast herself. Finally it should be noted that this kind of consistent, targeted, intensive, and focused recasting was carried out over six weeks' time in the ESL science class that met daily for about one hour. To conclude, this examination of studies in and out of L2 classrooms leads to the observation that recasts are only ambiguous when they are just one type among many reformulations moves used by teachers in immersion classes to respond to a wide range of learner error types. This by no means provides any justification for the abandonment of recasts as an effective means to draw learner attention to form (i.e., a relatively implicit, non-interruptive provision negative evidence) and certainly does not justify a focus-on-forms approach such as negotiation of form. Rather, given the promising findings from the wide range of studies showing preference for recent speech in subsequent language processing which all support the notion that L2 learners have the cognitive resources to notice the gap, it is far

better to adjust the recasting technique that teachers employ so that learners will be clear about what the material is which they need to be utilizing in these cognitive comparisons.

### CONCLUSION

After noting that much of the discussion of focus-on-form issues is often couched primarily in pedagogical rather than psycholinguistic terms and then raising the need for establishing the psychological reality of putative focus-on-form processes, this paper has presented a working taxonomy of cognitive correlates to familiar pedagogical notions, each supported by psycholinguistic studies. The cognitive correlates—concentrating mainly on memory, attention, cognitive comparison, mapping, and restructuring—were utilized in considering the three processing concerns of (a) cognitive resources involved in noticing the gap, (b) the feasibility of non-interruptive pedagogical interventions, and (c) the timing of focus on form, each of which arises from pedagogical recommendations. By examining psycholinguistic models and empirical research on memory and speech processing, we have seen that the cognitive resources of L2 learners potentially are great. Working memory is longer in duration and more complex in both its connection to long-term memory resources and its capacity to be attracted to language input that is outside of immediate focal attention. We have also seen that speech processing, while normally relatively automatic in operation, is not entirely encapsulated, hence that speech plans are amenable to modification, if the conditions for cognitive intrusions on utterance planning are facilitative and non-interruptive.

Finally, it has been suggested that, although there are some claims that the size of the cognitive window of opportunity for pedagogical intervention is even greater than psycholinguistic studies pointing to a window of something well under one minute, it is more prudent to assume that one of the most promising kinds of intervention is an immediate contingent recast, which can easily fit into working memory along with the original utterance to which it is to be compared. Results of recasting studies suggest that such cognitive comparison does lead to forms-function-meaning mapping and, hence, can be considered a successful means to promoting processing for language learning. An important caveat must be raised, however. With the exception of the recast studies, the experimental work discussed in this paper has been carried out with subjects possessing a mature, fully developed, fully functioning speech processing system. It remains for cognitive SLA research to carry out similar studies to discover whether speech processing of a developing L2 system is as robust as are fully developed systems in terms of memory capacity and preferences and of the possibility for uninterrupted processing of forms,

meaning, and function leading toward target-like mapping. If it is the case that IL speech processing is much the same as native-language speech processing, then the potential benefits of psycholinguistically motivated pedagogical interventions are, indeed, promising.

## REFERENCES

- Andersen, R. (1983). Transfer to somewhere. In S. Gass and L. Selinker (Eds.), *Transfer in language learning*. Rowley, MA: Newbury House.
- Andersen, R. (1984). The One to One Principle of language construction. *Language Learning*, 34, 77-95.
- Andersen, R. (1989). The theoretical status of variation in interlanguage development. In S. Gass, C. Madden, D. Preston, & L. Selinker (Eds.), *Variation in second language acquisition, Vol. 1: Psycholinguistic issues* (pp. 46-64). Clevedon, Avon: Multilingual Matters.
- Anderson, J. (1987). Skill acquisition: Compilation of weak-method problem solutions. *Psychological Review*, 94, 192-210.
- Anderson, J. (1982). Acquisition of cognitive skill. *Psychological Review*, 89, 369-406.
- Anderson, J., Fincham, J., & Douglass, S. (1997). The role of examples and rules in the acquisition of a cognitive skill. *Journal of Experimental Psychology: Learning, Memory and Cognition*, 23(4), 932-45.
- Baddeley, A. (1986). *Working memory*. Oxford: Clarendon Press.
- Baddeley, A., & Hitch. (1974). Working memory. In G. Bower (Ed.), *Recent advances in learning and motivation*. (Vol. 111). New York: Academic Press.
- Baddeley, A., Thomson, N., Buchanan, M. (1975). Word length and the structure of short-term memory. *Journal of Verbal Learning and Verbal Behavior*, 14, 575-589.
- Baker, N., & Nelson, K. (1984). Recasting and related conversational techniques for triggering syntactic advances by young children. *First Language*, 5, 3-22.
- Barton, M., & Tomasello, M. (1991). Joint attention and conversation in mother-infant-sibling triads. *Child Development*, 62, 517-29.
- Bialystok, E. (1994). Representation and ways of knowing: Three issues in second language acquisition. In N. Ellis (Ed.), *Implicit and explicit learning of languages*, (pp. 549-569). London: Academic Press.
- Bohannon, J., & Stanowitz, L. (1988). The issue of negative evidence: Adult responses to children's language errors. *Developmental Psychology*, 34(5), 684-689.
- Bowerman, M. (1988). The 'No Negative Evidence' problem: How do children avoid constructing an overly general grammar. In J. Hawkins (Ed.), *Explaining language universals* (pp. 73-101). Oxford: Blackwell.
- Bowerman, M. (1987). Commentary: Mechanisms of language acquisition. In B. MacWhinney (Ed.), *Mechanisms of language acquisition*. Hillsdale, NJ: Lawrence Erlbaum.

- Broadbent, D. (1984). The Maltese Cross: A new simplistic model for memory. *The Behavioral And Brain Sciences*, 7, 55-94.
- Butterworth, B. (1989). Lexical access in speech production. In W. Marslen-Wilson (Ed.), *Lexical representation and process*. Cambridge, MA: MIT Press.
- Cazden, C., Cancino, H., Rosansky, E., & Schumann, J. (1975). *Second language acquisition sequences in children, adolescents and adults*. Final report, Project No. 730744, National Institute of Education.
- Celce-Murcia, M. (1992). Formal grammar instruction: An educator comments ... *TESOL Quarterly*, 26(2), 406-408.
- Cheng, P. (1985). Restructuring vs. automaticity: Alternative accounts of skill acquisition. *Psychological Review*, 92, 414-423.
- Corder, S. P. (1967). The significance of learners' errors. *International Review of Applied Linguistics*, 5, 161-169.
- Cowan, N. (1988). Evolving conceptions of memory, storage, selective attention, and their mutual constraints within the human information processing system. *Psychological Bulletin*, 104, 163-191.
- Cowan, N. (1992). Verbal memory span and the timing of spoken recall. *Journal of Memory and Language*, 31, 668-684.
- Cowan, N. (1993). Activation, attention, and short-term memory. *Memory and Cognition*, 21, 162-167.
- Cowan, N. (1996). Short-term memory, working memory, and their importance in language processing. *Topics in Language Disorders*, 17, 1-18.
- Cowan, N. (1997). *Attention and memory: An integrated framework*. Oxford Psychology Series 26. Oxford: Oxford University Press.
- de Bot, K. (1996). Review article: The psycholinguistics of the output hypothesis. *Language Learning*, 46(3), 529-555.
- Deacon, T. (1991). Brain-language co-evolution. In J. H. M. Gel-Man (Ed.), *The evolution of languages*, (pp. 48-83). New York: Addison-Wesley.
- DeKeyser, R. (1997). Beyond explicit rule learning: Automatizing second language morphosyntax. *Studies in Second Language Acquisition*, 19(2), 1-39.
- DeKeyser, R. (1998). Beyond focus on form: Cognitive perspectives on learning and practicing second language grammar. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 42-63). Cambridge: Cambridge University Press.
- DeKeyser, R., & Sokalski, K. (1996). The differential role of comprehension and production practice. *Language Learning*, 46(4), 613-642.

- Dell, G. (1986). A spreading activation theory of retrieval in language production. *Psychological Review*, 93, 283-321.
- Dell, G., & O'Seaghdha, P. (1991). Stages of lexical acquisition in language production. In W. Levelt (Ed.), *Lexical access in speech production* (pp. 287-314). Cambridge, MA: Blackwell Publishers.
- Dell, G., & O'Seaghdha, P. (1992). Stages of lexical acquisition in language production. *Cognition*, 42, 287-314.
- Dell, G., & O'Seaghdha, P. (1993). Inhibition in interactive activation models of linguistic selection and sequencing. In (Ed.), Dagenbach, D. & Carr, T. (Eds.), *Inhibitory processes in attention, memory, and language* (pp. 409-453). New York: Academic Press.
- Dell, G., & Reich, P. (1981). Stages in sentence production: An analysis of speech error data. *Journal of Verbal Learning and Verbal Behavior*, 20, 611-629.
- Demetras, M., Post, K., & Snow, C. (1986). Feedback to first language learners: The role of repetitions and clarification requests. *Journal of Child Language*, 13(2), 275-292.
- Doughty, C. (1994). Fine tuning of feedback by competent speakers to language learners. In J. Alatis (Ed.), *Strategic interaction and language acquisition: Theory, practice, and research* (pp. 96-108). Washington, DC: Georgetown University Press.
- Doughty, C. (1998). Corrective recasts in and out of classrooms. Paper presented at the Edith Cowan Language Round Table. Edith Cowan University. Perth, Western Australia. June.
- Doughty, C. (1997). Meeting the criteria of focus on form. Paper presented in the symposium, *Focus on form in classroom interaction* (J. Williams & C. Doughty, organizers), at the 15th Second Language Research Forum. Michigan State University. October.
- Doughty, C., & Williams, J. (Eds.). (1998a). *Focus on form in classroom second language acquisition*. Cambridge: Cambridge University Press.
- Doughty, C., & Williams, J. (1998b). Issues and terminology. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 1-11). Cambridge: Cambridge University Press.
- Doughty, C., & Williams, J. (1998c). Pedagogical choices in focus on form. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 197-262). Cambridge: Cambridge University Press.
- Doughty, C., & Varela, E. (1998). Communicative focus on form. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 114-138). Cambridge: Cambridge University Press.

- Farrar, M. (1992). Negative evidence and grammatical morpheme acquisition. *Developmental Psychology*, 25, 1, 62-75.
- Farrar, M. (1990). Discourse and the acquisition of grammatical morphemes. *Journal of Child Language*, 17(3), 607-624.
- Farrar, M., Friend, J., & Forbes, J. (1993). Event knowledge and early language acquisition. *Journal of Child Language*, 20, 591-606.
- Ferreira, R. (1991). Effects of length and syntactic complexity on initiation times for prepared utterances. *Journal of Memory and Language*, 30, 210-233.
- Garrett, M. (1975). The analysis of sentence production. In G. Bower (Ed.), *The psychology of learning and motivation*, Vol. 9 (pp. 133-175). New York: Academic Press.
- Garrett, M. (1980). Levels of processing in sentence production. In B. Butterworth (Ed.), *Language production* (pp. 177-210). London: Academic Press.
- Gregg, K. (1984). Krashen's monitor and Occam's razor. *Applied Linguistics*, 5, 79-100.
- Harley, T. (1984). A critique of top-down independent levels models of speech production: Evidence from non-plan internal speech errors. *Cognitive Science*, 8, 191-219.
- Hulstijn, W. (1979). Selective attention and the orienting response. In H. Kimmel, E. Van Olst, & J. Orlebeke (Eds.), *The orienting reflex in humans* (pp. 557-566). Hillsdale, NJ: Erlbaum
- Ioup, G. (1984). Testing the relationship of formal instruction to the input hypothesis. *TESOL Quarterly*, 18, 345-350.
- Karmillof-Smith, A. (1992). *The child as linguist in beyond modularity*. Cambridge, MA: MIT Press.
- Kempen, G., & Huijbers, P. (1983). The lexicalization process in sentence production and naming: Indirect selection of words. *Cognition*, 14, 185-209.
- Krashen, S. (1982). *Principles and practice in second language acquisition*. Oxford: Pergamon.
- Krashen, S. (1984). A response to Ioup ... *TESOL Quarterly*, 18, 350-352.
- Larsen-Freeman, D. (1995). On the teaching and learning of grammar: Challenging the myths. In F. Eckman, D. Highland, P. W. Lee, J. Mileham, & R. R. Weber (Eds.), *Second language acquisition theory and pedagogy* (pp. 131-150). Mahwah, NJ: Lawrence Erlbaum.

- Leeman, J., Arteagoitia, I., Fridman, B., & Doughty, C. (1995). Integrating attention to form with meaning: Focus on form in content-based Spanish instruction. In R. Schmidt (Ed.), *Attention and awareness in foreign language learning* (pp. 217-258). Honolulu: University of Hawaii Press.
- Leow, R. (1993). To simplify or not to simplify: A look at intake. *Studies in Second Language Acquisition*, 15, 333-355.
- Levelt, W. (1989). *Speaking: From intention to articulation*. Cambridge, MA: MIT Press.
- Levelt, W. (1991). Accessing words in speech production: Stages, processes, and representations. In W. Levelt (Ed.), *Lexical access in speech production* (pp. 1-22). Cambridge, MA: Blackwell Publishers.
- Levelt, W. (1992). Accessing words in speech production: Stages, processes, and representations. *Cognition*, 42, 1-22.
- Levelt, W. (1993). Language use in normal speakers and its disorders. In G. Blanken, J. Dittman, H. Grimm, J. Marshall, & C. Wallesch (Eds.), *Linguistic disorders and pathologies: An international handbook* (pp. 1-15). Berlin: de Gruyter.
- Levelt, W., & Kelter, S. (1982). Surface form and memory in question answering. *Cognitive Psychology*, 14, 78-106.
- Levelt, W., Schriefers, H., Vorberg, D., Meyer, A., Perchmann, T., & Havigna, J. (1991). The time course of lexical access in speech production: A study of picture naming. *Psychological Review*, 89, 122-142.
- Lightbown, P. (1992). Getting quality input in the second and foreign language classroom. In C. Kramsch & S. McConnell-Ginet (Eds.), *Text and context: Cross-disciplinary and cross-cultural perspectives on language study*. Lexington, MA: D.C. Heath.
- Lightbown, P. (1998). The importance of timing in focus on form. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 177-196). Cambridge: Cambridge University Press.
- Long, M. (1991). Focus on form: A design feature in language teaching methodology. In K. de Bot, C. Kramsch, & R. Ginsberg (Eds.), *Foreign language research in crosscultural perspective* (pp. 39-52). Amsterdam: John Benjamins.
- Long, M. (1998). Focus on form in task-based language teaching. *University of Hawai'i Working Papers in ESL*, 16(2), pp. 35-49.
- Long, M., & Robinson, P. (1998). Focus on form: Theory, research, and practice. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 15-41). Cambridge: Cambridge University Press.

- Lyons, J. (1975). Deixis as a source of reference. In E. Keenan (Ed.), *Formal semantics of natural language*. Cambridge: Cambridge University Press.
- Lyster, R. (1998). Recasts, repetition, and ambiguity in L2 classroom discourse. *Studies in Second Language Acquisition*, 20(1), 51-81.
- Marcus, G. (1993). Negative evidence in language acquisition. *Cognition*, 46(1), 53-69.
- Meyer, A. (1991). Investigation of phonological encoding through speech error analyses: Achievements, limitations, and alternatives. In W. Levelt (Ed.), *Lexical access in speech production*. Cambridge, MA: Blackwell Publishers.
- Morgan, J., Bonano, K., & Travis, L. (1995). Negative evidence on negative evidence. *Developmental Psychology*, 31(2), 180-197.
- Miller, G.A. (1956) The magical number 7, plus or minus two: Some limits on our capacity for processing information. *The Psychological Review*, 63, 81-97.
- Ortega, L., & Long, M. (1997). The effects of models and recasts on the acquisition of object topicalization and adverb placement in L2 Spanish. *Spanish Applied Linguistics*, 1(1).
- Pienemann, M. (1989). Is language teachable? *AL*, 10(1), 52-79.
- Pinker, S. (1989). *Learnability and cognition: The acquisition of argument structure*. Cambridge, MA: MIT Press.
- Saxton, M. (1997). The contrast theory of negative input. *Journal of Child Language*, 24(1), 139-155.
- Schachter, J. (1981). The hand-signal system. *TESOL Quarterly*, 15, 125-138.
- Schenkein, J. (1980). A taxonomy for repeating action sequences in natural conversation. In B. Butterworth (Ed.), *Language production, Vol 1. Speech and talk* (pp. 21-47). New York: Academic Press.
- Schmidt, R. (1990). Consciousness, learning and interlanguage pragmatics. *University of Hawai'i Working Papers in ESL*, 9(1), 213-243.
- Schmidt, R. (1992). Psychological mechanisms underlying second language fluency. *Studies in Second Language Acquisition*, 14(4), 357-385.
- Schmidt, R. (1993). Awareness and second language acquisition. *Annual Review of Applied Linguistics*, 13, 206-226.
- Schmidt, R. (1994). Consciousness and SLA: Cognitive perspectives on intention, attention, awareness, and control. Paper presented at the annual AAAL meeting: Baltimore, MD.
- Schmidt, R. (Ed.). (1995). *Attention and awareness in foreign language learning*. Honolulu: University of Hawaii Press.

- Schmidt, R. (in press). The centrality of attention in SLA. In P. Robinson (Ed.), *Cognition and second language instruction*. Cambridge: Cambridge University Press.
- Schmidt, R., & Frota, S. (1986). Developing basic conversational ability in a second language. In R. Day (Ed.), *Talking to learn* (pp. 237-326). Rowley, MA: Newbury House.
- Schriefers, H., Meyer, A., & Levelt, J. (1990). Exploring the time course of lexical access in language production: Picture-word interference studies. *Journal of Memory and Language*, 29, 86-102.
- Schumann, J. (1978). *The pidginization process: A model for second language acquisition*. Rowley, MA: Newbury House.
- Sharwood Smith, M. (1985). From input to intake: On argumentation in SLA. In S. Gass & C. Madden (Eds.), *Input in second language acquisition*. Rowley, MA: Newbury House.
- Shiffrin, R. (1993). Short-term memory: A brief commentary. *Memory and Cognition*, 21(2), 193-197.
- Slobin, D. (1985). Crosslinguistic evidence for the language-making capacity. In D. Slobin (Ed.), *The crosslinguistic study of language acquisition, Vol. 2* (pp. 1157-1249). Hillsdale, NJ: Lawrence Erlbaum.
- Spada, N. (1997). Form-focussed instruction and second language acquisition: A review of classroom and laboratory research. *Language Teaching Abstracts*, 30, 73-87.
- Swain, M. (1998). Focus on form through conscious reflection. In C. Doughty & J. Williams (Eds.), *Focus on form in classroom second language acquisition* (pp. 64-82). Cambridge: Cambridge University Press.
- Swain, M. (1995). Three functions of output in second language learning. In G. Cook & B. Seidlhofer (Eds.), *Principle and practice in applied linguistics* (pp. 125-144). Oxford: Oxford University Press.
- Swain, M., & Lapkin, S. (1995). Problems in output and the cognitive processes they generate: A step towards second language learning. *Applied Linguistics*, 16(3), 370-391.
- Talmy, G. (1983). How language structures space. In H. Pick & L. Acredolo (Eds.), *Spatial orientation: Theory, research, and application*. New York: Plenum Press.
- Tomlin, R., & Villa, V. (1994). Attention in cognitive science and second language acquisition. *Studies in Second Language Acquisition*, 16(2), 183.
- VanPatten, B. (1989). Can learners attend to form and content while processing input? *Hispania*, 72, 409-417.

- VanPatten, B. (1990). Attending to form and content in the input: An experiment in consciousness. *Studies in Second Language Acquisition*, 12, 287-301.
- VanPatten, B. (1995). Cognitive aspects of input processing. In P. Hashemipour, R. Maldonado, & M. v. Naerssen (Eds.), *Festschrift in honor of Tracy D. Terrell*. New York: McGraw Hill.
- VanPatten, B., & Cadierno, T. (1993). Input processing and second language acquisition: A role for instruction. *The Modern Language Journal*, 77, 45-57.
- VanPatten, B., & Oikkenon, S. (1996). Explanation versus structured input in processing instruction. *Studies in Second Language Acquisition*, 18(4), 495-510.
- VanPatten, B., & Sanz, C. (1995). From input to output: Processing instruction and communicative tasks. In F. Eckman, D. Highland, P. W. Lee, J. Mileham, & R. R. Weber (Eds.), *Second language acquisition theory and pedagogy* (pp. 169-185). Mahwah, N.J.: Lawrence Erlbaum.
- White, L. (1987). Against comprehensible input: The input hypothesis and the development of second language competence. *Applied Linguistics*, 8, 95-110.
- Zobl, H. (1982). A direction for contrastive analysis: The comparative study of developmental sequences. *TESOL Quarterly*, 16(2), 169-183.

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