Studies in Second Language Acquisition **40** (2018), 693–706
doi:10.1017/S0272263117000250

Critical Commentary

SOME NOTES ON THE SHALLOW STRUCTURE HYPOTHESIS

Harald Clahsen*

University of Potsdam, Germany

Claudia Felser

University of Potsdam, Germany

Abstract

Since the Shallow Structure Hypothesis (SSH) was first put forward in 2006, it has inspired a growing body of research on grammatical processing in nonnative (L2) speakers. More than 10 years later, we think it is time for the SSH to be reconsidered in the light of new empirical findings and current theoretical assumptions about human language processing. The purpose of our critical commentary is twofold: to clarify some issues regarding the SSH and to sketch possible ways in which this hypothesis might be refined and improved to better account for L1 and L2 speakers' performance patterns.

INTRODUCTION

The Shallow Structure Hypothesis (SSH; Clahsen & Felser, 2006a, 2006b, 2006c, and much subsequent work) was originally proposed to account for L1/L2 differences in real-time sentence processing that could not obviously be accounted for by global-deficit hypotheses such as a shortage of computational resources or lack of automatization in L2 processing. It also sought to situate L2 processing research more firmly within existing psycholinguistic theories and models of language processing, and to emphasize the need for empirically founded assumptions about L2 processing to be integrated into theories of L2 acquisition. Assuming L1 and L2 speakers have available the same processing architecture and mental processing mechanisms, the core claim of the SSH

Our work on this article has been supported by an Alexander-von-Humboldt Professorship to Harald Clahsen. We thank the SSLA editors and reviewers for their thoughtful and constructive comments on earlier versions of our manuscript.

*Correspondence concerning this article should be addressed to Harald Clahsen, Potsdam Research Institute for Multilingualism, University of Potsdam, Karl-Liebknecht-Strasse 24-25, 14476 Potsdam, Germany. E-mail: harald.clahsen@uni-potsdam.de

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was that unlike native speakers, even highly proficient L2 speakers tend to have problems building or manipulating abstract syntactic representations in real time and are guided more strongly than native speakers by semantic, pragmatic, probabilistic, or surface-level information. We further hypothesized that the fast and efficient use of such information may enable learners to become highly effective L2 users, so that L1/L2 processing differences can often only be revealed using sufficiently sensitive experimental techniques.

When it was first proposed in 2006, the empirical evidence supporting the SSH came from sentence processing studies (mostly on relative-clause ambiguities and filler-gap dependencies) that demonstrated sensitivity to nongrammatical but reduced reliance on (morpho-)syntactic information during L2 compared to L1 comprehension. At the time, few studies were available on L2 morphological processing, which led us to the tentative conclusion "that at least in domains in which they are highly proficient, L2 learners can employ the same mechanisms for morphological processing as L1 speakers" (Clahsen & Felser, 2006a, p. 12). As more experimental studies on L2 morphology became available, L1/L2 differences in morphological processing also became apparent, however (e.g., Clahsen & Neubauer, 2010; Neubauer & Clahsen, 2009; Silva & Clahsen, 2008). These indicated that the L2 comprehension system relies on whole-form lexical storage in cases in which the L1 system employs morphological decomposition and computation. This contrast was initially interpreted as supporting the hypothesis that L2 processing is more dependent on declarative memory and less on the procedural memory system than L1 processing (Ullman, 2005). It soon became clear, however, that "more fine-grained linguistic distinctions are required to understand the nature of L2 morphological processing, beyond the basic procedural vs. declarative difference" (Clahsen, Felser, Neubauer, Sato, & Silva, 2010, p. 39). To provide two examples, advanced L2 learners were found to exhibit nativelike priming patterns for productive derived word forms but not for equally productive inflected forms (Kirkici & Clahsen, 2013), and lexical constraints on word-formation processes were found to affect L2 processing in the same way as L1 processing, whereas morphological constraints showed reduced effects (Clahsen, Balkhair, Schutter, & Cunnings, 2013; Clahsen, Gerth, Heyer, & Schott, 2015). These findings led us to extend the SSH to the processing of morphologically complex words (see, e.g., Clahsen et al., 2013, p. 25; Clahsen et al., 2015, p. 81; Krause, Bosch, & Clahsen, 2015, p. 618). In recent work, we have also tentatively extended the SSH by adding some assumptions about the relative timing of information sources, an issue we will return to in the following text.

We are very pleased to note that the SSH has since inspired many L2 researchers and psycholinguists to carry out experimental research on nonnative language processing. At the same time, we often see the SSH misrepresented in the research literature. In the first part of this commentary we will clarify a few things that are frequently misunderstood. In the second part, focusing on more recent findings from our research group, we will outline several ways in which the SSH might be further elaborated.

MISUNDERSTANDINGS AND CLARIFICATIONS

In the L2 processing literature, the SSH is often presented in a distorted or oversimplified way. Furthermore, the SSH has often been interpreted as a deficit hypothesis, a view that

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implies that the efficient use of grammatical information during language comprehension or production is somehow "better" than using nongrammatical information to the same end. This is not what we have claimed. The SSH's second clause hypothesizes that L2 processing may prioritize semantic, pragmatic, or other types of nongrammatical information, with L2 speakers potentially being *more* sensitive to these types of information compared to L1 speakers, although this part of our hypothesis has rarely been investigated (but see, e.g., Pan & Felser, 2011; Pan, Schimke, & Felser, 2015).

We acknowledge that at least part of the confusion is our own fault, resulting from the way the SSH was originally presented. The crucial point is this. Our keynote article (Clahsen & Felser, 2006a) introduced the SSH as positing *gradual* differences between L1 and L2 processing, holding that "representations adult L2 learners compute for comprehension are *shallower* and *less* detailed than those of native speakers … and rely *more* on non-structural information in parsing" (Clahsen & Felser, 2006a, pp. 3f.; our emphasis). In our response (Clahsen & Felser, 2006b) we subsequently spoke of "fundamental" and "qualitative" differences between L1 and L2 processing, however (Clahsen & Felser, 2006b, pp. 107, 118). With hindsight, our choice of these labels was unfortunate because even though these labels are imprecise and can be interpreted in different ways, they suggest a black-and-white picture that was not intended, given that the SSH posits gradual L1/L2 differences. We readily admit that this choice of wording may have led to misinterpretations of the SSH. In the following we will try to clarify the most common misunderstandings that we have come across in the recent L2 literature.

L2 SPEAKERS DON'T HAVE ANY SYNTAX

Even in its weaker forms such as "NNSs cannot deploy syntactic representations in the task of sentence processing" (Dekydtspotter, Miller, Schaefer, Chang, & Kim, 2010, p. 108) or "L2 sentence parsing involves only shallow syntactic structures" (Tanner, Nicol, Herschensohn, & Osterhout, 2012, p. 596), this kind of statement clearly overstates the SSH. Without syntax and the ability to build hierarchical representations we would not be able to comprehend simple sentences such as *The cat was chased by a mouse*, for example, and this is certainly not what the SSH would predict even for learners at lower proficiency levels. What we claimed instead was that L2 learners *underuse* syntactic information during real-time processing (e.g., Clahsen & Felser, 2006a, p. 21; our emphasis).

That said, our original hypothesis that "during L2 processing, learners compute grammatical representations that lack complex hierarchical structure" (Clahsen & Felser, 2006b, p. 111) appears to be too broad and general in the light of more recent findings. Proficient L2 speakers are indeed sometimes indistinguishable from native speakers even during the processing of highly complex sentences (e.g., Felser & Drummer, 2017), and L1/L2 processing differences often show up only where the creation or manipulation of abstract ingredients of grammatical representations is required (e.g., Boxell, Felser, & Cunnings, 2017). We suggested earlier that L2 learners' parsing problems might specifically pertain to the computation of discontinuous, grammatically mediated dependencies (Clahsen & Felser, 2006c), but recent findings suggest that an even more nuanced characterization is needed. Felser (2015) notes, for example, that forward dependencies tend to present less of a problem to L2 learners than dependencies whose

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computation requires reaccessing or manipulating previously built (partial) sentence representations.

An important but unresolved issue in psycholinguistics is the relationship between the grammar and the parser. As VanPatten and Jegerski (2010, p. 8) note, having acquired relevant grammatical knowledge "does not automatically entail the processing of something related." Learners who demonstrate nativelike grammatical knowledge are sometimes found to show nonnativelike processing patterns (e.g., Felser & Cunnings, 2012). This indicates that L2 speakers have difficulty putting their grammatical knowledge to use during real-time processing.

Regarding the relationship between the grammar and parser, the SSH makes two (relatively common) assumptions, first that linguistic knowledge, including grammatical knowledge, and the processor are separate systems, and second that grammatical knowledge feeds the processor during language comprehension and production along with other information sources. The processing system handles the real-time integration and timing of different types of information and is subject to computational resource limitations. The SSH acknowledges two possible sources of differences between L1 and L2 grammatical processing: nontargetlike grammatical knowledge or a nontargetlike processing system (Clahsen & Felser, 2006b, p. 117). Regarding the first possibility, a given grammatical constraint may simply be absent from the L2 grammar, or represented incorrectly. If we adopt the view that the linguistic constraints that form part of the knowledge system can be differently weighted (e.g., Smolensky, Goldrick, & Mathis, 2014), then it could also be that within the system of linguistic knowledge, grammatical constraints carry less weight than nongrammatical ones in the L2, in comparison to the L1 system; see the following text for further discussion. The second possible source is the processing system, with the L2 system potentially relying more strongly on non-grammatical than on grammatical information. In any given case, only one of these possibilities may apply, or both may apply in tandem. Empirical evidence for these two scenarios comes, for example, from studies that have reported offline/online differences, with L2 learners showing sensitivity to violations in online measures that is not reflected in their grammaticality judgments (e.g., Tokowicz & MacWhinney, 2005), or demonstrating nativelike grammatical knowledge in offline measures that does not constrain their initial parsing decisions (e.g., Felser & Cunnings, 2012).

Attributing to the SSH blanket statements such as "phrase-structure-based parsing principles … are inoperative in L2 processing" (Witzel, Witzel, & Nicol, 2012, p. 448), or "L2 learners … cannot establish dependencies outside of local domains" (Gabriele, Fiorentino, & Alemán-Bañon, 2013, p. 219) is unwarranted. To the extent that parsing principles are universal, they should also be available in L2 processing (Clahsen & Felser, 2006b, pp. 117, 120). A preference for the simplest analysis compatible with the current input, for example, has also been observed in L2 processing (e.g., Roberts & Felser, 2011). We realize that overstating—or creatively extending—the SSH might be tempting as it allows for predictions to be generated that are easily refutable; compare, for example, "L2 learners ... should not respect the RC island constraint because there is no RC representation in their analysis" (Omaki & Schulz, 2011, p. 570). Neither the SSH nor our studies on relative clauses have ever made such a claim.

The second clause of the SSH states that L2 speakers may be able to compensate for their potentially reduced ability to use grammatical information during processing by

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making efficient use of nongrammatical information. By no means does it claim that "context, pragmatic knowledge, and argument structure are the only processing strategies available to adult learners" (Slabakova, 2009, p. 291), however.

SHALLOW PROCESSING IS SPECIFIC TO L2 SPEAKERS

The SSH is based upon multiple-pathways models of language processing that were originally proposed to account for findings from L1 processing research (see Ferreira & Patson, 2007; Karimi & Ferreira, 2016, for review and discussion). Statements to the effect that "the core premise of the Shallow Structure Hypothesis [is] that natives do not process complex strings in a shallow manner" (Birdsong & Gertken, 2013, p. 119) or that the SSH is "a general architectural property of the L2 parser" (Omaki & Schulz, 2011, p. 564) are misguided. Neither L1 nor L2 speakers are restricted to a specific processing route.

The basic idea of multiple-pathways models is that there is more than one way of processing and mentally representing morphologically complex words, and more than one way of figuring out who did what to whom during sentence comprehension. Two (or possibly, more) different processing routes are assumed to operate in parallel, one of which involves creating a detailed grammatical representation of the input and the other one involving the heuristically driven construction of a "rough-and-ready" representation that lacks full grammatical detail. The SSH originally stated that in L2 processing "the shallow processing route predominates" (Clahsen & Felser, 2006b, p. 117), but given our assumption that both processing pathways operate in parallel, which of them will dominate in a given situation may also depend on factors such as the nature of the task or L2 proficiency (Lim & Christianson, 2013b).

Multiple-pathways models seem to us to be well suited in principle to account for many of the observed L1/L2 processing differences, although the models may well need refinement (compare, e.g., Karimi & Ferreira, 2016). Whilst the SSH claims that the likelihood of the heuristic pathway dominating is greater in L2 compared to L1 processing, details of the relative timing and weighing of different types of constraint in L2 versus L1 processing remain to be determined.

L2 PROCESSING IS NOT SUBJECT TO L1 INFLUENCE

In the absence of any explicit theoretical assumptions about how (or what kind of) grammatical properties of the L1 might affect real-time incremental processing in an L2, the SSH is largely agnostic regarding the role of L1 influence in L2 parsing. We hypothesized that "L1 transfer [should] influence L2 processing only indirectly, as a consequence of one or more of the knowledge sources that feed the processing system being affected by properties of the L1" (Clahsen & Felser, 2006b, p. 118). On the assumption that the hypothesized tendency to underuse grammatical information (and a corresponding overreliance on nongrammatical information) is independent of a learner's L1, we might expect L1 influence on L2 grammatical processing to be more limited in comparison to what has been reported in the L2 acquisition literature, however. Indeed, where L2 learners from typologically different L1 backgrounds are compared in processing tasks, L1 effects are often absent (e.g., Gerth, Otto, Nam, & Felser, 2017; Marinis, Roberts, Felser, & Clahsen, 2005; Roberts, Gullberg, & Indefrey, 2008; Sato &

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Felser, 2010; Silva & Clahsen, 2008). Attributing to the SSH the claim that "interlinguistic influence cannot occur during L2 processing" (Jegerski, VanPatten, & Keating, 2011, p. 482) is unwarranted, however.

L2 PROCESSING CAN NEVER BECOME NATIVELIKE

Although we speculated that L2 speakers' ability to make efficient use of non-grammatical information during processing might hinder grammatical parsing skills from becoming easily automatized, the SSH does not claim that "L2 learners can never achieve native-like syntactic parsing" (Dallas, DeDe, & Nicol, 2013, p. 770). What we argued instead was that "whether or not L2 learners can . . . develop nativelike parsing abilities will depend on their acquiring a nativelike grammar" (Clahsen & Felser, 2006b, p. 118). The deployment of grammatical constraints during parsing, the relative weighting of different types of information sources, or the use of a particular processing route are not under our conscious control, and increased exposure may well lead to the increased automatization or entrenchment of grammatical processing routines. Studies showing L1 and L2 speakers to have similar brain responses to linguistic stimuli might be particularly revealing in this regard (compare, e.g., Morgan-Short, 2014; Steinhauer, White, & Drury, 2009).

THE SHALLOW STRUCTURE HYPOTHESIS IS BASED ON NULL FINDINGS

Yet another kind of misrepresentation is the misrepresentation of the empirical findings that the SSH was originally based on. We continue to be puzzled by statements to the effect that the arguments for the SSH "rest on null findings" (Witzel et al., 2012, p. 424) or "were derived from null results" (Lim & Christianson, 2013a, p. 237). For illustration, consider our findings on relative clause ambiguities (Felser, Roberts, Gross, & Marinis, 2003; Papadopoulou & Clahsen, 2003), to which such statements are often explicitly related. In these studies, we found that L2 speakers showed nativelike online sensitivity to lexical-semantic disambiguation cues but unlike native speakers showed no clear disambiguation preferences where such semantic information was absent. This asymmetrical pattern was statistically robust and observed consistently across different L1/L2 combinations, and it is quite clearly not a null result.

DEVELOPING THE SHALLOW STRUCTURE HYPOTHESIS

Despite our concern for misrepresentation of the SSH in the L2 research literature to date, we also readily acknowledge that more than 10 years after its initial postulation and in the light of more recent research findings, it is clearly in need of refinement. In the following, we will outline some possible approaches toward developing the SSH further and advancing theory building in the field of bilingual language processing more generally.

VARIABILITY OF GRAMMATICAL CONSTRAINTS

As noted in the preceding text, the SSH is based on dual-pathways models of language processing that comprise both a heuristic and a grammatical (or "full parsing") route.

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We also pointed out that successful parsing using the grammatical route "depends on the availability (and accessibility) of sufficiently detailed, implicit grammatical knowledge" (Clahsen & Felser, 2006b, pp. 117f.). We effectively hypothesized that some aspects of the L2 grammatical knowledge are less robust than knowledge of the L1 grammar. Terms such as "less robust," however, suggest that there are *gradient* differences between the L1 and the L2 grammar that can in principle be quantified. This idea is different from the traditional view of grammatical knowledge as a *categorical* property, according to which a given speaker either "knows" or "does not know" a particular grammatical rule or constraint. At the time, we did not offer any formal model that could capture such gradient differences. Constraint-based approaches to language such as Harmonic Grammar and Gradient Symbolic Computation (e.g., Smolensky et al., 2014), which allow for representations to be graded and linguistic constraints to be weighted, offer a promising way forward. Recently, this approach has also been applied to bilingualism (e.g., Goldrick, Putnam, & Schwartz, 2016; Veríssimo, 2016). We believe that this represents a fruitful line of research for further developing the SSH using formally more explicit models for capturing gradual differences between L1 and L2 grammatical processing.

Regarding sentence-level processing, investigating how native versus nonnative speakers resolve structural or referential ambiguities is useful for examining the interplay of different types of constraint during processing. We will discuss this in more detail in the following text. Consider here for illustration an example from morphology, the so-called plurals-in-compounds effect. In English, for example, compounds with singular modifiers are more acceptable than those with plural ones, and amongst those with plural modifiers, compounds with regular plural modifiers are less acceptable than those with irregular ones; compare *goose/duck feeder*, ?*geese feeder*, **ducks feeder* (e.g., Cunnings & Clahsen, 2007). The plurals-in-compounds effect is subject to several subtle linguistic constraints, which have been widely studied in the psycholinguistic literature. One of these constraints prohibits regular inflectional processes to occur inside lexical compounds; this morphological constraint militates against forms such as **ducks feeder* that have compound-internal regular plural modifiers. Another constraint requires that compound modifiers should not specify the concept of NUMBER; this semantic constraint permits bare forms inside compounds but disallows plural modifiers. Previous L2 studies on plurals inside compounds have led to conflicting interpretations. Lardiere (1995) argued that the morphological constraint is inoperative in the L2 as regular plurals are not *consistently* omitted (i.e., in more than 75% of trials) from modifiers inside compounds. Other researchers observed that like L1 speakers, L2 learners judge compounds with regular plural nonheads as less acceptable and produce them less commonly than those with irregular plural and singular nonheads, concluding that L2 learners are indeed sensitive to the compounding constraints (e.g., Clahsen, 1995; Clahsen et al., 2015; García Mayo, 2006; Murphy, 2000). How can this apparent paradox be resolved? Constraint-based models that conceive of linguistic constraints as not only being violable but also associated with a specific strength or weight (e.g., Goldrick et al., 2016; Smolensky et al., 2014) offer a way of capturing such gradedness. Following these proposals, Veríssimo (2016) constructed a set of Harmonic Grammars to model the performance of both the L2 and the L1 speakers tested by Murphy (2000). In Veríssimo's account, the same compounding constraints formed part of both the L1 and the L2 model,

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but the weights were different. While the L2 grammar had the same weights for the semantic constraint as the L1 grammar, the morphological constraint had a by 40% reduced weight in the L2 grammar allowing it to be violated more often than in the L1. In this way, the models perfectly captured the proportions of regular and irregular plural responses in the two groups, and at the same time provided an account for the increased variability in the L2 output.

We believe that the idea of gradient differences between L1 and L2 grammars as assumed by the SSH can be better implemented with these kinds of model than in a framework that enforces binary decisions ("known" vs. "unknown"). Furthermore, as illustrated by Veríssimo's (2016) model, using constraint-based approaches allows us to quantify the extent to which L2 performance relies on grammatical versus non-grammatical information.

BILINGUALISM, (NON)-NATIVENESS, AND AGE OF ACQUISITION

The SSH is an attempt at understanding differences between native and nonnative processing of grammar. At the time the SSH was first put forward, the contrast between native and nonnative processing was conceived of as a comparison of two extremes: L1 speakers, on the one hand, that is, individuals who acquired a given language from birth, and L2 speakers, on the other, that is, individuals who learned the same language after having completed L1 acquisition. Although we considered age of acquisition (AoA) as the crucial variable that distinguishes native and nonnative grammatical processing, we were unable to specify precisely how and when fully nativelike grammatical processing would become nonnativelike.

Even though current bilingualism research covers a wide spectrum of bilingual individuals (including early and successive bilinguals), the SSH has focused on L1/L2 between-group comparisons. A promising avenue for further developing the SSH therefore is to examine bilingual performance across the AoA scale to investigate how grammatical processing in a given language is affected by the age at which it was acquired. Furthermore, this approach avoids some of the limitations of the usual "L1 versus L2" studies, because all bilinguals—irrespective of their AoA—know two languages, so that comparisons are not affected by any advantages or hampering consequences of bilingualism per se. However, treating bilingualism as a continuum requires larger samples and more sophisticated data analysis techniques than the more familiar factorial (between-group) designs. AoA may influence abilities and skills in a gradual way but may also have nonlinear effects with discontinuous, sharp changes after certain age boundaries, which would be indicative of sensitive periods of development (see Hakuta, Bialystock, & Wiley, 2003). Hence, to properly examine the role of AoA in language performance, a large number of participants spanning different AoAs and data analysis techniques that detect both linear and nonlinear effects are required.

Steps in this direction were taken in some of our recent studies. Consider, for illustration, AoA effects on (masked) morphological priming in German (Clahsen & Veríssimo, 2016; Veríssimo, Heyer, Jacob, & Clahsen, 2017). We tested a large sample of participants from the Turkish/German community in Berlin, all of whom acquired Turkish from birth and German at different ages. As potential predictors of participants' priming effects, the study included AoA, proficiency, length of exposure, and language

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use. Two sets of regression analyses were performed: (a) linear models to determine priming effects for the two experimental conditions (inflectional, derivational) and the two control conditions (orthographic, semantic); and (b) nonlinear models (viz., regression with breakpoints and local regression) to determine potential discontinuities in the function relating AoA to morphological priming. The results from the linear models showed that while semantic and orthographic primes did not produce any facilitation on target response times, there was a reliable priming effect for derived word forms that was constant throughout the AoA scale. In contrast, inflectional priming significantly interacted with AoA, decreasing with increasing AoA. Importantly, none of the other predictors of interest (proficiency, length of exposure, and use of German) showed any effects on priming. The statistical modeling results revealed a highly selective effect of AoA, which only modulated inflectional but not derivational priming. This finding fits with previous results from several between-group (L1/L2) studies that revealed L1-like derivational priming in late learners while inflectional priming was considerably reduced (relative to L1 priming) or altogether absent (e.g., Jacob, Heyer & Veríssimo, 2017; Silva & Clahsen, 2008).

From the perspective of the SSH, derivational priming is lexically mediated, resulting from lexeme-level entries for derived words that partially overlap with the lexeme entry of their corresponding base (e.g., $[[\text{bitter}]\text{ness}]_{N}$, - $[\text{bitter}]_{ADJ}$). By contrast, the output of a regular inflectional process is a feature-form pairing, and not a lexeme. Consequently, unlike derivational priming, masked inflectional priming cannot be lexically mediated, but presupposes deeper grammatical processing, specifically morphological (stem+affix) parsing, which according to the SSH is not fully operational in L2 processing; see Kirkici & Clahsen (2013) for further details. The Turkish/German study reported in the preceding text nicely shows how to pin down the source of native versus nonnative processing differences to an AoA effect for the processing of complex word forms. The results from this study suggest that late acquisition does not affect "language" but selectively modulates grammatical processing, a view that is consistent not only with a domain-specific sensitive period (Newport, Bavelier, & Neville, 2001) but also with the SSH.

REDUCTIONISM AND ITS LIMITS

The SSH claims that grammatical constraints may be less robust in the L2 than in the L1 and that L2 processing tends to rely more on nongrammatical information than on the grammatical route to interpretation than L1 processing. A possible response to these claims would be to ask whether differences between L1 and L2 processing cannot (at least in part) be reduced to other factors.

Several proposals have been made to account for observed contrasts in L1 and L2 performance in terms of nonlinguistic and/or nongrammatical differences between native and nonnative speakers. L2 processing may be more demanding in terms of general cognitive resources than processing one's native language, resulting in less automatic processing (e.g., McDonald, 2006). Another resource-limitation account holds that because lexical processing is particularly demanding in L2 comprehension, insufficient resources remain for syntactic processing (Hopp, 2014). L1/L2 contrasts have also been attributed to a different balance of brain structures and neural pathways

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involved in language processing (e.g., Ullman, 2005). Another idea is that L1/L2 performance differences might be reducible to memory operations that subserve language processing. One such proposal has recently been put forward by Cunnings (2017a). Assuming language processing involves cue-based memory retrieval (e.g., Lewis & Vasishth, 2005), Cunnings argues that for memory retrieval, the L2 sentence comprehension system assigns (a) the same weight as the L1 parser to lexical cues and to cues derived from the local syntactic and semantic context, (b) less weight than the L1 system to abstract syntactic cues, and (c) more weight to discourse-based cues compared to L1 speakers. This account essentially retains the main insight from the SSH, namely that L1 and L2 speakers differ in their sensitivity to grammatical and nongrammatical information, but recasts the native/nonnative difference in terms of a contrast in how different types of retrieval cue are used during sentence processing. This might be a promising way forward. Cunnings (2017a) tries to derive several L2 learners' difficulties in sentence processing from these memory considerations, thereby obviating the need to posit any deficiencies in L2 learners' syntactic knowledge or structure-building ability for the particular L1/L2 contrasts under consideration. Note, however, that regarding the question of *why* L2 sentence processing is more susceptible to memory interference, Cunnings (2017b) points to morphological processing as a potential source, which he assumes to be shallower in the L2 than in the L1. He maintains that the L2 system relies more on whole-word storage of complex words and less on morphological parsing than the L1 system, in line with the SSH. Assuming morphosyntactic information such as gender, person, and number are more difficult to access from whole-word entries, this then accounts for why the L2 parser's "encoding of relevant (morphosyntactic) features in sentence chunks in memory may be less robust" (Cunnings, 2017b, p. 7). While this is not the place for providing a detailed critique of Cunnings's proposal, we note that because syntactic representations, and in particular the functional categories and projections that provide their scaffolding, are built from morphosyntactic features, difficulties in accessing these features should lead to corresponding difficulty with syntactic structure-building (contra Cunnings). We also note that some findings from L2 sentence processing studies cannot be easily accounted for in terms of greater memory interference during L2 processing (compare, e.g., Boxell & Felser, 2017).

Reductionism is, of course, good scientific practice. The main problem of reductionist approaches, however, is that they can typically only provide partial accounts of the observed L1/L2 differences in grammatical processing. For instance, it is hard to see how the contrast between derivational and inflectional priming in L2 processing (e.g., Silva & Clahsen, 2008) can be explained in terms of nonlinguistic concepts such as reduced cognitive resources or increased memory interference. It is also unclear how processing resource limitations, lexical access problems, or memory interference in an L2 should lead to L2 comprehension being influenced by extrasentential discourse information in situations in which L1 comprehension is not (Pan & Felser, 2011; Pan et al., 2015). Regarding the processing of filler-gap dependencies, it is not obvious how either of the preceding factors might be responsible for sustained filler activation in L2 processing instead of position-specific reactivation as has been observed in L1 processing (Felser & Roberts, 2007; Jessen, Festman, Boxell, & Felser, 2017).

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THE TIMING OF GRAMMAR AND OTHER INFORMATION SOURCES

The original SSH also lacked assumptions about possible L1/L2 differences in the processing time-course, that is, about the relative points in time at which different information sources begin to affect processing. Considering the growing amount of empirical evidence that bears on this issue, including such assumptions would seem to be another desirable extension of the SSH. In more recent work, we started exploring how the SSH might be extended to capture differences in the relative timing of grammatical and nongrammatical information during L1 and L2 processing; see, for example, Clahsen et al. (2013) with respect to morphology, and Felser and Cunnings (2012) for sentence processing. More generally, the basic assumptions of the SSH lead us to expect that processing reflexes of grammatical information might be delayed in L2 compared to L1 processing, and/or in comparison to processing reflexes of nongrammatical information.

In studies using time-course sensitive experimental techniques, predicted effects of grammatical constraints are indeed sometimes found to be delayed in L2 in comparison to L1 processing, or vice versa for nongrammatical constraints. Comparing L1 and L2 speakers' processing of English reflexives, Felser and Cunnings (2012), for example, found that the grammatical constraint known as Condition A of the binding theory (Chomsky, 1981) was applied immediately in L1 processing but only became operative after some delay in L2 processing. The learners' eye-movement patterns led the authors to hypothesize "that the timing of discourse-level constraints precedes that of phrase structure-based coreference constraints in L2 processing" (Felser & Cunnings, 2012, p. 600).

L1/L2 differences in the relative timing of effects or of different information sources are also sometimes observed in studies on the processing of filler-gap dependencies. Examining comprehenders' sensitivity to complex subject islands using eye-movement monitoring, Boxell and Felser (2017) found that unlike native speakers of English, L2 speakers initially violated the island constraint by postulating gaps in unlicensed positions, showing sensitivity to island regions only in later processing measures. Delays in the timing of expected effects are also sometimes observed in studies using event-related brain responses, another experimental technique providing a fine-grained temporal resolution (see Morgan-Short, 2014; Steinhauer et al., 2009, for review and discussion).

Concluding that L2 processing is generally hampered by delayed sensitivity to information encoded in the input would most likely be wrong, however. Results from several reading-time studies indicate that some types of information may in fact influence processing *earlier* in an L2 than in the L1. This was the case, for instance, in Pan and colleague's (2011, 2015) studies on the influence of referential context information on ambiguity resolution. Although information provided in the preceding extrasentential context affected native and nonnative speakers' offline interpretation choices in the same way, only the nonnative participants' online ambiguity resolution preferences were affected by interpretation biases created by the referential context. In Roberts and Felser's (2011) study on the resolution of subject/object ambiguities, L2 speakers showed sensitivity to semantically implausible direct objects as soon as they encountered these, whilst comparable effects were delayed or absent in the native controls. A similar

https://doi.org/10.1017/S0272263117000250 Published online by Cambridge University Press

pattern was seen in an eye-movement monitoring experiment on *wh*-dependency formation reported by Felser, Cunnings, Batterham, and Clahsen (2012), with L2 speakers showing earlier sensitivity to implausible direct object fillers than did the native speaker controls. For morphology, results from a visual-world eye-tracking study on the time-course of compounding constraints (Clahsen et al., 2015) revealed that in L2 comprehension, the semantic constraint (against plural compound modifiers) became operative earlier in time (relative to the morphological constraint) than in L1 processing.

Taken together, these findings are suggestive of L1/L2 differences in the relative timing of grammatical versus nongrammatical information. The SSH should thus not only include assumptions about constraint weightings but also about the timing of different types of constraint or information sources in L1 versus L2 processing. We hope that the number of linguistically and psycholinguistically informed L2 processing studies will continue to rise, so that we can obtain a more comprehensive and nuanced picture of L1/L2 processing differences and similarities that will inform theory building or theory refinement.

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