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Building Bridges: Slavic Linguistics Going Cognitive

Steven Franks (1996) in his Reflections piece from the *Journal of Slavic Linguistics* made a comment that "...the walls that divide us [linguists] are coming down all over. What's next?", he asked. "Cognitive Science?" I think the answer to this question is a definite yes. The ability to produce and comprehend language is crucial for functioning in our society, and for the past two decades, linguists have devoted a great deal of attention to the question of how adult readers and listeners recover the linguistic structure of a sentence. Influenced by work in psychology and computer science, the research carried out by psycholinguists has increased our understanding of the psychological mechanisms underlying language performance. In this article, I provide an overview of the position of psycholinguistics in cognitive science and specifically, the emergence of psycholinguistic work in the field of Slavic languages and a tentative agenda for future research.

I first sketch the current state of cognitive science, including its goals, some practical aspects related to working in this field and the position that linguistics in general occupies in cognitive science. Then I present a more detailed analysis of the role of psycholinguistics as a central component of cognitively-oriented linguistic research. The emphasis is on the experimental and methodological developments that allow us to study language performance on-line and influence our understanding of language competence. The specific interest is in showing the importance of contribution of Slavic psycholinguists because Slavic data provide new testing grounds for current psycholinguistic theories developed predominantly for English. Finally, I try to identify

promising research directions and the topics for future research for which Slavic data will be most uniquely suited.

1. Cognitive Science and Linguistics as its Constituent Discipline

Cognitive science understood broadly (Lepore and Pylyshyn, 1999; Bechtel and Graham, 1998; Johnson and Erneling, 1997; Solso, 1997) comprises the investigation of the processes and mechanisms by which human beings and other systems, including machines and certain species of animals, acquire knowledge about their environment, store and retrieve that knowledge, and use it to carry out actions, manipulate the environment, and communicate. The central assumption of cognitive science is that intelligent processes can be modeled as an information processing system. To pursue a theory of intelligence based on this assumption requires an interdisciplinary approach involving computer and information science, psychology, linguistics, neuroscience, and philosophy. These five disciplines constitute a core of cognitive science complemented by a number of satellite disciplines such as mathematics, anthropology, biology, and instructional science. Schunn, Crowley, and Okada (1998:108) emphasize that cognitive science has emerged because scholars from these disciplines can gain new ideas, theories and methodologies from one another.

The field of cognitive science emerged in the late 1970s with the publication of the journal *Cognitive Science* and the organization of the Cognitive Science Society, important institutions for any academic discipline activities. I will rely on statistical data published by Schunn, Crowley, and Okada (1998) concerning the journal and the society to give a brief overview of cognitive science and the place of linguistics as one of its constituent disciplines. The field has been rapidly growing since its inception as reflected in editorial policies, reviewing practices, conference organization strategies, research funding, and the training of future scientists. Schunn, Crowley, and Okada report that the number of departments and institutes of cognitive science worldwide has grown to 47 by 1996. The constituent disciplines that dominate cognitive science are psychology and computer science, with linguistics coming in third, followed by neuroscience and philosophy. This hierarchy explains the distribution of methodologies in cognitive

science research; empirical studies of behavior and computer simulations predominate. Monodisciplinary methodologies (only empirical or only simulation) still constitute the majority of research, the use of work combining the methods of psychology and computer science (experiment plus simulation) has doubled in the last 15 years. While the Cognitive Science Society, the main professional organization which brings together computer scientists, psychologists, linguists, neuroscientists, and philosophers is still primarily a conjunction of researchers from different disciplines, cognitive science is on its way to becoming a separate discipline with distinct editorial and reviewing practices and professional society, conferences, and departments.

Cognitive Science (CS) centers and departments are flourishing in many places in the US and appear to be well supported both by private foundations and government. For example, the Institute for Research in Cognitive Science at the University of Pennsylvania established in 1990 is supported by an continuous training grant from the National Science Foundation and is one of 25 NSF-funded Science and Technology Centers in the US. Cognitive science programs and center in several large research universities, for example, in Brown University and Rutgers, are funded through the NSF Integrative Graduate Education and Research Training Program. Other major Cognitive Science programs exist at Cornell, the University of Rochester, Johns Hopkins University, MIT, University of California at Irvine, San Diego and Berkeley, to name a few. In such programs, several departments contribute faculty on a joint-appointment basis. Through the Cognitive Science programs and centers, fellowships from NSF and the National Institutes of Health are available for both undergraduate and graduate students. They offer degrees (Ph.D., MA, BA) and certificates in CS. In 1996, there were 20 universities in the US offering a degree in CS. Many of them also provide postdoctoral fellowships, an excellent starting point for young scholars in a market with very few available academic jobs.

Linguistics has historically been the third constituent discipline in cognitive science, following psychology and computer science. The premise is that cognitive science, understood as a broad discipline, allows us to approach the traditional goal of studying the language beyond the perspective of theoretical linguistics. The multidisciplinary

nature of the research goes much deeper in cognitive science than in many other interdisciplinary fields. For example, the study of how human language is understood by humans, might involve considerations that are equally widely dispersed across academic disciplines—including physical acoustics, psychophysics, linguistics, psycholinguistics, the study of discourse processes, as well as issues of philosophy of mind.

Let us consider a concrete example which illustrates why linguistics comes in only third among the five constituent disciplines in cognitive science. In the period between 1977 and 1995 divided into three year sample periods, only seven of the authors published in *Cognitive Science* had linguistics as their departmental affiliation. When Schunn, Crowley, and Okada (1998) analyzed the discipline of the literature cited in articles, they found 35 linguistics citations. Linguistics was one of only two disciplines (along with cognitive science per se) that represented more than 10% of citations at any point in these nine years. “The participation of linguistics in the journal is larger in citation data than in the affiliation data: while few linguists publish in *Cognitive Science*, a fair number of *Cognitive Science* authors read linguistics.” (Schunn, Crowley, and Okada, 1998:115). On the other hand, there were no references to Cognitive Science in *Linguistic Inquiry* between the years of 1980 and 1994

Why have linguists not taken a greater role in cognitive science? Several factors contribute to this effect; among those are editorial and reviewer bias, and asymmetries in the size of each constituent discipline. A sample on-line search performed by Schunn, Crowley, and Okada (1998) for the period of 1990 - 1995 showed that linguistics produced over 25% more conference papers than psychology but fewer journal articles and books. There is often disciplinary narrowness when we talk about theoretical linguistics. Because universities are mostly organized along disciplinary lines, it is hard to establish well-integrated cross-departmental programs. Establishment of greater infrastructure such as interdisciplinary institutes, is known to be a strong factor in the occurrence of collaborative research, yet limited resources devoted to funding research in linguistics in general present additional obstacles to this development.

Linguistics students who want to focus on cognitive science are expected to master linguistics just as every other student does. But because it is also important that cognitive

researchers acquire the theoretical framework and methodology of the basic disciplines, they are also expected to master parts of the many disciplines that contribute to cognitive science, a very challenging task. Despite all of this, such efforts may indeed be worth it. Affiliation with a Cognitive Science program for a linguist means not only obvious benefits stemming from interdisciplinary collaboration but also better funding for research and conference-related travel, more venues for publishing and presenting, and additional employment opportunities.

2. Psycholinguistics as a Central Component of Cognitively-Oriented Linguistic Research

There are literally hundreds of language-related topics in cognitive science — natural language processing, social cognition and language, voice recognition, knowledge acquisition, cognitive development, to name a few. “Not surprisingly, language appears to be a major topic in cognitive science. The psychology of language links linguistics and psycholinguistics. Linguists describe the product, whereas psycholinguists attempt to specify how language is produced and comprehended by the human brain and why and how it has evolved in the form it has.” (Denis 1998: 381) Thus, psycholinguistics, is in a perfect position to play the role of the central component of cognitively-oriented linguistic research. One argument in favor of psycholinguistics’ importance is that it investigates language as a human cognitive function and provides data that are relevant for other disciplines. Another factor is methodological expertise of psycholinguists in collecting and analyzing empirical data. This unites psycholinguistics with cognitive psychology, a foundation for any cognitive science program. Cognitive theory is the dominant paradigm in the US, and language is fundamental for cognitive functions. Thus, research on human cognition in general and psychology of language in particular should provide information and possible models that could inform computer science and constrain theoretical linguistics. Psychology and psycholinguistics by extension provide both the core theoretical and empirical basis for advancing the field. If cognitive science is to be a science, it must be based on empirical research that makes use of experimental procedures.

Historically, psycholinguistics started as a discipline which united three broad research fields, psychology of adult language, language acquisition, and biological foundations of language. However, in the past 15 years, these fields have branched out into separate but closely related disciplines, psycholinguistics per se, acquisition (see the article on acquisition and Slavic languages by Polinsky in this volume), and neurolinguistics. I will not have much to say about the latter two except for the cases of multidisciplinary research in psycholinguistics. (It is appropriate to mention here, however, that neurolinguistics, a constituent component of rapidly growing cognitive neuroscience, is gaining more and more weight.) The rapid growth of the field made it necessary to initiate a specialized annual conference and to publish new journals. Since its inception in 1987, the CUNY Annual Conference on Human Sentence Processing has expanded from a one-day round table discussion to a 200-plus participant multinational conference which sets scholarly standards in the field. In addition to more general psychology-oriented journals such as *Cognition*, *Journal of Memory and Language*, *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *Language and Cognitive Processes*, psycholinguistics is in the focus of the *Journal of Psycholinguistic Research*. Many Linguistics and Psychology departments in this country (University of Pennsylvania, University of Massachusetts at Amherst, Ohio State University, CUNY, University of Southern California, University of Arizona, University of California at San Diego, among others) have a strong psycholinguistic component in their curriculum, psycholinguistic laboratories with excellent experimental equipment and research funds, and graduate highly trained psycholinguists.

Psycholinguistics is concerned with psychological aspects of language studies (Cairns, 1999; Tarter, 1998). It must attempt to provide a comprehensive and unified theory of language behavior, accounting for how natural language constrains us into the set of processing and production strategies that characterize real-time language use. Two types of language behavior that constitute the core of psycholinguistic research are *production* and *comprehension* and are discussed separately in Section 2.2. *Speech production* (Bock, 1991) involves how a speaker translates information and intentions into the language formats available in a particular language. Production rules are not as

easily accessed by experimental techniques as in comprehension. *Comprehension*, often thought as a mirror-image of production, is concerned with what people do when they listen to speech, and it presupposes a multi-level analysis of the incoming speech at the phonological, lexical, syntactic, and discourse levels.

2.1. Experimental Methods and Techniques in Psycholinguistics

The crucial aspect of psycholinguistics *per se* which distinguishes it from mainstream linguistics and relates it to psychology is that its methodology is based on experimental techniques. The latter come in two varieties, *off-line* and *on-line*. Off-line techniques (Cowart, 1997) involve non-time-based measures, for example, recording a participant's subjective judgment of a stimulus. In off-line techniques no processing load can be measured. On-line methods rely on recording reaction times (measuring the time it takes a subject to make some subjective judgment). In contrast to off-line methods, on-line ones offer an insight into immediate, moment-to-moment language processes and allow measuring of processing load.

Both off-line and on-line methods are used in studying various aspects of production and comprehension, and some can be successfully applied to both. Traditionally, however, psycholinguistic research is heavily biased towards studying comprehension. An approximate estimate is that 80% of experimental work is focused on comprehension due to difficulty in eliciting comparable and consistent data from participants in a production experiment. In a comprehension study, the experimenter provides carefully designed and balanced stimuli.

Comprehension can be studied in reading or with spoken language. Methods in reading research (Haberlandt, 1994) are based on an important assumption that longer processing times reflect a greater processing load and require justification of the choice of stimulus materials (ecological validity). It is also assumed that components of reading include the word, sentence, and text levels. The two major classes of on-line methods in reading are summarized in (1):

- (1) 1. Reading-Time Methods
 - 1.1. Self-paced moving window

1.2. Recording of eye movements (with head immobilization)

2. Decision Methods

2.1. Lexical decision

2.2. Naming

2.3. Cross-modal priming

Self-paced moving window is the least complicated and the most popular experimental technique for studying comprehension in reading, and is predominantly used in Slavic psycholinguistics so far (see discussion in Section 3 below). In a self-paced moving window experiment, a chunk of text, usually a word or a phrase, appears on a screen and the reader exposes successive fragments of the text, the windows, by pressing a key on a computer keyboard or on a button-box. This allows the participant to read a passage at a pace that matches the internal comprehension processes. In addition to the assumptions mentioned above, the interpretation of reading times is based on two hypotheses, the immediacy and the eye-mind hypotheses. The immediacy hypothesis states that comprehension is incremental, fast, and without delay. The eye-mind hypothesis presupposes that the mind processes the word currently fixated by the eye. This technique while widely used, has limitations compared to a more direct method of recording eye movements. Most of these limitations such as low correlation between reading times and gaze durations ($r = .57$), reading times that are 80% longer, physical limitations of the presentation conditions, and lack of regressive eye movements are overcome in eye movement experiments.

Recording of eye movements (Rayner and Sereno, 1994) is the most direct on-line technique available so far in experimental psycholinguistics. Here the assumption is that eye movements are closely time-locked to processing and reflect mental processes involved in reading comprehension. As in the self-paced moving window technique, a text appears on a computer screen specially calibrated to track participant's eye movements. Movements are recorded together with fixations. This method is technically complicated and labor-intensive because it produces a huge amount of data: vertical and horizontal positions of the eye are sampled up to 1000 times per second. For each word, the following information is obtained: first fixation, a sum of total durations minus

regressions, fixation duration (usually 200-250 ms), and frequency of regressions (10-15% of eye movements are regressions). Variability associated with each of these measures is related to cognitive processing during reading. In contrast to the self-paced moving window technique, recording of eye movements is a natural on-line method, that does not require an artificially induced quality-control task. The main disadvantages of this method, in addition to expensive equipment and labor-intensive procedures, is the requirement that a participant's head be immobilized during the experiment. This is usually achieved with the help of a bite bar.

The second major class of experimental on-line methods used in studying reading comprehension is *decision methods*. The decision methods call for a speeded decision from the participant in response to a target item (yes/no; same/different; new/old, etc.). The reaction time is thought to reflect the activation of the information, both explicit and inferred. In the simplest case, it is inversely proportional to the activation of the information. In experiments with *lexical decision*, the participant sees a string of letters, for example, *candle* or *assintart*, and decides whether or not the string represents an English word. The latency of pressing one of two keys ('yes' or 'no') is assumed to reflect the access time of the word. Latencies are faster for more familiar words and are primed by semantically related and associated contexts. When *naming* task is used, participants read a study passage that is followed by the visual presentation of a target. The participant makes a vocal response such as naming the target item, or giving a one-word answer. Highly active concepts are more available for pronunciation, and positive targets are named more quickly.

Both lexical decision and naming tasks constitute a necessary component of *cross-modal priming*, a method developed twenty years ago (Swinney, 1979). It includes lexical decision or naming tasks as a basic component. The innovative characteristic of the cross-modal priming is the advantage of using two different modalities, visual and aural, in such a way that experimental stimuli are presented in one modality and primes in the other. For example, a cross-modal priming experiment with lexical decision, the participant listens to a sentence over headphones and sees a visually presented test item, the prime. The participant presses a button to answer the question of whether this prime

is a word of English or not. While cross-modal priming is less technically complicated than recording of eye movements, it requires very careful planning, selection and balancing of the target words, primes and control words. Prerequisites for conducting an interpretable experiment using this method include access to a large and accurate parsed corpus of the language, with absolute and co-occurrence frequencies, and large-scale norming data collected off-line.

The techniques introduced above are oriented towards research in reading comprehension. However, it is well known that reading is not a primary cognitive skill but an acquired one. People spend disproportionately more time listening than reading. Moreover, large classes of population such as, for example, preschool-age children and illiterate adults cannot read. Concentration on comprehension in reading leaves behind the basic skill of comprehension of speech and processing behaviors by these people. One reason for this imbalance is the lack of suitable experimental techniques to study spoken language comprehension. Recently, a new on-line technique which records the participant's eye movements using a *free-viewing eye-tracking system* has been developed (Tanenhaus, Spivey-Knowlton, Eberhard, and Sedivy, 1996; Ferreira and Henderson, 2004). It makes it possible to visually monitor the participant's interpretation of the context while spoken language is being processed. Participants' eye movements are recorded as they respond to spoken instructions asking them to move real objects. This technique provides a new means of examining the moment-by-moment processes of language comprehension, in the relatively natural situation of acting upon spoken instructions. So far, the free-viewing eye-tracking method has been successfully used for English to study word recognition (Allopena, Magnuson, and Tanenhaus, 1998) attachment ambiguities (Tanenhaus et al., 1995; Trueswell et al., 1999), referential ambiguity (Sedivy et al., 1999), pronoun resolution (Arnold et al., 2000) and language production (Griffin and Bock, 2000). The first experiments to apply this technique to study resolution of referential ambiguity in Russian are summarized below in Section 3.2.4.

2.2. Topics in Psycholinguistics

The experimental methods and techniques briefly described above constitute an empirical basis of psycholinguistics. Its main themes closely match the traditional subfields of theoretical linguistics. Phonological aspects of language are studied by *psychophonology*, syntax by *sentence processing*, and lexical semantics and to a certain extent morphology, comprise the studies of *mental lexicon*.

2.2.1. Speech Perception and Speech Production

The basis for psychophonology lies in *speech perception* (Yeni-Komshian, 1993). It is the process by which people decode spoken messages and by which they assign identity to speech sounds. Speech perception research is extremely recent in origin, becoming possible only with the development of equipment for speech analysis and synthesis. The basic task of speech perception is to extract phonetic segments from the speech signal and then organize them into higher units such as syllables and words. Thus, the major research issues have to do with delineation of the mechanisms we use in segmenting and recognizing speech. The work of Cutler and her colleagues (Cutler and Otake, 1994; Bradley, Sánchez-Casa, and Garcia-Albea, 1993; Cutler, Mehler, Norris and Segui, 1986) exemplifies the most important question in speech perception: what is the basic unit of perception and does it vary from language to language? Experiments with speakers of French, Spanish, English, and Japanese showed that the main unit of perception in Romance languages is a syllable, but in Japanese, it is a mora. Slavic languages which differ with respect to their syllabic structure and stress rules patterns (Russian vs. Czech) may contribute valuable data to this debate.

The mirror-image of speech perception in comprehension is the phonological component of speech production. The actual production of real-time speech is filled with pauses, hesitations, corrections, repeats and replacements, and slips of the tongue. The primary source of data in production is *speech errors* (Fromkin, 1988) because they allow us insight into the actual process which takes us from concept to realization of the message. Since errors result from misapplication of linguistic rules, they also serve as a

testing ground for whether the theoretical concepts linguists propose are matched in the way units are altered, exchanged, or lost. Note that to study production we need a relatively representative corpus of speech errors for any given language. While there are such corpora for English, German, French, and Spanish, there are no Slavic corpora yet (cf. Ceytlin, 1997).

2.2.2. Lexical Processing

Marslen-Wilson (1987:71) once wrote:

“To understand spoken language is to relate sound to meaning. At the core of this process is the recognition of spoken words, since it is the knowledge representations in the mental lexicon that provide an actual bridge between sound and meaning...”

(Marslen-Wilson 1987:71)

Lexical processing in comprehension is viewed as an instance of token-type assignment; that is, the job of the lexical processor is to discover the mental type of which a given word is a token. How is lexical processing organized so that when a particular sequence of letters occurs, a particular set of memory traces is automatically selected? Word recognition and lexical access constitute two major components of research on lexical processing and mental lexicon. Word recognition has been studied extensively in many languages using various techniques (Caramazza, Laudanna, and Romani, 1988; Allopenna et al., 1998) but only beginning in Slavic languages (Libben and Jarema, 2002).

Word recognition serves as the front end to lexical access. Models of lexical access have to specify three things. First, the input description, that is, how the input is represented so that the mental inventory of lexical units can be addressed. Second, the mechanism of association, or how lexical representations which are match candidates are discovered. Finally, the evaluation metric is required: How is the match between an input and a candidate evaluated? Three influential models of lexical access have been proposed, the Logogen (Morton, 1979), the Cohort (Marslen-Wilson, 1987), and the Search (Bradley and Forster, 1987; Forster, 1990) models, and each of the models addresses these questions from the point of view of English. How do the models of lexical access treat languages whose grammar is determined by rich inflectional and

derivational morphology? Several recent experiments in Serbian/Croatian (Feldman and Fowler, 1987), Russian (Gor and Chernigovskaya, 2001), Polish (Perlak and Jarema, 1999; 2001), and Bulgarian (Andonova et al., 2004) have been conducted to test various existing models of lexical access (see Section 3.2.3). Which of the proposed models fits other Slavic languages the best is a topic for future research.

2.2.3. Sentence Processing

Just as the grammar is the central object of investigation in theoretical linguistics, the human sentence processing mechanism, or the processor, is the focus of psycholinguistics and constitutes the goal of sentence processing research (Frazier, 1987; Tanenhaus and Trueswell, 1995). *The processor* (also known as *the parser*) reconstructs the syntactic structure of the sentence, the hierarchical organization of its constituents. Fodor (1995:220-221) gives the following definition of the processor and the principles it employs:

“One of the projects of psycholinguistic research is to map out the structural guesses that the sentence processor makes, by establishing which sentence completions are easy and which are difficult for all sorts of temporary ambiguity. From this we can hope to infer what kind of machine this processor is... With regard to phrasal structure, what the human processor likes best is simple but compact structures, which have no more tree branches than are necessary, and the minimal tree-distance (walking up one branch and down another) between any pair of adjacent words.”

(Fodor 1995:220-221)

The most revealing way to study processing mechanisms and principles is by investigating syntactic, or structural, ambiguities because processing of unambiguous sentences doesn't allow us to compare and tease apart various psycholinguistic hypotheses and theories.¹ A string of words is structurally ambiguous if it is compatible with more

¹ Obviously, there are other ambiguities in the language, for example, homophones, homographs, and lexically ambiguous words.

than one syntactic analysis. Such ambiguity can be global, as in (2), or temporary, as in (3) (3b is from Fedorenko et al., 2004); all examples are from Russian.²

- (2) a. Вчера приехавший артист выступил на концерте.
 Yesterday arrived-PART artist performed at the concert
 ‘Yesterday the artist who just came performed at the concert.’
- b. Чтение Маяковского продолжалось за полночь.
 Reading Mayakovsky-GEN continued after midnight
 ‘Mayakovsky’s reading continued after midnight.’
- (3) a. Банки стимулируют обещания вернуть Финляндию.
 Banks-ACC stimulate promises-NOM to return Finland
 ‘The banks are stimulated by promises to return Finland.’
- b. Непослушную девочку брата уговорила навестить
 Disobedient girl-ACC brother-ACC talked into visiting
 беспокоящаяся мать.
 worried mother-NOM
 ‘The worried mother talked the disobedient girl into visiting her brother.’
- (4) #Маленькому красные он дал яблоки мальчику.
 little-DAT-Sg red-ACC-Pl he gave apples-ACC-Pl boy-DAT-Sg
 ‘He gave the red apples to the little boy.’

Each sentence in (2) can have two equally grammatical interpretations. In (2a) it can be either the artist who came yesterday or the artist who performed yesterday. In (2b), it can be either reading of Mayakovsky’s poems or reading of poems by Mayakovsky himself. The examples in (3) are temporarily ambiguous: *банки* ‘the banks-NOM/ACC’ can be initially interpreted as the subject of the sentence resulting in a need to reanalyze this interpretation at the point of pragmatic disambiguation, the second NP *обещания* ‘the promises-NOM/ACC.’ In sentence processing, such sentences are known as *garden-path*

² The following abbreviations for grammatical features are used: PART- participle, NOM – nominative case, GEN – genitive, ACC – accusative, DAT – dative, PREP – prepositional, Sg – singular, Pl – plural, MASC – masculine, FEM – feminine.

sentences (Frazier, 1987). Together, globally ambiguous (2), garden-path sentences (3), and grammatical but unacceptable sentences (4) constitute the most revealing testing grounds for different theories of sentences processing.

The central issue in current work on sentence processing is to describe how readers and listeners recover the linguistic structure of a sentence and how they coordinate different types of constraints to resolve numerous ambiguities that arise during on-line comprehension. This issue has received the lion's share of attention resulting in two major competing classes of models in sentence processing. A preference for detailed theories of processing is a hallmark of the cognitive science approach and, to a great extent, is the source of the theoretical and empirical contribution to our current understanding of language comprehension. The two most influential theories can be broadly defined as *modular* and *interactionist*. According to the modular approach, processes which construct the syntactic structure of a sentence initially operate independently from processes that are responsible for semantic and pragmatic interpretation of a sentence in discourse. In contrast, the interactionist models assume that syntactic interpretation takes places with respect to a reader or listener's knowledge of the contents of the prior discourse; this knowledge forms the context in which the sentence is processed. Thus, in the modular structure-based Garden-Path model (Kimball, 1973; Frazier and Fodor, 1978; De Vincenzi, 1991; Frazier and Clifton, 1996, among others), context does not influence the initial preferences in resolving local ambiguities as the syntactic structure is being built, but only later gets incorporated into semantic interpretation. In the interactive Constraint-Based model (MacDonald, Pearmutter, and Seidenberg, 1994; Tanenhaus and Trueswell, 1995, among others), the parser is capable of coordinating the linguistic properties of the message with information from the context to determine processing commitments. On this it bases its ambiguity resolution strategies. The debate over which model should be preferred has generated a great number of empirical studies, and untested languages like Slavic may cause substantial modifications to existing theories of sentence processing.

Note, however, that while cross-linguistic studies in syntax have been important for some time, only recently has cross-linguistic investigation come to be used as a research

paradigm for studying sentence processing. This development is parallel to development of the Principles-and-Parameters model in the generative grammar theory (Chomsky, 1986) and relies on the concept of the Universal Grammar. It is not plausible that a grammar is composed from scratch by every infant, therefore, it must be largely innate. By the same token, it is equally implausible that processing routines are composed from scratch by every infant and, thus, they too must be largely innate, (i.e., there is universal parser.) But we know that grammars cannot be entirely innate because of cross-linguistic variation. In contrast, parsers might be entirely innate, if their only source of variation is the grammar they work with. What kind of data would necessitate giving up this null hypothesis of the universal parser? The answer is : different parsing strategies (as revealed in ambiguity resolution, processing of garden path sentences, and processing complexity metrics) for the same structure in different languages.

The development of this research program brought under consideration data from numerous different languages. For example, one principle of the Garden-Path model in particular, Late Closure (Frazier, 1987), has been proposed as a candidate for possible cross-linguistic variation in processing. The Late Closure (LC) principle requires that when possible, incoming material should be attached into the clause or phrase currently being parsed (i.e., the lowest possible nonterminal node dominating the last item analyzed.) Thus, globally ambiguous sentences of the form exemplified in (5) for English and their exact counterparts from Spanish (6), should be processed according to LC: the interpretation (a) should be preferred over (b) because the relative clause *who was on the balcony* is supposed to attach low, i.e., it should modify the second NP *the actress* in the complex NP *the servant of the actress*.

- (5) Someone shot *the servant* of *the actress* who was on the balcony.
 a. Someone shot the actress who was on the balcony.
 b. Someone shot the servant who was on the balcony.
- (6) Alguien disparó contra *el criado* de *la actiz* que estaba en el balcón.

If LC is a universal principle of parsing, the low attachment of the relative clause (5a) should be preferred in all languages. However, experimental investigation of many revealed that for the sentences in (5)-(6), the low attachment interpretation is preferred only in English (Clifton and Frazier, 1996; Gibson et al., 1996). In all other languages such as Spanish (6) (Cuetos and Mitchell, 1988; Cuetos et al., 1996), French (Zagar et al., 1997), Italian (De Vincenzi and Job, 1993), German (Hemforth et al., 2000; Sauerland and Gibson, 1998), Dutch (Brysbaert and Mitchell, 1996) and Japanese (Kamida and Mitchell, 1996), high attachment is preferred. Recently, more detailed explanations regarding factors that influence preferences in relative clause attachment ambiguity have been proposed. It turns out that many factors such as type of preposition, referentiality, argumenthood, definiteness, deverbal derivation, and focus assignment can change attachment preferences. How do Slavic languages behave with respect to the Late Closure principle? First attempts to uncover the role of LC in Slavic are discussed in Section 3.2.4 below.

The work of Swinney (1979) on cross-modal priming has opened another very productive research topic, that of processing of empty categories. Linguistic theories differ with respect to whether they postulate empty categories at all and if so, what the inventory of these empty categories is. While Head-Driven Phrase Structure Grammar (Pollard and Sag, 1994; see also the article by Przepiórkowski in this volume) allows only for one type of empty categories, the Wh-trace, represented as a slash category, the standard GB theory identifies four possibilities, with NP-trace, PRO, and *pro* in addition. In sentence processing, constructions which involve empty categories created by syntactic movement of arguments are known as *filler-gap dependencies*. Empirical findings on psychological reality of empty categories may provide crucial evidence on

distinguishing between different linguistic theories. The psycholinguistic approach to empty categories involves finding what mental representations people assign to filler-gap sentences when they comprehend them, and then looking at what empty categories the representations contain. Using cross-modal priming technique, Nicol and Swinney (1989) found reactivation of the semantically related probe at the gap position of the Wh-word in the sentences with relative clauses, and crucially, not in other positions. These findings were taken as evidence for psychological reality for the Wh-trace. Subsequent experiments (Bever and McElree, 1988) showed that for PRO and NP-trace, antecedent reactivation is much more sluggish and less precisely tuned to syntactic constraints.

Although Wh-Movement was the central topic in the investigation of filler-gap dependencies, other types of movement are studied as well. In particular, noncanonical word orders created by Scrambling appear to produce controversial results. Clahsen and Featherston (1999) found antecedent priming at the trace position of the scrambled direct object in German, while Bader (1994) argued that in self-paced reading experiments, there was no difference in reaction times between German unscrambled and scrambled sentences. Increased reaction times (RTs) in scrambled sentences as compared to control ones is usually taken as evidence for processing load. Word order effects in processing of Slavic languages are discussed in Section 3.2.4 below.

3. Slavic Psycholinguistics: Current State

The field of theoretical Slavic linguistics can be considered well established, on a par with linguistic research in other language families such as Romance, Germanic, and Asian. Franks (1996:4) named quite a few Slavic linguists who successfully work in phonology, syntax, and semantics of Slavic languages. Among these people, there are senior and junior scholars who publish in general linguistics journals, such as the *Linguistic Inquiry*, *Language*, *the Natural Language and Linguistic Theory*, and present at theme-oriented conferences, NELS, LSA meetings, ESCOL, WCCFL, GLOW. At the same time, a Slavic forum, the Annual Workshop on Formal Approaches to Slavic linguistics (FASL), and a specialized journal, *the Journal of Slavic Linguistics*, provide

an opportunity to discuss in detail issues in theoretical Slavic linguistics from a generative perspective.

3.1. Geography

It is well known that syntax is at the heart of FASL, with small infusions of phonology and semantics. In the past four years, however, we have seen signs of the situation starting to change, with the Workshop issuing calls for papers which include topics beyond traditional theoretical linguistics. In 1999, for the first time, FASL-8 had a special session on cognitive science and Slavic languages thereby providing a forum for computational linguists and psycholinguists who have comprehensive knowledge of Slavic language data. There are so far only few people who work on Slavic psycholinguistics but fortunately more laboratories are becoming interested in cross-linguistic experimental research, and our number is growing. A number of experimental studies in Russian, Serbian, Croatian, Bulgarian, and Polish have been conducted and published that investigate processing aspects of verbal morphology (Gor and Chernikovskaya, 2001; Perlak and Jarema, 1999), the role of grammatical gender (Mirković et al., 2005; Sekerina and Pugach, 2005; Taraban and Kempe, 1999) agreement errors in production (Nicol and Wilson, 2000), grammatical features (Fedorenko et al., 2004), relative clause attachment ambiguity (Lovrić, 2000; Sekerina, 2002; Sekerina et al., 2004), processing of free word order (Sekerina, 1997; 1999b; Stojanović, 1999) and referential processing (Sekerina, 1999a).

Even more exciting is emergence of psycholinguistic laboratories in Europe (Germany, Bulgaria, Czech Republic, Russia) conducting experimental work with Slavic languages. In Germany, an active research program on processing of information structure in Russian is carried out at the Institut für Slavistik at Leipzig University (Zybatow and Mehlhorn, 2000; Mehlhorn, 2004), on psychophonology at the Max-Planck Institute for Human Cognitive and Brain Sciences (Alter, 1997; Alter et al., 2001) and at the Universität des Saarlandes (Andreeva et al., 2001). Research on Bulgarian gender processing and Bulgarian picture naming norms is underway at the New Bulgarian University (Szekely et al., 2004; Andonova et al., 2004). A team of linguists

from the Charles University in Prague is conducting a large scale norming data on the order of constituents in Czech (Sgall, Pfeiffer, Dressler, and Půček, 1995; Sgall, 2001). This interest in Slavic psycholinguistics among European scholars is reflected by an rapidly growing number of presentations in this area at the Formal Description of Slavic Languages (FDSL) conference, a European counterpart of the FASL Workshop held every two years since 1995 at Leipzig and Potsdam in Germany.

Finally, despite its traditional closeness, a number of departments in Russia have the potential to embark on the experimental psycholinguistic work similar to the western research program. In St. Petersburg, Tatiana Chernigovskaya leads the St. Petersburg's school of psycholinguistics whose main areas of research are neurolinguistics (Chernigovskaya, 1994; 1999) and acquisition (Ceytlin, 1997). Given the resources and an impressive academic support infrastructure, experimental investigations of language performance in normal Russian-speaking adults is the next logical step. The Program in Theoretical and Applied Linguistics at the Philological Department of the Moscow State University has established a new experimental psycholinguistic laboratory in which relative clause attachment ambiguity and agreement errors in production in Russian are currently being investigated (Fedorova, 2004; Fedorova, 2005; Fedorova and Yanovich, 2005).

3.2. Topics

Because research on Slavic psycholinguistics is new, relatively few topics have been investigated so far. There are two common ways of approaching an unresearched language. The first is to take an existing line of research in English (and other languages) and modify it to accommodate Slavic data. The goal is to see whether the English results can be directly replicated or whether Slavic languages demonstrate some interesting differences. It is an excellent way to initiate one's graduate career as a Slavic psycholinguist. This kind of work is exemplified by Nicol and Wilson (2000), Sekerina (1997, 1999a), Stojanović (1999), Stamenov and Andonova (1998) (see below). The second, more challenging approach is to take specific a phenomenon specific to Slavic and to try to work out the psycholinguistic analysis for it, including choosing a new

hypothesis or technique. Ultimately, critical contributions of Slavic psycholinguistic research to theorizing about human processing mechanisms will lie in this second approach. Such innovative experiments by Zybatow and Mehlhorn (2000), Fedorenko et al. (2004) and Sekerina (1999b) are discussed below. To relate Slavic psycholinguistic work to the discussion of general psycholinguistics in Section 2, Slavic experiments are divided according to the topics introduced therein, production, lexical processing, and sentence processing. Necessarily, due to the space limitations, these will be sketchy; I refer the reader to the original articles for details.

3.2.1. Psychophonology (Zybatow and Mehlhorn, 2000; Alter et al., 2001).

Zybatow and Mehlhorn (2000) report the results of an elicited production study designed to investigate experimentally the prosodic means of expressing focus in Russian. Focus is one of the components of *Information Structure* (Junghanns and Zybatow, 1997) in which different discourse functions are associated with various syntactic constituents in the sentence. Focus is understood as the most prominent information from the speaker's perspective in a given context and can be of three types: neutral, contrastive, and verum. The idea behind the experiment is to find out whether the three types of focus have special prosodic characteristics in production and, if so, what these characteristics are. Sixty experimental sentences were embedded in appropriate contexts to form dialogues to guarantee the recognition of focus (7).

(7) A: Мне было очень смешно, когда я узнала, что твой дядя захотел купить
I-DAT was very funny when I found out that your uncle wanted to buy
дом в Италии. Он же всегда еле-еле сводил концы с концами.
a house in Italy He always barely was makings the ends meet
'I laughed when I found out that your uncle wanted to buy a house in Italy.
He was always barely making the ends meet.'

В: Но это так. [_{Focus} купил] мой дядя этот дом. Он неожиданно
получил в наследство много денег

But it is true. BOUGHT my uncle this house. He unexpectedly
received in inheritance a lot of money

‘But it is true. My uncle did buy this house. He unexpectedly inherited a lot of
money.’

Eight female participants have been recorded as they read the sentences aloud. The set of prosodic parameters were identified which differed for the three focus types. First, the participants were able to correctly identify the position of the focused constituent in the sentence as was reflected in their accent placement. Second, the neutral focus was distinct from both the contrastive and verum focus in terms of fundamental frequency F0 (HL* in the ToBI transcription, Jun, 2005) and length of the focus exponent (medium lengthening). The contrastive and verum focus were both produced with LH*+L pitch contour and substantial lengthening of the focus component. Thus, Zybatow and Mehlhorn showed that sentences with the same word order but ambiguous with respect to their information structure can be successfully disambiguated in production, given the appropriate context.

Alter et al. (2001) addressed the question of how focus is prosodically encoded in Russian looking at two additional prosodic correlates, accent placement and phrasing. Current research on prosody distinguishes between two types of languages: with prosodic realization of focus and with morphosyntactic realization of focus. In the first type, only accentuation and not prosodic phrasing is affected; in the second, there are focus-induced phrasing effects. Alter and colleagues recorded elicited production by one native female Russian speaker who read question-answer pairs with the answer in the form of NP₁ V₀ [PP] [NP₂]. Then they analyzed the prosodic means of encoding focus in Russian (both phrasing and accent were important). The preferred strategy used by the speaker depended on the position and type of focus: sentence-initial or -final and wide/narrow/contrastive. The results showed both the focus-induced prosodic phrase restructuring and differences in tonal alignment in Russian.

3.2.2. Production (Nicol and Wilson, 2000).

The previous research on English (Bock and Miller, 1991) has shown that participants make number errors in subject-verb agreement when the head NP is separated from the verb by intervening phrases (8a). However, there are fewer agreement errors when the intervening NP is a pronoun (8b):

- (8) a. The bill from the accountants ... was/*were
b. The bill from them ... was/*were

Nicol and Wilson (2000) hypothesized that Case-marking of the intervening NP may reduce its ability to influence the agreement process. Russian provides an opportunity to test this hypothesis because both nouns and pronouns are obligatorily Case-marked. Thirty-two native Russian speakers listened to four different types of sentence-initial fragments, repeated them and then finished the sentence (9).

- (9) a. Бухгалтер. Счет от бухгалтера ...
accountant the bill from the accountant
b. Бухгалтеры. Счет от бухгалтеров ...
accountants the bill from the accountants
c. Бухгалтер. Счет от него...
accountant the bill from him
d. Бухгалтеры. Счет от них ...
accountants the bill from them

The results showed that the participants produced significantly more agreement errors with the plural intervening NPs (9b, d), but the type of this NP (pronoun or lexical NP) had no effect on error rate. The error percentages were roughly equal to the error percentages from pronouns in the English study (see example (8b) above) which supports the initial hypothesis that Case-marking of the intervening NP reduced the extent to which it may interfere with agreement.

3.2.3. Lexical Processing (Feldman and Fowler, 1987; Perlak and Jarema, 2001; Gor and Chernigovskaya, 2001).

Some experiments on the organization of the mental lexicon of morphologically rich languages have shown that decision reaction times (see (1) above) were quicker with the NOM form of the noun than with any other Cases regardless of their frequencies. These results supported the Satellite model of the mental lexicon: the NOM form is central in storage and access while other Case forms cluster around the NOM but are equal among themselves. Feldman and Fowler (1987) investigated Serbo-Croatian nouns in order to answer the question of how nouns in singular inflected for Case might be related in the mental lexicon in reading. They replicated the earlier pattern of results, supporting the satellite model. Their data point in the direction of all inflected cases of noun forms being represented fully in the mental lexicon; but these forms are grouped together, with morphological relatedness as a basic principle of organization.

Perlak and Jarema (2001) investigated how aspectual forms of two regular verb classes are accessed and represented in Polish in an attempt to distinguish between three models of lexical access: the decomposition model, the full listing model, and the dual-access model. They contrasted aspectual forms derived from existing Polish verbal stems and from non-existing verbal stems. Twenty-seven native Polish speakers had to identify the target as a word or nonword of Polish, using the lexical decision task (see (1) above). The results showed significant differences in reaction times for perfective/imperfective infinitives and word stem for the existing verbal stems but not for nonwords. This was taken as evidence for the importance of the morphological structure in the lexical access of verb forms that favored the dual-access models of the mental lexicon.

Gor and Chernigovskaya (2001) investigated representational factors that are crucial for processing of verbal morphology in Russian. In dual-access models, regular verb forms are computed in a rule-processing system (no frequency effects), while irregular verbs are processed in associated memory (frequency-sensitive). In the single-access models, both regular and irregular verbs are processed by one single mechanism in associative memory, and, therefore, both classes of verbs should show frequency effects.

A list of 48 past tense plural forms derived from nonce verbs was presented to 27 native Russian speakers who generated the present tense third person forms in singular and plural. The results showed that the participants generalized the conjugational present tense formative *-j-* to all verbal stimuli (*мыть* ‘to wash’ ⇒ *мою* ‘I wash’ vs. **луть* ⇒ **лью*) supporting the dual-access models in which type frequencies and productivity of verb classes play a peripheral role in default processing of verbal morphology.

3.2.4. Sentence Processing

In the following section, I will illustrate several current lines of research in sentence processing of Slavic languages whose grammars are characterized by rich morphology and considerable freedom of word order. The topics chosen for this overview include resolution of lexical ambiguity in Bulgarian (Stamenov and Andonova, 1998), processing of filler-gap dependencies in Serbian/Croatian and Russian (Stojanović, 1998; 1999; Sekerina, 1999a), and complexity in Russian (Fedorenko et al., 2004; Sekerina, 1999b). Finally, I will discuss a case study, processing of the relative clause attachment ambiguity in Russian, and potential contribution of the Slavic data in general to this debate.

Stamenov and Andonova (1998) used the cross-modal priming technique (see (1) above) to investigate the time course of antecedent reactivation during sentence processing in Bulgarian. The technique requires extensive pretesting of the experimental materials to balance them with respect to lexical biases and frequencies. The materials were complex sentences with object-relative clauses in which the lexically-ambiguous object of the embedded verb was fronted; the sentences were placed in a strongly biasing context. The probes were presented in three different positions in the sentence to determine what meanings of the lexically-ambiguous fronted object were activated. The results partially replicated the English study by Love and Swinney (1996). All meanings of the ambiguous word were activated in the position immediately after the lexical ambiguity, as in English. However, at a later point, 700 ms prior to the verb, all meanings still remained active in Bulgarian but only the context-relevant one was reactivated for English. Stamenov and Andonova attributed this difference in processing

between Bulgarian and English to freedom of word order and earlier cues in gender/number agreement ambiguity resolution between the relative pronoun and the object noun in Bulgarian which obviate the appearance of a gap.

Freedom of word order, or Scrambling, is a promising testing ground for contribution of Slavic studies to the general theory of sentence processing. The debate about psychological reality of empty categories and complexity of processing of extracted arguments can be a crucial argument in distinguishing between traceless and trace theories of grammar and testing the predictions of universal parsing principles. A movement analysis of Scrambling in Slavic along the lines of the Principles-and-Parameters theory (Chomsky, 1986) carries a particular consequence for the theory of sentence processing, i.e., that scrambled word orders in Slavic can be analyzed as filler-gap dependencies in which the scrambled phrase (a filler) leaves a trace (a gap) in its D-Structure position.

Stojanović in her dissertation (1999), a part of which is published in Stojanović (1998) built on the previous off-line work with Serbo-Croatian (Urošević, et al. 1986; 1988) and describes a series of experiments on processing of different word orders in this language. In the first experiment, 32 native Serbo-Croatian speakers read two types of temporarily ambiguous relative clauses using the self-paced reading technique. The *koi*-relative clauses are derived via Wh-movement while the *što*-relative clauses involve operator-movement. The materials were designed to test the Minimal Chain Principle (MCP) (De Vincenzi, 1991) which implies that the parser does not delay gap postulation. For the *koi* relative clause, the subject interpretation should be preferred (10a), while for the *što*-relative clauses, the reverse is true: the object interpretation is preferred. This is because the resumptive clitic which binds the object precedes the *pro* subject (11b).

(10) a. Rečima se nije moglo opisati venčanje koje je izazvalo divljenje ...

b. Rečima se nije moglo opisati divljenje koje je izazvalo venčanje ...

(11) a. Zoran₁ nije prepoznao policajca₂ što ga₁ je kaznio prekoračenja brzine.

b. Zoran nije prepoznao policajca₂ što ga₂ je optužio za zloupotrebu vlasti.

The results showed that the parser followed the MCP. In (11), postulation of a false gap resulted in increased RTs at the postverbal positions for the object relatives (11b) only. In (10), the RTs were increased on the verb *je izazvalo*, providing evidence that the parser postulated the seemingly required object gap.

In the second experiment, the predictions of the MCP were tested for the three scrambled word orders, SVO, SOV, and OSV, illustrated in (12) for OVS:

(12) Celo selo je bilo svesno toga da je divljenje izazvalo venčanje čak i kod gostiju iz grada.

Because it took the participants longer to read the OVS sentences (in position-by-position comparisons), Stojanović hypothesized that the parser reanalyzes the first NP *divljenje* ‘surprise’ in (12) as the moved object, in support of the MCP. However, the absence of a significant differences between SOV and OSV suggests that the parser delays thematic role assignment until the disambiguating information is encountered, in contrast to the no-delay clause of the MCP. The inconclusiveness of the results makes it necessary to do much more work before we can describe and analyze the exact nature of the parsing mechanism used in on-line thematic role assignment in Scrambling languages.

Sekerina (1999b) also used the self-paced reading technique to ask similar questions with respect to processing of different word orders in unambiguous sentences in Russian. In the first experiment, control sentences (13a) in the canonical word order were contrasted with D(irect) O(bject)- Scrambling (13b), and Wh-movement (13c):

(13) a. Послушная девочка понесла больной бабушке
Obedient girl-NOM carried sick Grandma-DAT fresh
свежую клубнику в корзинке.
strawberries-ACC in the basket

- b. Свежую клубнику послушная девочка понесла
 fresh strawberries-ACC obedient girl-NOM carried
 больной бабушке в корзинке.
 sick Grandma-DAT in the basket
- c. Какую клубнику послушная девочка понесла
 Which strawberries-ACC obedient girl-NOM carried -
 больной бабушке в корзинке?
 sick Grandma DAT in the basket

The sentences were presented in isolation and were followed by comprehension questions. The main goal of this experiment was to compare processing of Wh-movement constructions that indisputably require postulation of a filler-gap dependency, and Scrambling constructions. When the grammar requires a movement analysis of a construction, it adds a processing cost (increased RTs) to its analysis in comprehension. If Scrambling involves movement of the scrambled NP, then both the Wh-Movement (13c) and the DO-Scrambled (13b) sentences will be read slower than their control (13a). The results showed the increased RTs at the indirect object position for both DO-Scrambling and Wh-Movement but the latter two did not differ from each other. Thus, an extracted argument, whether a moved Wh-word or scrambled, must undergo more (or deeper) processing than an *in situ* argument.

In addition to phrasal Scrambling, Russian also exhibits a different type of Scrambling, the so-called *Split Scrambling* (14), an operation which breaks up NPs and PPs and moves one or both of their subparts into different positions in the sentence. This operation derives discontinuous constituents in which modifiers of all kinds are separated from the noun head by other material in the clause.

- (14) Шумную₁ купили наши соседи _____₁ собаку.
 Noisy-ACC bought our neighbors-NOM dog-ACC
 ‘Our neighbors bought a noisy dog.’

The two models of sentence processing introduced above (see Section 2.2.3), the Garden-Path theory and the Constraint-Based theory, predict that there will be a processing load associated with phrasal Scrambling as compared to sentences which do not involve Scrambling. Split Scrambling should induce even greater processing load relative to phrasal Scrambling although the source of this cost is argued to be different for the two theories. The Minimal Chain Principle of the Garden-Path theory (De Vincenzi, 1991) predicts that filler-gap dependencies are harder to process due to a movement chain in a construction with filler-gap dependencies between the moved phrase and its trace. For the Constraint-Based theory, a higher cost associated with processing of Split Scrambling is predicted because filler-gap constructions are far less frequent than sentences without such dependencies and because they are presented in isolation.

The predictions of both theories that Scrambling constructions should have a higher processing load were tested in the self-paced reading experiment (Sekerina, 1999b). Sentences with split constituents (NPs and PPs), as in (15b), were contrasted with the control sentences with phrasal Scrambling (15a), and the pair (15a, b) was contrasted with two sentences that started with a categorically ambiguous (Noun/Adjective) word (15c, d); the slash indicates the frames at which RTs were recorded:

- (15) a. О студентке/ вспоминал/ мой двоюродный брат/ постоянно.
About student -PREP thought my cousin all of the time
'My cousin thought about the female student all of the time.'
- b. О красивой/ вспоминал/ мой двоюродный брат/ студентке.
About beautiful-PREP thought my cousin student-PREP
'My cousin thought about the beautiful female student.'
- c. О знакомой/ вспоминал/ мой двоюродный брат/ постоянно.
About acquaintance thought my cousin all of the time
'My cousin thought about the female acquaintance all of the time.'
- d. О знакомой/ вспоминал/ мой двоюродный брат/ студентке.
About beautiful-PREP thought my cousin student-PREP
'My cousin thought about the beautiful female acquaintance.'

Eighty-eight native Russian speakers participated in the experiment. The results showed that the participants experienced a surprise at the verb frame in (15b) because the adjective *красивой* ‘beautiful-PREP’ requires a head noun whose appearance is delayed until the end of the sentence. For this sentence to have a grammatical continuation, it is necessary at this point to hypothesize a Split Scrambling construction. In contrast, the categorically ambiguous word *знакомой* ‘acquaintance-PREP’ in (15c, d) can be construed as a noun, and is equal to the control sentence in (15a). By the same token, the increased RTs were recorded at the last frame *студентке* ‘student-PREP’ in (15d) where the unexpected appearance of the noun required a reanalysis to reconstruct *о знакомой* and *студентке* as a split PP. These results suggest that Split Scrambling imposes an additional processing load on the parser as compared to phrasal Scrambling.

Fedorenko et al. (2004) investigated the effects of Case in processing of Russian, another important issue for which Slavic data may prove to be essential. The question under consideration was whether Case repetition may increase processing complexity and whether repetition of other morphosyntactic features such as gender, number, and person can have the same effect. The four types of sentences were tested using the self-paced reading technique:

- (16) a. Непослушную девочку сестру уговорила навестить
Disobedient girl-ACC sister-ACC talked into visiting
беспокоящаяся мать.
worried mother-NOM
‘The worried mother talked the disobedient girl into visiting her sister.’
- b. Непослушную девочку брата уговорила навестить
Disobedient girl-ACC brother-ACC talked into visiting
беспокоящаяся мать.
worried mother-NOM
‘The worried mother talked the disobedient girl into visiting her brother.’

c. Непослушную девочку брату уговорила позвонить.

Disobedient girl-ACC brother-DAT talked into calling

беспокоящаяся мать

worried mother-NOM

‘The worried mother talked the disobedient girl into calling her brother.’

d. Непослушную девочку сестре уговорила позвонить

Disobedient girl-ACC sister-DAT talked into calling

беспокоящаяся мать.

worried mother-NOM

‘The worried mother talked the disobedient girl into calling her sister.’

The sentences in (16) differed with respect to abstract Case (the same in (16a, b), different in (16c, d)) and phonological form of the Case-marker (the same in (16a, c), different in (16b, d)). The results showed that it took the participants longer to read the sentences with the same abstract Case (16a, b) than with different Case, but the reverse was found for the phonological form, (increased RTs for the sentences with different phonological Case-markers (16b, d)). Thus, Case repetition was found to contribute to processing complexity in Russian. In addition, when the word *сестры* ‘sister-ACC’ was replaced with the word of different semantic gender *дядя* ‘Dad-ACC’, the processing complexity decreased. The general conclusion drawn for this experiment is that semantically meaningful (+interpretable) features, such as gender and number affect processing complexity differently from semantically empty (-interpretable) features, such as abstract Case.

Referential Ambiguity (Sekerina, 1999a). Recall that the two major theories of sentence processing, the Garden-Path and the Constraint-Based, differ radically with respect to what information can influence the initial parsing in real-time fashion. In the modular Garden-Path model, context does not influence the initial preferences in resolving local ambiguities as the syntactic structure is being built by the parser; only later it gets incorporated into semantic interpretation. In the interactionist Constraint-Based model, the parser is capable of coordinating the linguistic properties of the

message with information from the context to determine processing commitments. Traditionally, it has been difficult to observe contextual effects in studying language comprehension due mostly to the fact that it is usually investigated under artificial conditions, i.e., reading of either isolated sentences or short paragraphs. Recently, a new free-viewing eye-tracking technique has been adapted for studying on-line language processing which records the participant's eye movements (Tanenhaus et al., 1996; Ferrreira and Henderson, 2004) and makes it possible to visually monitor the participant's interpretation of visual context. This technique provides a new means of examining the moment-by-moment processes of participants' spoken language comprehension in the relatively natural situation of acting upon spoken instructions.

This technique was first applied to Russian to study the effects of visual context in resolving referential ambiguity in Russian (Sekerina, 1999a). Eye movements of 14 Russian speakers were monitored as they moved small flat shapes on a vertical board that differed in color and represented nouns of different grammatical gender. The participants saw three different types of visual displays schematically represented in (17):

- (17) a. Unambiguous: red car, silver car, yellow flower, green horse
- b. Early Point-of-Disambiguation: red car, silver car, red flower, green horse
- c. Late Point-of-Disambiguation: red car, silver car, red squirrel, green horse

The display in (17b) differed from (17c) in that it contained the second red object *цветок* 'flower-MASC' was in masculine, in contrast to the target red object *машина* 'car-FEM' in feminine. In (17c), both red objects, *машина* 'car-FEM' and *белка* 'squirrel-FEM' were feminine. The participants manipulated the objects in displays following the instructions in (18):

(18) a. Пожалуйста, красную машину положите в Позицию 9.

Please red-FEM-ACC car-FEM-ACC put in Position 9

b. Пожалуйста, красную положите машину в Позицию 9.

Please red-FEM-ACC put car-FEM-ACC in Position 9

‘Please, put the red car in Position 9.’

With such instructions, visual displays (17b, c) were referentially ambiguous because both contained two red objects. However, the adjective *красную* ‘red-FEM-ACC’ in (17b) provides early disambiguation (the ending of the adjective is masculine in agreement with its head noun *цветок* ‘flower-MASC’). In contrast, (17c) remained referentially ambiguous until the head noun *машины* ‘car-FEM’ appeared in the spoken instructions.

The results showed evidence for incremental processing with respect to a visually presented set of potential referents. In particular, the data indicated that nouns modified by adjectives were interpreted incrementally. The participants considered the competitor object as soon as they started processing the adjective without waiting for the disambiguating information. This was evident even in the Split Scrambling condition (18b), where the head noun was separated from the modifying adjective by the verb. The point of disambiguation, as determined by the instruction in conjunction with the display, clearly influenced when eye movements occurred. Eye movements to the target object began shortly after the disambiguating word. Thus, the position of the head noun which was manipulated in the experiment (adjacent to the adjective in phrasal Scrambling and separated by the verb in Split Scrambling) made no difference. Moreover, the participants were even faster in launching an eye movement to the target object in the Split Scrambling condition, usually fixating on the target prior to hearing the head noun in the instruction. This suggests that Russian speakers have immediate access to the prosodically-marked contrast present in Split Scrambling, as required by discourse requirements of contrastive function associated with this type of Scrambling in Russian.

Late Closure in Russian (Sekerina, 2002). In Section 2.2.3, one of the central issues of the theory of syntactic processing, universality of processing principles, has been exemplified by the Late Closure debate. Numerous experimental studies have challenged the universality of the low attachment preference initially found in English. Several studies have shown that the pattern of preferences is altered when different prepositions such as *with* or *near* are used in the complex NP (Cuetos et al., 1996). Such lexical prepositions appear to favor low attachment of the relative clause, that is, they override otherwise preferred high attachment in languages like Spanish in favor of low attachment. As it turns out, low attachment is universally preferred in constructions with lexical prepositions in all of the languages examined so far.

Note that with the exception of Japanese, the languages tested were either Romance or Germanic. How is the relative clause attachment resolved in Slavic? Two pilot off-line experiments were conducted in Russian in a paper-and-pencil questionnaire format (Sekerina, 2002). Experiment 1 gathered ratings data by judging which of the two competing interpretations of globally ambiguous sentences was preferred. Globally ambiguous sentences were of two types depending on whether they contained a complex NP with a lexical preposition or without one. Experiment 2 gathered global reading time data (and answers to follow-up comprehension questions) for the same two types of globally ambiguous Russian sentences. The goal of both experiments was to find out which of the two possible attachment preferences, high or low, is preferred in Russian .

There were eight experimental sentences, four with a complex NP without a preposition NP₁ NP₂-GEN RC (19a), and four with a lexical preposition NP₁ Prep NP₂ RC (19b):

- (19) a. Николай хорошо знал сына полковника, который погиб
Nikolaj well knew the son colonel-GEN who died
в автомобильной катастрофе.
in a car accident
'Nikolaj knew well the son whose father, the colonel, died in a car accident.'
(Low attachment interpretation)
'Nikolaj knew well the colonel's son who died in a car accident.'
(High attachment interpretation)
- b. Иллюстрации к рассказам, которые были присланы на конкурс,
Illustrations for stories that were sent to the contest
исполнены мастерски.
are performed professionally
'The illustrated stories which were sent to the contest are performed
professionally.'
(Low attachment interpretation)
'The stories which were sent to the contest have illustrations performed
professionally.'
(High attachment interpretation)

In Experiment 1, participants were instructed to read each sentence carefully and then rate two possible unambiguous paraphrases which reflected one of the two available interpretations. The scale ranged from 0 (no such meaning) to 3 (the meaning immediately comes to mind, right after reading the sentence). In Experiment 2, participants had to read sentences in a self-paced reading mode (see (1) above) and answer a yes/no comprehension question which was specifically designed to query one of the two potential interpretations of the sentence.

The results of Experiment 1 showed that the high attachment interpretation was judged significantly more accessible than its competitor, and this pattern was consistent across individual sentences. Moreover, the high attachment preference held regardless of whether the complex NP was prepositionless, as in (19a), or contained a lexical

preposition, as in (19b). For Experiment 2, the response preference data arising from Experiment 2's comprehension questions confirm the findings of Experiment 1 with 75% preference for high attachment. Overall, the findings from both experiments place Russian with the majority of languages studied so far. Unlike English, but similar to Spanish, Italian, French, German, Dutch, and Japanese, Russian prefers to attach globally ambiguous relative clauses high. However, although low attachment is universally preferred in constructions with lexical prepositions across all the languages, Russian appears to be an exception to this rule: even in sentences with lexical prepositions high attachment was preferred.

Don Mitchell and his colleagues at the University of Exeter (England) and Janet Fodor and her graduate students at the City University of New York are conducting a large scale cross-linguistic project looking at such diverse languages as Rumanian, Swedish and Hebrew. The next step is be to add other Slavic languages, in addition to Russian and Croatian (Lovrić, 2000) to complement the only two language families, Romance and Germanic, well studied so far with respect to relative clause attachment ambiguity. Comparisons with other Slavic languages look especially promising in deciding which of the currently debated accounts of relative clause attachment ambiguity, the Tuning hypothesis (Cuetos et al., 1996), the Proximity hypothesis (Gibson et al., 1996), or the Implicit Prosody hypothesis (Fodor, 1997), works the best for Slavic. This is the first attempt in comparative psycholinguistics to achieve the impressive breadth of data coverage which has become the hallmark of generative phonology and syntax.

4. Slavic Psycholinguistics: Future Directions

Slavic psycholinguistics is in its infancy, and its future directions and topics are too numerous to be counted; its most important contributions are yet to come. In this section, I discuss the directions in which one hopes research will proceed. First, I indicate areas in which advances in Slavic psycholinguistics are likely to occur and then identify issues that currently are not being investigated, but merit attention in future research.

Slavic psycholinguistics will continue to evolve in several directions: (1) Slavic data will help shape current theoretical issues of debate; (2) more and more research in Slavic psycholinguistics will become the center of collaborative and interdisciplinary cognitive science projects; and (3) new topics will arise from Slavic data which will receive increasing attention from experimental psycholinguists.

Theoretical Issues. Several issues in psycholinguistic research are currently debated. Two of these issues have a particularly noticeable impact on experimental work. The first concerns the nature of the human sentence processing mechanism, principles and strategies it employs, and types of information it utilizes. I have briefly mentioned two major models of sentence processing. At one extreme, Lyn Frazier (University of Massachusetts) and colleagues have argued for a modular parser which is informationally-encapsulated, uses strictly local syntactic information in constructing the first parse of a sentence, and follows universal principles of ambiguity resolution/structure building. At the other extreme, Michael Tanenhaus (University of Rochester) and colleagues define the parser as a highly interactive system which rapidly utilizes various sorts of information, including semantic, pragmatic, and contextual information, in constructing the parse and is attuned to lexical and statistical preferences in individual languages. Data from Slavic languages, with their discourse-driven freedom of word order and rich morphology, have the potential to trigger major modifications to the existing theories. Precedents from other languages are abundant. As far as the Garden-Path theory is concerned, data from Italian (De Vincenzi, 1991) which allows for null subjects, led to proposing a new universal principle, the Minimal Chain Principle, to account for processing of empty categories. Data from Dutch (Brysbaert and Mitchell, 1996) forced the psycholinguists working on the problem of relative clause attachment ambiguity to test psycholinguistic hypotheses against corpus data. Currently, there is little experimental work within the the Constraint-Based model on languages other than English. Ultimately, we would like to settle on a model which adequately explains processing of as many languages as possible.

The second issue of interest concerns using psycholinguistic data to find experimental evidence for psychological reality of linguistic constructs. For example, what is the unit

of perception across languages? Have we uncovered the comprehensive set: phoneme, mora, syllable, and foot? Lexical stress, shifting stress paradigms, complex consonant clusters, fleeting vowels, and sophisticated word-internal sandhi rules of Slavic languages still await their turn in this debate. In syntax, research on empty categories is another particularly controversial issue. While Bever and McElree (1988) claim experimental evidence for Wh-trace, NP-trace and PRO, Nicol and Swinney (1989) argue in favor of only Wh-trace, and McKoon, Radcliff, and Ward (1994) question the entire validity of the cross-modal priming technique for investigation of empty categories. Slavic languages have all four empty categories, including *pro* and are characterized by extensive Scrambling. Experiments on various Slavic languages using the particularly revealing cross-modal priming technique can result in important contributions to this debate.

Interdisciplinary Projects. The conventional research strategy in psycholinguistics has been to devise tasks designed to isolate specific processing components under controlled, experimental conditions. Although this reductionist strategy is tried and true, it must be balanced by consideration of how the component processes might be reintegrated into a broad theory of language. Interdisciplinary linguistic collaboration offers one means of addressing the integration problem which lies in the center of cognitive science. A comprehensive theory of language performance must simultaneously explain the wide range of phenomena associated with processing. It must be able to account for the variety of underlying grammatical structures (theoretical linguistics), how language usage as recorded in various corpora affects processing mechanisms (computational linguistics), how language processing is implemented in the brain (neurolinguistics), and how children learn to parse (acquisition and learnability). Consequently, numerous interdisciplinary research projects are under investigation.

Use of cross-modal priming technique crucially depends on developing and testing experimental materials matched for frequency and other important lexical properties (Swinney, 1979). Investigation of verb lexical biases and thematic preferences (Garnsey et al., 1997) in the interactionist constraint-based models requires a labor-intensive initial component of searching through parsed corpora to extract co-occurrence restrictions on

verbs and their complements. Researchers in acquisition are looking to psycholinguistics in search of an answer to the question whether processing mechanisms are responsible for helping children acquire verbs as a sort of syntactic ‘bootstrapping’ (Gillette et al., 1999) and how children learn to parse linguistic input that is ambiguous (Trueswell et al., 1999).

Consider an hypothetical example of an interdisciplinary project. Most English verbs are ambiguous between the past tense form and past participle. When an unergative or unaccusative verb is used in reduced relative clauses like *The horse raced...* and *The butter melted...*, sentence fragments are temporarily ambiguous between active and passive continuation. However, if English speakers are attuned to the statistical regularities of English, they should be able to avoid misparsing such sentences, because they can choose a particular continuation based on lexical biases and frequency of occurrence of these verbs in various environment. This information comes from such existing corpora for English from the Linguistic Data Consortium at the University of Pennsylvania (<http://www ldc.upenn.edu>) which are tagged and parsed. A computational linguist verifies the experimental materials provided by a psycholinguist against such a corpus and runs statistical analyses. Results of a psycholinguistic study with English adults serve as a starting point to investigate acquisition of unergative and unaccusative verbs by children. Neurolinguists who work with special populations such as aphasics, patients with brain lesions, and children with developmental language disorders provide data on how processing of unergative and unaccusative verbs is disrupted. The ultimate hypothesis of language competence with unergative and unaccusative verbs thus becomes testable against multi-faceted human language behavior.

With Slavic data, this interdisciplinary cognitive science approach is yet to emerge. Slavic neurolinguistics is represented by a number of unrelated studies with aphasics and does not yet exist as a separate language family subfield in general neurolinguistics. Computational Slavic linguistics is on the rise: interesting work on morphological parsing is being done at the University of New Mexico (Sheremetyeva and Nirenburg, 2000; McShane et al., 2000) (see also other papers from the special session on computational linguistics at FASL-8 published in King and Sekerina, 2000). The

exciting news is there are several on-line Slavic corpora which allow for extraction of lexical and frequency information (although neither is tagged or parsed): Uppsala Russian corpus maintained by the University of Tuebingen (<http://www.sfb441.uni-tuebingen.de/bl/korpora.html>), the Oslo corpus of Bosnian texts (<http://www.tekstlab.uio.no/Bosnian/Korpus2.html>) and Bulgarian corpus (<http://www.hf.uio.no/east/bulg/mat/index.html>). A group of linguists at the Charles University in Prague is testing the first sample corpus of parsed Czech sentences (<http://ucnk.ff.cuni.cz>) using the Tree-Adjoining Grammar algorithm successfully applied to other languages. Finally, acquisition of Slavic (see the article by Polinsky in the present volume) is gaining more momentum. Slavic psycholinguistic research will profit tremendously from collaborative efforts in these fields.

Developing Topics of Research. As in active domain of research, new topics and issues are constantly being identified and pursued by psycholinguists working with Slavic data. In this final section of my paper, I will consider syntactic topics which are likely to influence research in the area of sentence processing. Traditionally, work in sentence processing relies heavily on theoretical research conducted in syntax. Slavic syntax offers an wide selection of issues to inspire future psycholinguistic experiments. This list is far from being exhaustive; it is more of an attempt to identify directions which would seem of particular interest to think about in connection with Slavic languages.

(1) *Types of Structural Ambiguities in Slavic* have not been researched at all. Yet, structural ambiguity plays a very important role in sentence processing (Pritchett, 1992). Globally and temporarily ambiguous sentences are used by different theories as grounds to test their principles and strategies of parsing. While there are potentially universal types of ambiguities, language-specific ones represent the necessary challenge. A comparison of structurally ambiguous sentences common to all Slavic languages and unique to each of them represents the first indispensable step in designing Slavic-specific experiments.

(2) *Grammatical Features*, Case, gender, number, and animacy, could naturally assume one of the central roles in Slavic psycholinguistics. Case is the most prominent of abstract features and initial steps in this direction are being taken (see Fedorenko et al.,

2004, discussed above). Many current studies in sentence processing address the issue of how grammatical gender is processed in languages other than English (Brown et al., 2000) with mixed results. Mirković et al., (2005), Nicol and Wilson (2000) and Sekerina (1999a) report some interesting effects of gender in Russian which remain to be explained.

(3) *Multiple Wh-Movement and Clitic Placement* in Bulgarian and Serbian/Croatian have been the focus of many theoretical articles, in particular, by Željko Bošković and his colleagues at the University of Connecticut. It is an important topic in syntax since it provides testing grounds for the theory of functional projections, Superiority, and phonology-syntax interface. Processing of multiple Wh-Movement constructions in various Slavic languages could contribute to the ongoing psycholinguistic debate of empty categories and complexity of filler-dependencies. Related questions can be addressed with respect to Long Distance Movement and anaphora binding.

(4) *Aspect* and its role in verb lexical semantics represents a complex set of issues especially characteristic of Slavic languages. The contribution of verb information to on-line processing is very much in the center of psycholinguistic work aimed at testing the theories of sentence processing. It remains to be shown how verb aspect and its usage with different syntactic constructions can be studied in an experimental setting.

(5) *Scrambling and Information Structure* have the potential of keeping Slavic psycholinguists very busy because word order issues are central to the adequate grammatical description of any Slavic language. The few experimental studies reported above have barely scratched the surface. Very little is known about processing of scrambled sentences under appropriate discourse conditions, a very challenging task from the experimental design point of view. Prosodic means of expressing information structure provide a natural connection between production and comprehension studies and call for multimodal experimental investigation.

(6) The issue of *Null subjects/ Pro-drop* and implicit arguments in general has inspired a very productive line of research in acquisition. In sentence processing, the Minimal Chain Principle (De Vincenzi, 1991) has resulted from investigating null subject sentences in Italian. Some Slavic languages are described in the syntactic literature as

pro-drop; others exhibit mixed properties with respect to the *pro*-drop parameter. Cross-linguistic comparison between them may be especially fruitful.

(7) *Negation/Genitive of Negation* is yet another long-standing problem in Slavic syntax. A recent article by Babyonyshev et al. (2001) reports the results of a series of acquisition experiments with Russian children which may have important consequences for learnability. Psycholinguistic investigation of how adults process scope ambiguities created by negation and logical operators in Slavic languages will most certainly have an impact on the grammatical treatment of these phenomena.

Finally, let me name just a few of other intriguing areas of Slavic grammar which merit a psycholinguistic investigation. These include, but are not limited to copula sentences, secondary predication, dative subjects, impersonal constructions, and the entire complex of verb-related issues such as argument structure expressed by morphological means, unaccusativity/unergativity, and reflexives. These relevant and interesting topics will keep Slavic psycholinguists very busy.

My vision for the future of Slavic psycholinguistics is that it eventually will position itself as the critical, respected interface between Slavic linguistics in general and cognitive science. As this nascent bridge becomes firmly established, Slavic linguistics will be centrally positioned in the scientific world which is rapidly moving toward the integration of disciplines of mind.

Epilogue: Six years later

Six years have passed since this chapter was written for the Workshop on Future of Slavic Linguistics (SLING2K) held at Indiana University in Bloomington in 2000 (<http://www.indiana.edu/~slavconf/SLING2K/>). What could be worse than finding out that you have misunderstood the present and have been wrong about the future? Fortunately, Slavic psycholinguistics has indeed made considerable progress in these six years in establishing itself as a bridge between theoretical Slavic linguistics and cognitive science.

The traditional way to investigate Slavic languages by modifying existing research ideas from English and other languages to accommodate Slavic data has continued to

contribute toward success of Slavic psycholinguistics, as demonstrated by a series of studies on the relative clause attachment ambiguity in Russian and Bulgarian (Fedorova and Yanovich, 2005; Sekerina et al., 2004). New data from less researched Slavic languages have become available for processing of grammatical gender in Serbian (Mirković et al., 2004). Innovative work that combines multiple response measures has appeared on Russian (Marian and Spivey, 2003a; 2003b; Marian et al., 2003). Marian and Spivey showed how multiple-measures approach which utilized both free-viewing eye-tracking and event-related brain potentials (ERPs) can shed light on organization of mental lexicon and nature of lexical representations in bilingual Russian-English speakers. With exciting new advances in computational linguistics, Slavic psycholinguists can now rely more on more extensive and sophisticated Slavic corpora, compensating for the weaknesses of empirical Slavic databases. For example, the new on-line National Corpus of Russian (<http://www.ruscorpora.ru>) has recently been made available that provides not only extensive lexical and frequency characteristics of more than 65 million words but is also equipped with a sophisticated search engine based on grammatical features. A new Conference on Cognitive Science designed to attract cognitive scientists from Russia and East Europe was successfully inaugurated in Kazan' in 2004 and will continue to take place biannually in Russia (<http://www.cogsci.ru/cogsci06/index.htm>).

What are the emerging directions in which Slavic psycholinguistics will evolve in the current decade? The answer is, as this article demonstrates all too well, that nobody knows. We can at best speculate on a few of them. First, it will become increasingly important to study Slavic languages from the point of view of neurolinguistics as cognitive neuroscience continues its rapid progress. Second, it is evident that relying just on one methodology and one measure may not be enough. Combining multiple measures such as eye-tracking and ERPs can shed light on multidimensional aspects of language processing. This will obviously require sophisticated laboratories and interdisciplinary collaboration of psycholinguists with computer scientists and engineers.

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