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A Superficial Resemblance Does Not Necessarily Mean You Are Part of the Family: Counterarguments to Coulson, King and Kutas (1998) in the P600/SPS-P300 Debate

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Two recent studies (Coulson et al., 1998; Osterhout et al., 1996) examined the relationship between the event-related brain potential (ERP) responses to linguistic syntactic anomalies (P600/SPS) and domain-general unexpected events (P300). Coulson et al. concluded that these responses are highly similar, whereas Osterhout et al. concluded that they are distinct. In this comment, we evaluate the relative merits of these claims. We conclude that the available evidence indicates that the ERP response to syntactic anomalies is at least partially distinct from the ERP response to unexpected anomalies that do not involve a grammatical violation.

INTRODUCTION: THE ISSUES

It is not unheard of within the field of psycholinguistics to encounter two research reports that appear to support contradictory answers to some research question. So it is with two recent reports by Coulson, King and Kutas (1998) and Osterhout, McKinnon, Bersick and Corey (1996). The research question concerns the relationship between two positive waves observed in the scalp-recorded event-related brain potential (ERP). Specifically, the question is whether the ERP response to a variety of

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syntactic anomalies (variously labelled the "P600 effect" and the "syntactic positive shift"; hereafter the "P600/SPS") is a manifestation of the domain-general response to unexpected, task-relevant events (the P300 family of positivities). Osterhout et al. conclude that the P600/SPS is (at least to an interesting degree) distinct from the P300 family. Coulson et al. conclude that the P600/SPS is in fact another instantiation of the P300 family. From this they conclude that the reported P600/SPS effects are indicative of "the way that participants update the contextual models which govern their expectations" (p. 47), and are, therefore, more indirectly linked to core language processes *per se* than other ERP effects such as the N400 (Kutas & Hillyard, 1980) and the left anterior negativity (or LAN; Neville et al., 1991).

The aims of this comment are three-fold. First, we consider the experimental conditions necessary to determine whether or not the P600/SPS is "just another" P300. We will argue that Coulson and co-workers' experimental design is less than optimal for investigating this question.[1] Second, we will argue that the relationship between the P600/SPS and language processing events is in no way different in principle from the relationship between other language-relevant ERP effects/components and language processing. Third, we discuss apparent problems raised by Coulson et al. (for example, variability in the P600/SPS across experiments), and what we believe are misconstruals of our theoretical position. We conclude that the weight of the evidence supports the claim that the ERP response to syntactic anomalies is at least partially distinct from the response to unexpected anomalies that do not involve the grammar.

IS THE P600/SPS A MEMBER OF THE P300 FAMILY?

At least under certain experimental conditions, a disparate set of syntactic anomalies elicits a large-amplitude positive wave in the ERP (the P600/SPS; for a review, see Osterhout, McLaughlin, & Bersick, 1997). This effect has been elicited by anomalies involving number and gender agreement, phrase structure, verb subcategorisation, verb tense, constituent movement, and case. In most reports, the P600/SPS begins about 500 msec after onset of the anomalous word, persists for several hundred milliseconds, and is largest over centroparietal scalp regions.[2]

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[1] The content of this comment also applies (in general) to a recent report by Gunter, Stowe and Mulder (1997). Gunter et al. conclude that the P600/SPS is a member of the P300 family for reasons similar to those offered by Coulson et al. (1998).

[2] Although there has been some variation in the latency and scalp distribution of the P600/SPS across experiments, this variation has not been as great as described by Coulson et

Clearly, the P600/SPS is qualitatively distinct from the N400 effect elicited by semantically or pragmatically anomalous words (Kutas & Hillyard, 1980). Less clear, however, is the relationship between the P600/SPS and the P300 family. The P300 is elicited by a wide variety of attended, task-relevant stimuli (for a review, see Donchin, 1981). P300 amplitude is a function of the probability, salience and informational content of the eliciting stimulus, with the most improbable, salient and informative stimuli eliciting the largest-amplitude P300s (Ruchkin et al., 1990). The peak latency of the P300 varies as a function of stimulus complexity and ranges from about 300 to 800 msec (Fabiani, Gratton, Karis, & Donchin, 1987).

Given that syntactic anomalies are both unexpected and relevant to the task of reading, it is reasonable to ask whether the P600/SPS is a member of the P300 family. Unfortunately, this is not a simple question. The P300 is not a monolithic component reflecting activity in a single neural source. Instead, the P300 is a composite waveform made up of at least three distinct components, each of which is generated by different neural sources (Johnson, 1989, 1993; Sutton & Ruchkin, 1984): the frontocentral P3a (Squires, Squires, & Hillyard, 1975), the large-amplitude centroparietal P3b (the classic P300) and a longer latency, longer duration late positive slow wave (Squires et al., 1975). In most reports, the P3b is the largest-amplitude subcomponent. The relevant point is that the P600/SPS might be a manifestation of the neural events underlying just one subcomponent of the P300 complex, or of one or more of these subcomponents plus other effects that do not contribute to the P300. This complexity is further increased by evidence that the subcomponents of the P300 are themselves composites of activity in an indeterminate number of independent neural sources (Johnson, 1993). Although direct evidence is currently lacking, it seems likely *a priori* that the P600/SPS is also a composite of activity in numerous neural sources. Thus, the question of whether the P600/SPS is a member of the P300 family is, in our opinion, less relevant than the question of whether the brain response to anomalies that involve formal,

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al. (1988, pp. 28–29). For example, Coulson et al. claim that the P600/SPS to phrase structure violations onsets immediately in the study of Hagoort et al. (1993) and at 500 msec in the study of Osterhout and Holcomb (1992). This claim is incorrect. As is extensively discussed in Hagoort et al. (1993), the P600/SPS in their phrase structure violation condition is elicited to the word preceding the noun that renders the sentence formally ungrammatical. As they argue, at this earlier position the preferred syntactic structure can no longer be maintained. As has been found in other studies (Osterhout & Holcomb, 1992), the P600/SPS is elicited to the word that renders the subject's preferred syntactic analysis untenable, which is not limited to the class of formal grammatical violations. Crucially, in the study of Hagoort et al. (1993), the onset is at 500 msec to the word that renders the preferred phrase structure impossible. The onset is thus not at all immediate.

rule-governed aspects of language is partially or entirely distinct from the response to anomalies that do not involve the grammar.

The distinctiveness of two brain responses can be assessed in several ways. First, the distinctiveness of the underlying neural events can be assessed by comparing the scalp distributions of the two effects. Effects with distinct distributions are necessarily generated by at least partially distinct brain systems (cf. Johnson, 1993). Second, the functional distinctiveness of the two components can be assessed by determining whether they are differentially sensitive to stimulus and task manipulations (e.g. manipulations of the probability or salience of the anomaly); if so, the effects are probably distinct functionally. Third, and most critically, one can determine whether the effects are additive. This can be accomplished by presenting stimuli that are expected to elicit both brain responses simultaneously and comparing the response to the "doubly anomalous" stimuli to the response to each type of anomaly in isolation. This approach follows from Helmholtz's Rule of Superposition, which maintains that electrical fields propagating through a conductive medium summate where they intersect. Evidence of additivity strongly implies independence of the underlying neural sources.[3]

Osterhout et al. (1996) employed all of these strategies. They presented sentences containing a syntactic anomaly (subject–verb agreement violations, e.g. "The doctors *believes* the operation was a success"), a physical anomaly that did not involve the grammar (a word in upper-case letters, e.g. "The doctors BELIEVE the operation was a success"), or a doubly anomalous word that was both an agreement violation and in upper-case letters. The proportion of trials containing an agreement violation or an upper-case word was manipulated (20 *vs* 60%), and the salience of the anomalies was manipulated by either asking subjects to decide whether each sentence contained an anomaly, or to simply read the sentence for comprehension. Osterhout and co-workers' findings can be summarised as follows: Whereas upper-case words elicited the classic P300 complex (a frontocentral P3a, a centroparietal P3b peaking at about 500 msec, and a late slow wave), agreement violations elicited a late positive wave with a distinct morphology, time course, amplitude and scalp distribution. Furthermore, although the amplitude of the response to upper-case words

[3] The converse reasoning is far weaker. For example, evidence that two brain potentials have similar scalp distributions does not necessarily entail that they are generated by a similar or identical neural source. Similarly, evidence that two brain responses are both sensitive to some stimulus or task manipulation does not necessarily entail that the two brain responses are manifestations of a single neural or cognitive system. Finally, a failure to find perfect additivity does not necessarily entail that the neural events underlying the two brain responses are identical. These issues (and their implications) are discussed at length elsewhere in this paper.

was reliably and robustly affected by the probability and salience of the anomaly, these factors had smaller and unreliable effects on the response to agreement violations.[4] Finally, the upper-case and agreement anomalies had additive effects when both were presented simultaneously, and this additivity approximated a linear summation when the presumably non-additive effects of task relevance were taken into account.[5] Osterhout et al. concluded that the P600/SPS is, at least to an interesting degree, neurally and cognitively distinct from the P300 family.[6]

In the study of Coulson et al. (1998), subjects read sentences containing one of two types of syntactic anomaly (subject–verb number disagreement or erroneous case makings on pronouns) and well-formed control sentences. As in the study of Osterhout et al., Coulson et al. manipulated

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[4] Coulson et al. claim that, in the study of Osterhout et al., the probability manipulation had a similar but smaller effect on the response to agreement violations, relative to its effects on the response to upper-case words. This claim is erroneous. The P600/SPS effect to agreement violations was actually of larger amplitude in the high-probability condition, although this effect was not statistically reliable. By contrast, the positivity elicited by upper-case words was much larger in amplitude when these words were improbable.

[5] Gunter et al. (1997) argue that, because Osterhout et al. did not find perfect additivity in the "doubly anomalous" condition, their results do not support the claim that the P600/SPS and P300 are distinct (p. 674). Given that these brain responses are in all likelihood composites of activity in many neural sources, one should not be surprised to find that they are not completely independent. For example, it seems likely that both responses are sensitive to the task relevance and informational content of the anomaly. And, indeed, when Osterhout et al. took this factor into account, the response to the doubly anomalous words closely approximated the summation of the responses to the two types of anomaly in isolation.

[6] Gunter et al. (1997) provided additional critiques of the study of Osterhout et al. (1996). Gunter et al. argue that (a) the actual probabilities of the upper-case and agreement anomalies differed dramatically; (b) the upper-case words were more salient than the agreement violations and might have drawn attention from the agreement anomalies, making them less salient; (c) it is not valid to compare manipulations of low-level factors such as the physical appearance of a word with manipulations of higher-level factors such as syntactic form. Our response to these criticisms are as follows: (a) We agree that it is difficult to discern what subjective expectations subjects might bring with them to the laboratory or develop during the course of an experiment. Nonetheless, it is incontrovertably true that for both the upper-case and agreement violations condition, the anomalies were much more probable in the "probable" condition than in the "improbable" condition, and that this manipulation had robust and reliable effects on the ERP response to upper-case words but not on the response to agreement violations. (b) Subjects detected both the upper-case words and agreement violations on the vast majority ($> 90\%$) of all trials. Furthermore, the agreement violations elicited a very large (approximately $5\,\mu V$) and extremely robust positivity that could be observed at most electrode sites. It seems unlikely that the agreement anomalies were not sufficiently salient. (c) The claim that we have confounded the "unexpectedness/ungrammaticality" factor with the "levels-of-processing" factor, and therefore should not compare the brain responses to upper-case words and agreement violations, seems non-sensical to us. The point at issue is whether these two responses are manifestations of a similar brain process, even though they are elicited by different stimulus manipulations.

the proportion of trials in which the anomaly occurred (20 *vs* 80%). Critically, however, Coulson et al. did not present any non-syntactic anomalies with which to compare the response to syntactic anomalies. Instead, they explicitly assumed that the effects of a grammatical violation could be attributed to a "P600/SPS" response, whereas the effects of probability could be attributed to a "P300" (or more specifically P3b) response:

> In our paradigm, the effect of Grammaticality on the ERP is attributed to the neural generators of the P600/SPS, while the effect of Probability is attributed to the neural generators of the P3b. Moreover, ··· ERP methodology affords two methods for comparing the brain response to Grammaticality and Probability. First, if the same neural generators underlie the P600/SPS and the P3b, the Grammaticality and Probability effects should have the same scalp distribution. Second, because independent neural generators have additive effects on the amplitude of the ERP, we can infer the relationship between underlying neural generators from the additivity or non-additivity of Grammaticality and Probability effects. (Coulson et al., 1988, pp. 31–32)

We think this paradigm is problematic. The authors assume that a sensitivity to probability manipulations signifies the presence of the P300 complex, or of some subcomponent of the P300. But such an assumption is surely unwarranted. Although the P300 complex is clearly sensitive to probability manipulations, it does not follow that all probability-sensitive responses are P300s. This is because it is highly unlikely that the P300 complex is the *only* probability-sensitive brain response. In fact, Coulson et al. (1998, p. 44) report that the other effect they observed (the early negativity) also showed a sensitivity to probability: "As was the case for the late positive response, the negativity elicited by ungrammatical relative to grammatical stimuli was larger for improbable than for probable items". The sheer sensitivity to the probability of the violation thus in no way sets the P600/SPS apart from other language-relevant ERP effects. It could thus very well be that the ERP response to syntactic anomalies is probability-sensitive, at least under certain experimental conditions, but at the same time distinct (either entirely or partially) from the response to unexpected, task-relevant events that do not involve the violation of a grammatical rule.

The implications of this possibility are severe. If syntactic anomalies elicit a probability-sensitive "P600/SPS" but not the P300 complex, then manipulations of probability and grammaticality would *not* be expected to differentially affect the scalp distribution of the ERPs. And because in the study of Coulson et al. (as well as in that of Gunter et al., 1998) the response to syntactic and non-linguistic anomalies cannot be compared directly, it is impossible to determine the distinctiveness of these responses

by contrasting their morphologies, distributions and probability-sensitivities. Most critically, it is also impossible to determine whether or not these two brain responses are additive and, hence, independent. Note here that the finding of similar (i.e. insignificantly distinct) distributions of the grammaticality effect and the probability effect does not suffice. This has to do with the so-called "inverse problem". Determining the generators for the scalp-recorded surface potentials is an ill-posed problem. That is, a unique solution for the location of these generators cannot be found in the absence of additional constraints on the solution space. Although one can assume that different distributions of scalp-recorded potentials are generated by (at least) partially non-overlapping generator ensembles, the opposite does not hold. The inverse problem implies that identity of distribution does not guarantee identity of generators. Thus if Coulson et al. (1998, p. 45) conclude that the "identity of the P600/SPS and the P3b was further suggested by the similarity in the scalp distribution of the grammaticality and probability effects", this is not more than mentioning one possibility without, however, proving that the other possibility (non-identity) is excluded or even less likely. The more crucial test, therefore, is the one evaluating the additivity or non-additivity of the ERP responses to grammatical anomalies and to anomalies that do not involve a violation of a grammatical rule. This is exactly what Osterhout et al. (1996) did, but which was not done in the studies of Coulson et al. (1998) and Gunter et al. (1997).

Coulson et al. (1998) also provide circumstantial evidence in support of their P300 interpretation of the P600/SPS by arguing that the response to syntactic anomalies is sensitive to the salience of the anomaly. Specifically, the case violations in their study elicited larger positivities than the agreement violations. Coulson et al. argue that the case violations were more salient than the agreement violations. However, no independent behavioural evidence is provided that the case violation was indeed more salient to subjects than the agreement violation. Hagoort, Brown and Groothusen (1993) and Hagoort and Brown (in press) not only collected ERP data for agreement and phrase structure violations, but also on-line grammaticality judgements to the same violations in another group of subjects. In both studies, the P600/SPS was larger in amplitude to the phrase structure violations than to the agreement violations. However, according to the on-line grammaticality judgement data, subjects detected both types of violations for approximately the same number of items (99 *vs* 97% in reading; 98 *vs* 97% in listening, respectively), indicating that the salience of both violations was almost identical. This finding proves that salience of the violation does not predict the size of the P600/SPS effect, which we take as circumstantial evidence against the P300 family membership of the P600/SPS.

In summary, the results reported by Coulson et al. (1998) suggest that the amplitude of the brain response to syntactic anomalies is sensitive to extreme manipulations of probability, under certain experimental conditions. Unless one is willing to assume that the P300 complex is the only brain response that is sensitive to probability manipulations, this result, by itself, does not show that the brain response to syntactic anomalies is functionally or neurally similar to the brain response to task-relevant, unexpected events that do not involve the violation of a grammatical rule.[7] Conversely, Osterhout et al. (1996), by directly contrasting the response to syntactic and non-linguistic anomalies, observed that the ERP responses to these two categories of anomaly summated when presented simultaneously. Such evidence indicates that the neural response to syntactic anomalies is, at least to an interesting degree, distinct from the neural response to non-linguistic anomalies. This is true even if both responses are shown to be sensitive to probability manipulations and if both categories of anomaly engage a common subset of neural sources.

ON THE LANGUAGE SPECIFICITY OF ERP RESPONSES

Our claim, then, is that the ERP response to syntactic anomalies is distinct from the ERP response to both semantic/pragmatic anomalies and non-linguistic anomalies. The permissible inference is that at least a subset of the neural (and, by extension, cognitive) processes that respond to these categories of anomaly are separable and distinct. Such a finding *is consistent with* the claim that separable syntactic and semantic processes exist, and that these processes are (to some extent) distinguishable from non-linguistic processes. However, we know very little about the cognitive processes made manifest by these language-sensitive ERP effects. In particular, we do not know whether these effects reflect linguistic processes directly or, instead, reflect processes that are correlated with but indeterminately removed from the linguistic processes themselves (cf. Osterhout et al., 1997; Rugg & Coles, 1995). Until we know more about these underlying processes, stronger inferences about the separability and modularity of linguistic processes remain premature.

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[7] Coulson et al. (1998) offer other reasoning to buttress the claim that the P600/SPS is a P300. For example, they note that the effects of probability could be seen in the response to *grammatical* stimuli; the response to the critical word was more positive-going in the P600/SPS window when grammatical sentences were improbable. This is an interesting finding. However, the reasoning applied above applies here as well: It is not clear that a sensitivity to probability necessarily entails that the brain response is a member of the P300 family.

What is, however, important in the context of this reply is that, to the best of our knowledge, it is at the moment impossible to claim that *any* language-relevant ERP response is language-specific or directly rather than indirectly reflecting the language processes under investigation. This holds for N400, lexical processing negativities (LPN), LAN and P600/SPS alike. What then explains the tendency to debate these issues for the P600/SPS but not or less so for the other ERP-responses? Our guess is that this is an accidental consequence of the history of the psychophysiological research field. In this field, the P300 stands out as a hallmark of its strength. Much is known about the antecedent conditions of P300 effects. A general, but highly underspecified, account has been put forward in terms of context updating to explain the behaviour of this component. The P300 as a hallmark of the field acts as an attractor for effects that are similar in latency and polarity. The psychophysiological attractor landscape does not have other attractors with the same strength. This, presumably, is the reason why the other language-relevant ERP-effects are left alone. But this is a byproduct of accidental history, not an issue of principle. Therefore, we believe that in this respect the P600/SPS is not unique among its ERP and language fellows. That is, it will always require clever and careful experimentation to allow ERP effects to impact our understanding of the human language system, with control over potentially confounding factors such as probability, salience, and so on.

To be clear, we have never claimed that the P600/SPS is necessarily a language-specific ERP response; nor do we believe are the N400, LPN or LAN. However, we are of the opinion that with language as input, these ERP-responses supervene on the spatiotemporal aspects of the neural machinery that subserves language processing. In this light, the findings of qualitatively distinct ERP effects can be seen as an indication of the processing and/or representational uniqueness of the underlying components of the neurocognitive machinery (cf. Hagoort, Brown, & Osterhout, in press).

ON VARIABILITY

Coulson et al. (1998, p. 27) contend that results in the P600/SPS literature "defy unified explanation in terms of syntactic theory". They support this contention by citing differences across experiments in the onset and scalp distribution of the effect. Given the apparent variability in the response, it is, they claim, "far from clear how we can systematically map the disparate ERP responses onto either general syntactic principles or properties of the specific languages involved" (p. 29). As an aside, we note that if the authors are correct in this observation, for the same reason their unified explanation in terms of P300 and context updating is excluded as well.

However, we disagree with both the premise and conclusion of this argument. Despite Coulson and co-workers' claims to the contrary, P600/SPS onset has been remarkably consistent across experiments. Typically, the positive shift to syntactic anomalies has an onset between 400 and 500 msec and persists for at least several hundred milliseconds, although an earlier onset has been observed in experiments involving relatively rapid presentation of words in the sentences (McKinnon & Osterhout, 1996; Osterhout & Holcomb, 1993). There has been variation across experiments in scalp distribution. However, because the P600/SPS probably reflects the simultaneous activation of numerous neural sources, such variation should not be surprising. Each experiment brings with it a unique blend of stimuli, anomalies, task demands, and so on. These varying conditions probably recruit the multiple neural system underlying the P600/SPS to varying degrees across experiments, resulting in significant variations in the distribution and amplitude of the activity as it is recorded from the scalp.[8]

ON THE MULTIPLICITY OF RESPONSES TO SYNTACTIC ANOMALIES

Coulson et al. (1998, p. 29) find "especially disconcerting" the observation that more than one ERP effect has been associated with syntactic anomalies. Several studies have reported that syntactic anomalies elicit a negative-going effect of variable onset and duration (typically between 200 and 500 msec), and with a variable scalp distribution (although most typically reported to be largest over anterior left-hemisphere sites, hence the term "left anterior negativity" or LAN; Münte, Heinze, & Mangun, 1993; Rösler, Pütz, Friederici, & Hahne, 1993). As in the study of Coulson et al., a LAN and P600/SPS are sometimes observed in the same epoch of activity (Osterhout & Holcomb, 1992). We do not believe there is anything disconcerting in finding that more than one ERP effect might prove to be sensitive to grammatical anomalies. Indeed, variability in these responses might prove to be beneficial. It seems unlikely that syntactic processing involves a single neural/cognitive process; hence, corresponding multi-

[8] One potential interesting difference in the distribution of P600/SPS effects is the one between grammatical violations and syntactic ambiguities. The violation effects usually have a clear posterior distribution. In cases where more than one syntactic structure can be assigned to an incoming string of words (syntactic ambiguity), information forcing the processes to overwrite the initially preferred one tends to elicit a more equally distributed P600/SPS (cf. Hagoort & Brown, in press; Van Berkum et al., 1997). If this difference is upheld in future studies, it might point towards the possibility that functionally different subcomponents can be distinguished in the P600/SPS effects. This again would mean that the unification of syntactically relevant effects that are subsumed under the heading of a family of P600/SPS effects in terms of a general P3b context updating account is highly unlikely.

plicity in the ERP responses to syntactic events might be more of a virtue than a vice (cf. Friederici, Hahne, & Mecklinger, 1996; Neville et al., 1991).

ON THE DISTINCTIVENESS OF THE ERP RESPONSES TO SYNTACTIC AND SEMANTIC ANOMALIES.

Coulson et al. (1988) suggest that the "difference in the brain response to syntactic and semantic/pragmatic anomalies has been overstated" (p. 23) and that "claims that all and/or only syntactic anomalies elicit late positivities are overstated or at worst spurious" (p. 54). Let us be explicit and clear about what our claim is: Our claim is that, at least under certain experimental conditions (when sentences rather than word pairs are presented, when the critical word is embedded in the sentence instead of in sentence-final position, etc.) involving certain languages (e.g. English and Dutch), the ERP response to semantically or pragmatically anomalous words is dominated by a large increase in the N400 component, whereas the response to a disparate set of syntactic anomalies is dominated by a large-amplitude positive shift. This claim is neither overstated nor spurious but is supported by a large and growing literature (for a recent review, see Osterhout et al., 1997). Nor is it an overstatement to claim that these responses are qualitatively distinct. Furthermore, the amplitudes of the N400 and P600/SPS effects have been shown to vary systematically with manipulations of semantic and syntactic variables, respectively (Kutas & Hillyard, 1984; Osterhout, Holcomb, & Swinney, 1994).

These claims are simply atheoretical restatements of empirical observations we and others have reported. It is clear that these claims do not generalise to all experimental conditions. For example, semantically and syntactically anomalous words sometimes elicit both an N400-like effect and a positive shift when they appear in sentence-final position. It is equally clear that stimuli other than syntactic anomalies elicit positive shifts (see Osterhout, 1997, for a discussion of this point). Nonetheless, in our view it is significant that these two categories of anomaly consistently and reliably elicit distinct brain responses under well-designed and well-controlled experimental conditions.

ON MODULARITY

Coulson et al. (1988, p. 30) argue that our interpretation of the P600/SPS has led "even the most sensible reader to think" that our findings support a modular parser view. We do not feel responsible for misreadings of "even the most sensible reader", since this is what we have never claimed. It is one thing to say that there is evidence for a level of syntactic computation; it is quite another to say that syntax is informationally encapsulated from

lexical or discourse influences, as is argued, for example, in the garden path model of Frazier and colleagues (Frazier & Rayner, 1982). We ourselves have provided evidence that the P600/SPS is modulated by lexical and discourse factors (e.g. Osterhout et al., 1994; Van Berkum, Brown, & Hagoort, 1997). Whether or not the parser is informationally encapsulated is an empirical issue that cannot be concluded from the sheer presence of an ERP effect that supervenes on syntactic processing. What Coulson et al. presumably mean is that there is no parsing at all. They seem to opt for a language processor without different levels of representation, but one in which the "lexicon, morphology, and syntax form a continuum of symbolic structures in which traditional syntactic structures are the most schematic" (Coulson et al., 1988, p. 53). We believe that recent ERP evidence is largely inconsistent with this notion (cf. Osterhout et al., 1997).

CONCLUSION

The weight of the evidence to date is consistent with the notion that the response to syntactic anomalies is distinct (at least to an interesting degree) both from the response to semantic anomalies and from the domain-general response to unexpected events. The most compelling evidence favouring a distinction between the "P600/SPS" and "P300" is that these effects summate (Osterhout et al., 1996). Of course, as is the case with any scientific hypothesis, this hypothesis must constantly be re-evaluated in the face of new evidence. One can easily imagine additional supportive and more definitive evidence. For example, it has been found that agrammatic aphasics who show a relatively normal P300 response to unexpected events in a classical tone oddball task, nonetheless do not always show a P600/SPS response to syntactic anomalies (Wassenaar, Hagoort, & Brown, 1997). It is conceivable that, conversely, amnesics who show the P600/SPS response will not exhibit a P300 to non-linguistic anomalies. Invasive (intracranial recordings; Nobre, Allison, & McCarthy, 1994) or other non-invasive (MEG or fMRI; Menon et al., 1997) brain-based methods might allow a more precise evaluation of the neural processes underlying these brain potentials. It seems reasonable to suggest that a definitive resolution of the "P600/SPS-P300" question awaits such evidence.

However, the outcome of this debate is of limited relevance for studying theoretically motivated psycholinguistic issues. Unless one aims at formulating language processing theories in terms of (in our eyes overly general) notions such as context updating, the actual testing of specific psycholinguistic models can profit from the existence of qualitatively distinct, language-relevant ERP effects, the P600/SPS not excluded. This is

true even though the actual cognitive and biological processes underlying these ERP effects remain obscure (cf. Osterhout, 1994).

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