Minimality as vacuous distinctness: Evidence from cross-linguistic sentence comprehension

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Abstract

Psycholinguistic theorising has long been shaped by the assumption that the processing system endeavours to minimise structures/relations during online comprehension. Within the scope of a recent cross-linguistic, neurocognitive model of sentence comprehension (Bornkessel and Schlesewsky, 2006), we also proposed that the assumption of a very general ‘Minimality’ principle can account for a variety of psycholinguistic findings from a range of languages. In the present paper, we review empirical evidence for this notion of Minimality, before going on to discuss its limitations. On the basis of this discussion, we propose that, rather than constituting an independent processing principle, Minimality should be considered a subcase of a more general requirement for sentential constituents to be distinct from one another. We show that this notion of “Minimality as Distinctness” (MaD) can straightforwardly derive a wide range of findings on cross-linguistic sentence comprehension, while additionally serving to simplify the overall processing architecture.

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1. Introduction

The notion of “minimality” or “economy” has long played a central role in theoretical linguistics (e.g. Bresnan, 2001; Chomsky, 1995, 2000; Grimshaw, 1997, 2000). According to this perspective, there is an advantage for less complex representations and dependencies. This is reflected, for example, in a preference for smaller structures and for fewer or more local dependency relations (e.g. movement chains). Very similar assumptions have also shaped psycholinguistic theorising since its earliest days. For example, a very early proposal (the “derivational theory of complexity”, DTC) held that the complexity of comprehending a sentence is proportional to the number of transformations required to derive that sentence (e.g. Miller and Chomsky, 1963; Miller and McKeen, 1964; Miller, 1962). Subsequently, various “minimality” notions for sentence processing were proposed, including a preference for minimal phrase structure representations (e.g. Frazier and Fodor, 1978; Frazier and Rayner, 1982), a ban on vacuous structure building (Gorrell, 1995), an advantage for minimal chains (de Vincenzi, 1991), a reduction of cognitive
processing complexity via the avoidance of unmotivated predictions of upcoming sentence constituents (Gibson, 1998), and a preference for minimal revisions (Frazier and Clifton, 1998). In view of this abundance of minimality-based approaches targeting a variety of levels of representation, Fodor and Inoue (Fodor, 1998; Inoue and Fodor, 1995) proposed a generic minimality principle termed “Minimal Everything”, which they described as being “not a strategy, but a way of life” (Fodor, 1998:292).

In a similar spirit to “Minimal Everything”, we recently proposed a principle called “Minimality” as part of a cross-linguistic neurocognitive model of language comprehension (the extended Argument Dependency Model, eADM; Bornkessel and Schlesewsky, 2006). The formulation of the Minimality principle is given in (1).

1 Minimality (Bornkessel and Schlesewsky, 2006:790)
In the absence of explicit information to the contrary, the human language comprehension system assigns minimal structures. This entails that only required dependencies and relations are created.

Crucially, Minimality is assumed to apply at all levels of representation. It thus governs both structure building and argument linking (i.e. the mapping of an argument’s form onto its corresponding meaning). It is also predicted to apply at further levels (e.g. with respect to the pragmatic integration of an utterance), though this remains to be tested explicitly (but see Burkhardt, 2006; Burkhardt and Roehm, 2007, for some initial evidence).

In the present paper, we present an overview of recent empirical findings which support the eADM’s notion of Minimality (section 2). We then go on to argue that – in contrast to our own previous assumptions – Minimality is not in fact a basic principle of online processing in and of itself, but that it rather appears to be a special case of a more general “distinctness” requirement (section 3). This requirement states that sentential constituents (e.g. arguments) should be maximally distinct from one another, thereby avoiding interference (see McElree, 2006). However, the simplest way to be distinct is to be the only element of a particular category. Minimality can therefore be viewed as “vacuous distinctness” at all levels of the form-to-meaning mapping. We argue below that this assumption leads to a significant simplification of the overall processing architecture.

2. Cross-linguistic evidence for Minimality in real time comprehension

The aim of this section is twofold. First, we will discuss recent cross-linguistic results which support the conception of Minimality advanced within the eADM (section 2.3). Second, by building on these results, we will explore several processing phenomena in which Minimality appears to conflict with other principles of online comprehension (section 2.4). Before embarking upon a closer discussion of Minimality, however, we will introduce a crucial concept in language comprehension research, namely incremental interpretation (section 2.1), and will provide a short description of the basic properties of the eADM (section 2.2).

2.1. Incremental interpretation as a basic property of real time sentence comprehension

One of the biggest challenges – if not the biggest challenge – for models of language comprehension lies in the need to explain how the language processing system manages to perform a form-to-meaning mapping in real time. Thus, in contrast to the perspective adopted in theoretical linguistics, a specification of the representations which subserve the form-to-meaning mapping does not suffice. Rather, comprehension models must also take into account which information types become available at which point in time and must specify when and how these information types are used to construct these representations online. In this regard, it is standardly assumed that the processing system attempts to maximise interpretation at each point within a sentence, even in the face of incomplete information (ambiguity). This basic property of the comprehension architecture is known as incremental interpretation (e.g. Crocker, 1994; Stabler, 1994). As an illustration, consider the following example from Japanese (from Kamide and Mitchell, 1999).

2 Kyoju-ga gakusee-ni toshokansisho-ga kasita mezurasii
professor-NOM student-DAT librarian-NOM lent unusual
komonjo-o miseta.
ancient.manuscript-ACC showed
‘The professor showed [the student] the unusual ancient manuscript which the librarian had lent [the student].’
In (2), the dative NP _gakusee-ni_ could either be an argument of the main clause (in which case the professor showed the manuscript to the student) or of the relative clause (in which case the librarian lent the manuscript to the student). Thus, if interpretation is not to be delayed, the processing system must choose between these two options when it encounters the dative NP in spite of the fact that it has no explicit evidence for one or the other. By comparing globally ambiguous sentences like (2) with sentences disambiguated towards one of the two possible readings (by way of including either main clause or relative clause verbs which did not take a dative argument), Kamide and Mitchell (1999) were able to show that the matrix argument reading is, in fact, preferred. This observation provides strong converging support for the assumption of incremental interpretation even in consistently head-final languages like Japanese.

This notion of incremental interpretation will be of crucial importance for the discussion of Minimality as a strategy of incremental processing. It also constitutes a basic architectural assumption of the eADM, which will be introduced briefly in the next section.

2.2. Basic architectural assumptions of the extended Argument Dependency Model (eADM)

The extended Argument Dependency Model (eADM; Bornkessel and Schlesewsky, 2006; see also Schlesewsky and Bornkessel, 2004) is a cross-linguistically motivated neurocognitive model of language comprehension which is based upon the observation that, from a cross-linguistic perspective, phrase structure representations must be treated separately from representations allowing for a relational interpretation of sentence constituents. In a first stage of processing, a basic phrase structure representation based only upon word categories is assigned. Crucially, this representation is compatible with a variety of argument orders; both a subject–object–verb and an object–subject–verb order are assigned the same basic phrase structure representation of NP-NP-V. (Note that this model assumes no movement operations and no empty categories such as traces or pros.) For a detailed motivation of these architectural assumptions, see Bornkessel and Schlesewsky (2006). Alterations to the phrase structure that occur in phase 1 of processing and that involve a monotonic extension of the previously assumed phrase structure representation (i.e. adding of information by means of “extension to the right”) are not costly within the model (cf. Kimball, 1973; Sturt and Crocker, 1996). In a second phase of processing, relational interpretations are assigned on the basis of phrase structure-independent linking rules. These rules operate upon a restricted set of information types (e.g. morphological case marking, linear position, animacy) and are defined on a language-specific basis. For example, languages such as German, Japanese or Russian draw primarily upon morphological case marking for argument interpretation, while languages such as English rely more heavily upon linear order. Dispreferred linking operations (e.g. the required interpretation of a nominative argument as an Undergoer rather than an Actor in a language such as German) engender additional processing costs, as do mismatches between the relational information processed in phase 2 and previous assumptions about the phrase structure made in phase 1. Finally, in a third stage of processing, further information types such as world knowledge and discourse context are taken into account in order for full interpretation to be accomplished. Furthermore, processes of revision/repair and a well-formedness check occur in this phase.

Crucially for present purposes, the eADM assumes that argument interpretation is constrained and determined by two basic processing principles: the “Minimality” principle which was already mentioned above and a second principle termed “Distinctness” (Bornkessel-Schlesewsky and Schlesewsky, to appear, 2008; Schlesewsky and Bornkessel, 2004). Whereas Minimality calls for the avoidance of unnecessary relations, hence resulting in a preference for intransitive structures and events (see below), Distinctness steps in when such a minimal reading cannot be upheld. Under these circumstances, the primary aim of the processing system is to establish a hierarchical relation between the arguments (argument A > argument B). Such an argument hierarchy may be viewed as a basic, verb-independent interpretation of the relation between the arguments: the default interpretation of A > B corresponds to something like “A acts on B”, i.e. to an interpretation in which A is a prototypical Actor and B is a prototypical Undergoer. However, alternative interpretations of the same hierarchy (e.g. “A experiences B” or “A possesses B”) are also possible (see Primus, 1999). The establishment of argument hierarchies of this type is based on a set of hierarchically ordered, relational information types referred to as _prominence hierarchies_, which are defined on the basis of cross-linguistic observations (e.g. Aissen, 2003; Comrie, 1989; Croft, 2003). For example, animate arguments are more prominent than inanimate arguments and definite/specific arguments are more prominent than indefinite/non-specific arguments. Furthermore, argument prominence is also determined by language-specific information types such as case marking (e.g. German, Russian, Hindi) and linear order (e.g. English). In an optimal (“unmarked”)...
transitive relation, the Actor argument outranks the Undergoer argument on all dimensions of prominence (Aissen,
2003; Comrie, 1989). The arguments are therefore maximally distinct from one another. Thus, once Minimality – in
the sense of a preference for intransitive events – can no longer be upheld, processing choices are determined by the
endeavour to establish maximal Distinctness between the arguments. When this is not possible, increased processing
costs ensue.

2.3. Empirical evidence for minimal relations

One of the basic premises of the Minimality principle (see 1) is that relations and dependencies are preferentially
kept to a minimum during online comprehension. This makes the prediction that, when encountering an argument
during online comprehension, the processing system will take this to be the only argument in the sentence. In this way,
no relations or dependencies (e.g. no thematic hierarchy) must be established between this argument and other
arguments. Additional processing effort can thus be avoided. Converging support for the assumption that an initial
argument is preferentially interpreted as the sole argument in an intransitive relation stems from empirical studies
using event-related brain potentials (ERPs). The ERP method is very well suited to the investigation of real time
language comprehension because it provides a direct measure of electrical brain activity with a temporal resolution in
the range of milliseconds. It is further a multidimensional method and can thereby reveal qualitative dissociations
between different language-related processes. (For a brief introduction to the ERP method, see Appendix A.) Using
ERPs, Bornkessel et al. (2004) examined sentences such as (3).

(3) Herbert fragte sich, ...
  Herbert wondered ...
  a. ... welcher Autor ... den Senator ... kritisierte.
     ... [which author]NOM ... [the senator]ACC criticised
     ‘... which author criticised the senator.’
  b. ... welchen Autor ... der Senator ... kritisierte.
     ... [which author]ACC ... [the senator]NOM criticised
     ‘... which author the senator criticised’

At the position of the second argument in sentences such as (3a/b), Bornkessel et al. (2004) observed increased
processing costs in the form of a centro-parietal negativity (N400) for (3a) vs. (3b), i.e. for the canonical subject-
before-object order in comparison to the object-initial order (see Fig. 1A). This facilitation for the object-initial

![Fig. 1. Grand average ERPs at the position of the second argument (onset at the vertical bar) in nominative-before-accusative (dash-dotted line) vs.
accusative-before-nominative (solid line) structures. This comparison is shown for German in Panel A and for Japanese in Panel B. The data are from
Bornkessel et al. (2004) and Wolff et al. (in press), respectively. Negativity is plotted upwards. The topographical maps depict the scalp distribution
of the ERP effect at its maximum (NP2ACC – NP2NOM).](image)
structure can be interpreted as a consequence of Minimality: an initial nominative is compatible with both an
intransitive and a transitive continuation but, via Minimality, is analysed as the sole argument of an intransitive event.
An initial accusative, by contrast, unambiguously calls for a transitive interpretation and, thereby, for a second
argument. Thus, the second argument is predicted in the accusative-initial sentence (3b) and its processing is thereby
facilitated in comparison to the second argument in the nominative-initial sentence (3a).

Further findings attest to the cross-linguistic stability of the “transitivity extension” effect. Thus, as is apparent
from Fig. 1B, a very similar ERP response was observed at the position of the second NP in Japanese sentences as in
(4) (example from Wolff et al., in press).

(4) a. 二週間前
nisyuukanmae
two weeks ago
‘Two weeks ago’

判事が
judge-NOM

大臣を
minister-ACC

招きました
manekimasita

invited

b. 二週間前
nisyuukanmae
two weeks ago
‘Two weeks ago’

判事を
judge-ACC

大臣が
minister-NOM

招きました
manekimasita

invited

Like German, Japanese shows a centro-parietal negativity at the position of a second (accusative) argument following
an initial nominative (4a) in comparison to a nominative argument following an initial accusative. Thus, the extension
from an intransitive to a transitive reading also appears to be costly in this language.

Crucially, the finding of a similar electrophysiological pattern in Japanese and German allows us to further narrow
down the possible range of interpretations for the effect at NP2. For German, one might argue that the facilitation for a
subject following an object could be due either to a prediction at an interpretive level (i.e. for a transitive event) or to a
prediction at a structural level (i.e. for the subsequent realisation of a second, nominative-marked argument within the
phrase structure representation). These two levels of representation are closely intertwined in German because this
language does not allow subject-drop. In Japanese, by contrast, subject-drop is a possible (and highly frequent) option.
Hence, the occurrence of an initial accusative cannot lead to a clear structural prediction for a nominative.1 The
facilitation for the processing of a second NP in an object-initial structure must therefore be due to an interpretive rather
than a structural prediction, namely to the prediction of a transitive (two-argument) as opposed to an intransitive (one-
argument) event. In this way, the negativity at NP2 in (3a/4a) appears to reflect the costs of extending an intransitive to a
transitive interpretation.

In addition to accounting for the data in German and Japanese, the notion of minimal interpretation rather than
minimal structure is compatible with several other observations. First, it has long been assumed that the extension of
phrase structure representations “to the right” (i.e. without the need to alter the structure already built) is not costly
(e.g. Kimball, 1973; Sturt and Crocker, 1996). Second, studies using the visual world paradigm suggest that the
language processing system may anticipate upcoming arguments even though they are not necessarily required. For
example, Altmann and Kamide (1999) reported predictive eye movements to appropriate objects of optionally
transitive verbs (e.g. to a cake as the only edible object in the display for sentences such as The boy will eat . . . ). Here,
the verb unambiguously calls for a transitive event interpretation, though a transitive syntactic structure is not
necessarily required. Hence, the prediction of an upcoming argument does not violate Minimality, but rather serves to
further specify the object of a required underlying transitive relation. Altmann and Kamide’s findings are therefore

1 Note that the representations employed by the eADM include no empty categories (i.e. no traces, no pros etc.). Thus, like a number of theories of
grammar (e.g. Bresnan, 2001; Culicover and Jackendoff, 2005; Van Valin, 2005), the model assumes that argument interpretation is not determined
with reference to a phrase structural position, but rather via a set of linking mechanisms. From this perspective, the subject is not structurally
represented at all in a Japanese sentence involving subject-drop. However, this premise is not crucial to the point being made here because even
under the assumption that the subject is represented by a pro, the empty category should be placed higher in the structure than the accusative (i.e. it
should precede the accusative in terms of linear order). Otherwise, the processing system would need to assume a scrambled structure, which is
dispreferred in the absence of concrete evidence that scrambling has indeed occurred (see section 2.3 for a more detailed discussion of this issue).
compatible with the view that the processing system prefers minimal event interpretations, but strives towards a full specification of arguments once a minimal interpretation can no longer be upheld (e.g. when encountering a verb such as eat).²

Minimal interpretations in the sense described above can also account for the well-known preference to interpret a functionally ambiguous initial argument as the “subject” of the sentence (e.g. de Vincenzi, 1991; Frazier and Flores d’Arcais, 1989; Schriefers et al., 1995, among many others). As an illustration of this preference, consider the following examples from Turkish (Demiral et al., 2008).

(5)  a. Dün adam gördüm.
    Yesterday man see-Past-1st.Person.Sing
    “I saw (a) man yesterday”

     b. Dün taş gördüm.
    Yesterday stone see-Past-1st.Person.Sing
    “I saw (a) stone yesterday”

Like Japanese, Turkish is an SOV language which allows subject drop (corpus counts suggest that subjects are dropped in 70% of all transitive clauses; Çakıcı, 2005). In addition, Turkish has differential object marking (DOM) such that only specific objects are marked for accusative case (see von Heusinger and Kornfilt, 2005). From the perspective of online processing, this introduces an ambiguity between subjects and (non-specific) objects, both of which are not case-marked. Thus, when the processing system encounters the pre-verbal argument in sentences like (5), both of these interpretations are, in principle, possible. Furthermore, neither leads to a marked structure because of the possibility of subject-drop: when the subject is first or second person, it is preferentially dropped (as in the examples in 5) as the referent is unambiguously recoverable from the inflection on the verb (see Demiral et al., 2008, for questionnaire results showing a preference for subject-drop under these circumstances). Strikingly, in spite of these two equally unmarked and highly acceptable options, Demiral et al. (2008) observed a clear preference for a subject analysis of the initial NP. This preference was reflected in increased processing costs (in the form of an early frontal positivity) at the position of the disambiguating verb in sentences such as (5) in comparison to unambiguous object-initial control sentences (see Fig. 2).

Moreover, as is apparent from Fig. 2, the ERP results did not differ between sentences with animate (5a) and inanimate (5b) ambiguous arguments, thus suggesting that the subject-preference is not influenced by semantic/thematic considerations (see Schlesewsky et al., 2000, for similar observations from German).

What, then, might be the source of the subject-preference? The data from Turkish indicate that it can be derived neither via semantic considerations nor in terms of structural choices. Structural explanations of the subject-preference typically assume that it results from the endeavour to minimise filler-gap dependencies (i.e. the structural distance between the ambiguous element and its trace, see Crocker, 1994; Frazier, 1987) or movement chains (de Vincenzi, 1991). However, both a subject and an object analysis of the arguments in (5) is compatible with these arguments occurring in their base positions, thus rendering such structure-based metrics inapplicable. An alternative possibility is that the subject-preference arises from the need to saturate agreement as soon as possible, thereby avoiding open dependencies (Schlesewsky and Bornkessel, 2006; see also Bornkessel and Schlesewsky, 2006). Thus, the first argument that can possibly agree with the verb is analysed as the subject of the sentence. From this perspective, a constituent that can form part of an agreement relation (either a verb or an NP) is assigned a feature [+agrt] and thereby generates the prediction for the second constituent in that agreement relation (i.e. for the verb if the NP was processed first and vice versa).

While a proposal along these lines appears rather attractive, more recent findings suggest that its predictions are not borne out. In an ERP study using sentences such as (6), Burkhardt et al. (2007) observed differences between an (apparent) agreement mismatch between an NP and an intransitive verb (6a) and the same type of mismatch involving

² This line of argumentation also explains the general preference for a direct object reading in sentences such as While the men hunted the deer ran through the woods (see Staub, 2007, for an overview). Here, too, the subordinate clause verb (to hunt) unambiguously calls for a transitive interpretation, even though it is compatible with an intransitive syntactic structure. Hence, the preferred interpretation of the deer as the direct object of the subordinate clause rather than the subject of the main clause only serves to further specify the object of the transitive event that has already been postulated.
When comparing sentences as in (6) with control sentences involving a singular-marked auxiliary, Burkhardt et al. (2007) observed a left-anterior negativity (LAN) for (6a) but not for (6b). Thus, the agreement mismatch between the auxiliary and the first NP only engendered increased processing costs when the verb signalled that this NP would be the only one in the sentence. This pattern appears incompatible with a general processing strategy which penalises a delayed saturation of agreement. Rather, it suggests that the processing of a non-agreeing NP is not costly when the processing system “knows” that another NP must be encountered at a later point in the sentence. From this perspective, the endeavour to saturate agreement as quickly as possible can be viewed as an epiphenomenon of the above-mentioned, more general minimality strategy according to which an initial argument should be analysed as the only argument in the sentence. Converging support for this assumption stems from the observation that a subject-preference for an initial ambiguous argument has also been observed languages without subject-verb agreement, namely Chinese (Wang et al., in press) and Japanese (Wolff et al., submitted).

2.4. The limitations of Minimality proper

The empirical findings presented in the last section suggest that the language processing system attempts to avoid transitive event interpretations whenever possible. Thus, the extension towards a transitive relation is costly even in

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3 One possible caveat regarding this claim is that an agreement-based strategy may only apply when the critical NP is processed before the verb (i.e. as an ambiguity resolution strategy that applies to NPs rather than to verbs, for which it is immediately clear that they form part of an agreement relation). If true, this would mean that an NP preceding the verb would be analysed as bearing [+agrt] by default, while an NP processed after the verb would only be analysed as agreeing if its features matched those of the verb. However, this presupposes that the processing system pursues a bottom-up analysis strategy, the assumption of which is not straightforwardly compatible with the observation that the ERP effects in sentences such as (6) are conditioned by the type of clause-initial verb.
canonically ordered sentences. Furthermore, a subject reading of an initial ambiguous argument is preferred because this allows for the assumption of an intransitive relation to be upheld. In view of these observations, it appears crucial to ask how far-reaching such a minimality-based processing strategy might be, i.e. under which circumstances it is upheld and how it might be rendered inapplicable. An interesting test case for this question is provided by one of the classical ambiguities that has been discussed in the sentence processing literature, namely the so-called “NP-S ambiguity”. Consider example (7), from Garnsey et al. (1997):

(7) The senior senator regretted the decision had ever been made public.

When the processing system reaches the position of the decision in (7), there are two possible analyses of this NP: it could either be the direct object of the main clause verb (as in The senator regretted the decision) or the subject of an embedded clause (as in 7). The ambiguity is therefore between two types of complements, a noun phrase and a sentence (hence: “NP-S”).

From the perspective of the present discussion, NP-S ambiguities are interesting because they involve an ambiguity between a transitive event with two arguments (the NP-reading) and two hierarchically ordered intransitive events (the S-reading). When the critical NP is processed, the processing system must therefore decide whether it should analyse this NP as the object in a transitive event or whether the assumption of two events is to be preferred. Findings on English suggest that processing costs within the disambiguating region of sentences such as (7) (i.e. the region in which it becomes clear that an S-reading is required) are influenced by a variety of factors including the lexical bias of the verb and the plausibility of a direct object reading for the postverbal NP (e.g. Garnsey et al., 1997; Osterhout et al., 1994; Pickering and Traxler, 1998; Trueswell et al., 1993). These results are in line with a range of observations from several languages suggesting that verb transitivity information crucially determines the processing of arguments encountered in post-verbal positions (e.g. Burkhardt et al., 2007; Ferreira and McClure, 1997; Pablos, 2006; Staub et al., 2006; Staub, 2007). However, Pickering et al. (2000) provided compelling evidence for a general direct object preference in the processing of NP-S ambiguities, by demonstrating effects of direct object plausibility in the ambiguous region even for verbs that were biased towards an intransitive reading.

Due to the specific properties of English sentence structure, verb-specific information is always available when the disambiguating region is encountered in an NP-S ambiguity. Hence, general (i.e. verb-independent) preferences cannot be examined in these constructions. The examination of other languages might therefore be helpful in shedding further light on the question of whether the processing system ever shows a general preference for two events over one.

A language that appears particularly well suited to examining this issue is Japanese. Recall from section 2.1 that Japanese is a strictly head-final language, thereby leading to potential ambiguities with respect to the question of whether an argument belongs to the matrix clause or to an embedded clause. Nonetheless, findings in the literature suggest (a) that an incremental analysis of preverbal constituents takes place even under these circumstances, and (b) that the processing system prefers an analysis in which all arguments belong to one clause. This was shown, for example, by Kamide and Mitchell (1999). The example sentence from their study, which was discussed as example (2) above, is repeated here for convenience.

(8) Kyooju-ga gakusee-ni toshokansisho-ga kasita mezurasii professor-NOM student-DAT librarian-NOM lent unusual komonjo-o miseta. ancient.manuscript-ACC showed

‘The professor showed [the student] the unusual ancient manuscript which the librarian had lent [the student].’

As discussed above, Kamide and Mitchell (1999) observed a preference for a matrix clause reading of the dative argument as evidenced by increased reading times on the final (matrix) verb when this verb did not take a dative argument.

Beyond the observation that Japanese is processed incrementally, more fine-grained results suggest that the preference for a single-clause analysis of all of the arguments is abandoned in favour of a multi-clause analysis when two arguments are not sufficiently different in morphological terms. Consider the following examples from Miyamoto (2002):
(9) a. Obasan-ga yoboyobo-no toshiyori-o gakusei-ga kousaten-de
woman-NOM feeble old-man-ACC student-NOM intersection-LOC
mita takushii-ni isoide noseta.
saw taxi-DAT hurry put
‘The woman put in a hurry the feeble old man in the taxi that the student saw at the intersection.’
b. Obasan-ga yoboyobo-no toshiyori-o guuzen-ni kousaten-de
woman-NOM feeble old-man-ACC by chance intersection-LOC
mita takushii-ni isoide noseta.
saw taxi-DAT hurry put
‘The woman put in a hurry the feeble old man in the taxi that she saw at the intersection by chance.’

At the position of the second nominative-marked argument in sentences such as (9a) (gakusei-ga, ‘student-NOM’), Miyamoto (2002) observed increased reading times in comparison to the corresponding region (guuzen-ni, ‘by chance’) in sentences such as (9b). (Note that a similar effect was also found in a direct comparison between nominative- and accusative-marked arguments in two further conditions. Hence, the reading time increase cannot be due to a categorical difference.) Miyamoto interpreted this finding as evidence for nominative case marking as clause boundary-inducing information (see also Yamashita, 1997). This means that, when the processing system encounters a second nominative-marked argument, it postulates a second clause rather than attempting to integrate this argument into the matrix clause.4

In an additional study, Miyamoto (2002) showed that a two clause analysis may also be induced in the absence of completely identical morphological marking on two arguments. Thus, he observed a similar (though perhaps somewhat smaller) effect to that discussed above in sentences that were identical to those in (9) except for the fact that the initial argument was marked with the topic particle –wa rather than the nominative case marker –ga. As wa-marked arguments can also be objects, the “identity” between the wa-marked and the ga-marked argument appears to suggest that a topic-marked argument is preferentially analysed as a subject in Japanese. Converging support for this assumption stems from a recent ERP study on wa-initial sentences in Japanese (Wolff et al., submitted). Examples are shown in (10).

(10) a. 二週間前 判事は 大臣を 招きました
nisyuukanmae hanzi-wa daizin-o manekimashita
two weeks ago judge-TOP minister-ACC invited
‘Two weeks ago, the judge invited the minister.’

b. 二週間前 判事は 大臣が 招きました
nisyuukanmae hanzi-wa daizin-ga manekimashita
two weeks ago judge-TOP minister-NOM invited
‘Two weeks ago, the minister invited the judge.’

The sentences in (10) both involved only a single clause. In the case of (10a), the wa-argument was disambiguated towards the subject of the sentence, while it was disambiguated towards an object reading in (10b). As mentioned above, there should be a clear preference to interpret the topic-marked argument as the subject of the sentence. Hence, the disambiguation towards an object reading was expected to engender increased processing costs. For present purposes, however, it is the position at which these costs emerge that is of particular interest. Crucially, Wolff et al. (submitted) employed auditory presentation and additionally manipulated the prosodic segmentation of the material

4 Converging support for this assumption stems from the observation that sentences in which the presence of an embedded clause is signalled by two identically-marked arguments engender lower reading times at the position of the disambiguating head noun (analogous to taxi in 9) in comparison to a corresponding condition without two identically marked arguments prior to this position. Miyamoto (2002) observed this effect for sentences with two accusatives and sentences in which a nominative-marked argument follows a topic-marked argument (see below). While it was not observable for “double nominative” sentences such as (9a), he argues that this might be due to the fact that two nominatives render a sentence confusing to process. Nonetheless, the overall data pattern clearly suggests that a second occurrence of a particular case marking leads to the postulation of an embedded clause.
such that there was either a prosodic boundary after the wa-argument or no such boundary. As is evident from Fig. 3, increased processing costs – in the form of a central negativity – were observed at the position of NP2 in the absence of a prosodic boundary and at the position of the verb when a boundary was present. (Note that the ERP effect of interest was always observed when comparing the two sentence structures in (10) under identical prosodic conditions. Thus, it cannot be due to the presence or absence of a prosodic boundary per se, but must rather be attributed to the combination of prosodic information and case marking.)

These findings thus suggest that wa-marked arguments are indeed preferentially analysed as subjects and that this analysis is upheld for as long as possible. When the prosodic information is compatible with a two clause analysis (i.e. when there is a boundary after the first argument), the subject reading of NP1 is upheld and a second clause is postulated. This means that, as in Miyamoto’s (2002) findings, the assumption of two (possibly intransitive) events is apparently less costly than the assumption of a single transitive event. When the verb is encountered, however, it becomes apparent that this analysis cannot be upheld and that a reanalysis towards a single (object-initial) clause, and thereby towards a single transitive event, is required. In the absence of a prosodic boundary after NP1, by contrast, the prosodic information signals that a single clause analysis is required. Hence, the processing system is forced to reanalyse the topic-marked NP as an object, as evidenced by the negativity for (10b) vs. (10a) at the position of NP2. Consequently, no effect is observable at the position of the clause-final verb.

In summary, the data from Japanese suggest that arguments are preferentially integrated into a single clause, thereby calling for an extension from intransitive to transitive or even ditransitive events. However, this preference is not upheld at any cost: when two arguments are identically case marked, a second clause – and therefore a second event – is assumed. Most importantly, exact identity of argument marking is not required for the postulation of a second clause/event, as a similar phenomenon can also be observed in sentences with a topic-marked argument and a nominative-marked argument. This suggests that the processing system “switches” from a single clause/event analysis to a two clause/event analysis when the assumption of a single clause/event does not allow for unmarked transitivity/ maximal distinctness (see section 2.2) to be upheld. Under these circumstances, it appears less costly to assume two separate events rather than a single marked transitive event.

A related issue concerns the interpretation of dative arguments. In languages such as German or Japanese, a dative-marked argument can be either the object of a two-argument verb or the indirect object of a three-argument
verb. From the perspective of a pure minimality-driven processing strategy, we should expect the two-argument reading to be preferred. However, this does not always seem to be the case, as suggested by the results of a study by Kamide et al. (2003). Using the visual world paradigm, they examined Japanese sentences such as (11).

(11) a. weitoresu-ga kyaku-ni tanosigeni hanbaagaa-o hakobu.
   ‘The waitress will merrily bring the hamburger to the customer.’

b. weitoresu-ga kyaku-o tanosigeni karakau.
   ‘The waitress will merrily tease the customer.’

As they heard sentences such as (11), participants viewed a display containing a waitress, a customer and a hamburger. At the position of the adverb (at which point a sentence such as (11a) is ambiguous between a two-argument and a three-argument reading), significantly more looks were made to the hamburger in sentences such as (11a) as opposed to (11b). This finding suggests that, at least on a certain proportion of trials, the processing system adopts a goal (or ‘Proto-Recipient’ in generalised role terms; Primus, 1999) reading of the dative argument and thereby anticipates an upcoming Theme (or Proto-Patient/Undergoer). Hence, the processing preference is not solely determined by the endeavour to minimise the number of arguments/possible dependencies between arguments, but also by the prototypicality of a particular reading for an argument bearing a particular type of marking: whereas dative arguments are non-prototypical objects in a two-argument relation, they are prototypical indirect objects in a three-argument relation. (Note, however, that the preference for a ditransitive reading in the Kamide et al. study may also have been influenced by the presence of a visual scene that contained a plausible ditransitive event and/or by the prosodic realisation of the sentence, which likely signalled the presence of an additional pre-verbal constituent following the adverb.)

From the findings discussed in the preceding paragraphs, it appears that the question of which of two readings is more “minimal” than the other – and hence should be preferred during online comprehension – cannot be answered in an absolute way. Rather, minimality in this sense seems to be crucially constrained and determined by the particular properties of the relation between the arguments. When this deviates from the unmarked option to a particular degree, the assumption of two events rather than one appears to be chosen as the “minimal” reading. We will explore the relationship between minimality and interpretive properties of argument relations in more detail in the next section.

3. Minimality as vacuous distinctness

The discussion of Japanese in the last section suggested that the preference for a single minimal event is not always paramount in determining processing behaviour. Rather, there may be circumstances under which two separate (and possibly intransitive) events or an unmarked ditransitive event are preferred over the assumption of a marked transitive event. This state of affairs indicates that there may be considerably more overlap between the Minimality principle and the second major processing principle within the eADM (Distinctness; see section 2.2) than we previously thought. Recall that, whenever a relation involves more than one argument, incremental interpretation is driven by a preference for maximal argument Distinctness as determined with reference to argument prominence hierarchies. In the following, we will examine the hypothesis that Minimality is simply a subcase of Distinctness in this sense, as the simplest way to be distinct is to be the only element of a particular category (e.g. a single argument). To this end, we will firstly discuss some further findings that speak in favour of “Minimality as vacuous distinctness” (section 3.1), before turning to a more detailed consideration of the theoretical consequences of such a claim (section 3.2).

3.1. Minimality as Distinctness: some initial evidence

As we will show in this section, the assumption of Minimality as a subcase of a more general Distinctness requirement is not only attractive from the perspective that it reduces two processing principles down to one. Rather,
such an assumption also provides an elegant explanation for a wide range of cross-linguistic findings in the domain of word order processing.

As a point of departure, consider the following phenomenon. Studies on word order permutations in German have revealed a characteristic electrophysiological response (the “scrambling negativity”) to the processing of a scrambled object, i.e. an object preceding the subject in the medial region of the clause (e.g. Bornkessel et al., 2002, 2003; Rössler et al., 1998; Schlesewsky et al., 2003). The critical sentence structures are illustrated in (12).

(12) Herbert sagte, ...  
    Herbert said ...

(a) ... dass der Autor den Senator kritisierte.  
    ... that [the author]_NOM [the senator]_ACC criticized  
    ‘... that the author criticized the senator.’

(b) ... dass den Autor der Senator kritisierte.  
    ... that [the author]_ACC [the senator]_NOM criticized  
    ‘... that the senator criticized the author.’

In scrambled (object-before-subject) sentences such as (12b), the order permutation is immediately apparent when the first argument is encountered due to overt morphological case marking. In comparison to the corresponding unmarked subject-initial sentence (12a), (12b) engenders a scrambling negativity at the position of the first argument.

Interestingly, the scrambling negativity cannot be viewed as a general mismatch response to an object at the left edge of the middlefield, as there are several circumstances under which no such effect is observed. This is the case, for example, in sentences such as (13).

(13) ... dass dem Autor der Senator applaudierte.  
    ... that [the author]_DAT [the senator]_NOM applauded  
    ‘... that the senator applauded the author.’

The crucial difference between example (13) and example (12b) is that, in contrast to initial accusatives, initial datives are compatible with a structure including only a single argument, for example in passives such as (14).

(14) ... dass dem Autorapplaudiert wurde.  
    ... that [the author]_DAT applauded was  
    ‘... that the author was applauded.’

The comparison between (13) and (12b) thus suggests that a scrambling negativity is absent when the initial object could be the only overt argument in the sentence. This interpretation is corroborated by the finding that a dative at the left edge of the German middlefield does engender a scrambling negativity when a possible passive reading has already been ruled out by previously processed information such as an auxiliary that is only compatible with an active reading (Rössler et al., 1998; Schlesewsky et al., 2003).

A second type of structure in which an initial object does not engender a scrambling negativity is illustrated in (15), from Schlesewsky et al. (2003).

(15) Dann hat ihm der Lehrer den Spaten gegeben.  
    then has himDAT [the teacher]_NOM [the spade]_ACC given  
    ‘Then the teacher gave him the spade.’

In structures such as (15), the initial dative pronoun ihm does not engender a scrambling negativity in spite of the fact that a one-argument (passive) reading of the dative is ruled out by the active auxiliary hat (and a non-pronominal dative argument in the same position indeed engenders a scrambling negativity). Schlesewsky et al. (2003) attributed this finding to the fact that an object-initial order is licensed in the German middlefield when the initial object is a pronoun, i.e. to the presence of an independent linearisation rule which requires that pronouns should precede non-pronominal arguments (e.g. Lenerz, 1977; Müller, 1999). As this rule mirrors the more general cross-linguistic...
observation that pronouns are more prominent than non-pronominal arguments (e.g. Aissen, 2003; DeLancey, 1981), the absence of a scrambling negativity in (15) can be interpreted as showing that this effect does not occur when the initial object is highly ranked on some prominence hierarchy.

Taken together, the German findings can be interpreted as follows. Linear order in the middlefield is organized according to argument prominence, i.e. in the optimal case, the more prominent argument will linearly precede the less prominent argument (for neuroimaging evidence in this regard, see Bornkessel et al., 2005; Bornkessel-Schlesewsky et al., submitted; Grewe et al., 2005, 2006). A scrambling negativity results whenever such a mismatch between prominence and linear order can already be detected at the position of the first argument in the middlefield. For example, an initial non-pronominal accusative argument always engenders a scrambling negativity because (a) a nominative argument must follow at some later point in the sentence, and (b) the initial accusative cannot outrank the nominative in terms of prominence. A prominence-linearisation mismatch, in which the Undergoer precedes the Actor but with no justification via a different prominence hierarchy, is thus immediately detectable. As described above, there are two ways by which such a mismatch (and, thereby, a scrambling negativity) can be avoided. Firstly, the initial object might be highly prominent according to some other prominence hierarchy (e.g. if it is a pronoun). Secondly, the initial object may be compatible with an analysis in which it is the only argument in the sentence. In the latter case, the correspondence between prominence and linear order is trivially satisfied because there is no second argument that might outrank the first in terms of prominence. Hence, a scrambling negativity for initial wh-questions or relative clauses (Fiebach et al., 2002; Friederici et al., 1998) can therefore be derived from the vacuous satisfaction of prominence-based Distinctness.

Strong converging support for such a view is provided by data on word order processing in languages that allow subject-drop. Thus, recent findings from Turkish and Japanese – two SOV languages with flexible word order and a high propensity for subject drop – suggest that neither of these languages shows a scrambling negativity for initial accusatives in the default case (Demiral et al., 2008; Wolff et al., in press). This observation is fully in line with the predictions of the “Minimality as Distinctness” (MaD) hypothesis: In Turkish and Japanese, an initial object can always be analysed as the sole overt argument in a clause with a dropped subject. (Note that such an analysis is even possible in the absence of a context, because the dropped subject can nonetheless readily be interpreted as a speech-act participant, i.e. first or second person.) Hence, a prominence-linearisation mismatch can generally be avoided at this position. Wolff et al. (in press) were further able to show that, under presentation conditions which render it highly likely that the initial accusative has been scrambled to a position in front of the subject, a scrambling negativity can be observed at the position of an initial accusative object even in Japanese. Under these circumstances, the low prominence of the object thus again leads to a mismatch with linear order because the processing system anticipates a second overt argument (as in German).

Finally, the MaD-hypothesis elegantly derives the finding that a scrambling negativity is only observable for “scrambled” objects in German (i.e. for objects at the left edge of the middlefield), but not for clause-initial objects in wh-questions or relative clauses (Fiebach et al., 2002; Friederici et al., 1998). Like pronouns at the left edge of the middlefield, these initial objects are rendered more prominent by an additional feature (e.g. +wh). Insofar, the MaD-hypothesis accurately derives processing phenomena in the domain of word order permutations both within and across languages.

3.2. Minimality as Distinctness: consequences for the architecture of the eADM

The discussion in the preceding sections indicated that an interpretation of Minimality as a subcase of Distinctness seems rather appealing in view of a range of empirical findings. Furthermore, such an assumption leads to a simplification of the overall processing architecture because two basic principles can be reduced down to one. In this section, we will therefore briefly sketch out the consequences of the MaD-hypothesis for the overall architecture of the eADM.

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6 Alternatively, prominence-based Distinctness may be restricted to certain local domains. This is suggested, for example, by the findings from Japanese that a biclausal interpretation may be preferred when it serves to alleviate a violation of Distinctness that would occur under a single clause interpretation (see section 2.3). From this perspective, the absence of a scrambling negativity for object-initial wh-questions and relative clauses may be due to the fact that, in these types of sentences, the initial object is positioned in the German prefield. As the prefield can, by definition, only host a single constituent, argument linearisation is not an issue within this domain of the German clause. Hence, no prominence-linearisation mismatch can occur and no scrambling negativity is elicited (see Wolff et al., in press).
In Phase 1 of processing, the major principles of structure-building can be characterised in terms of Distinctness. Firstly, the construction of basic constituents such as noun phrases, which is generally assumed to proceed according to principles such as X'-theory or analogous theoretical assumptions in other approaches, can be described as adhering to a level of categorial Distinctness. For example, a phrasal constituent cannot have two heads as this would violate Distinctness in the strongest sense: heads cannot be rendered distinct from one another by means of additional features. When such a violation occurs, it engenders an early left anterior negativity (ELAN) and leads to a massive disruption of processing (see Friederici, 2002). A second consequence of categorial Distinctness is that, at the sentence level, the simplest and most unmarked structure is one consisting of an argument (NP) and a verb. Here, the two constituents in the structure are maximally distinct by way of their different categories, while at the same time providing the minimal amount of information required for the description of a particular event/state of affairs (for converging support from language typology, see DuBois’ Preferred Argument Structure principle: DuBois et al., 2003; DuBois, 1987). 7

The processing mechanisms taking place in Phase 2 are concerned with the establishment of interpretive relations between elements within a sentence. They therefore go beyond categorial information and the question of which categories may co-occur with one another, and rather serve to assign argument hierarchies in accordance with the available prominence information (amongst other things which are not of primary interest here). In essence, phase 2 processes serve to guarantee the distinctness of elements that are not categorically distinct. For example, arguments should ideally be as distinct as possible from one another in terms of all dimension of prominence precisely because they belong to the same category. To a certain degree, Minimality in this phase of processing is therefore already determined by categorial Distinctness: the only NP in a sentence is both categorially distinct and (vacuously) distinct in terms of prominence. However, the processing costs arising in this processing phase are independent of categorial Distinctness per se, but rather result from prominence mismatches between arguments. These can be avoided either by way of a perfect alignment of prominence hierarchies (such that the Actor outranks the Undergoer in terms of all prominence dimensions and precedes it in terms of linear order) or by way of a vacuous fulfilment of prominence requirements in the case of only a single argument. 8

The possible role of Distinctness in Phase 3 of processing remains somewhat more speculative than the discussion of the previous two phases above. The crucial question in this regard appears to be whether the additional information that is processed in Phase 3 (e.g. discourse context, plausibility) may serve to further modulate Distinctness. It is currently not clear whether this is the case or not (but see Bornkessel, 2002, for evidence that these information types do not modulate Distinctness in Phase 2 of processing). One possible hypothesis might be that the relevance of Phase 3 information differs from language to language. For example, Chinese and Tagalog are often described as languages in which argument prominence is primarily constrained by pragmatic information (e.g. Bisang, 2006). Assuming, then, that the assignment of information types to particular phases of processing is universal (though this remains to be demonstrated), the difference between languages such as Chinese and Tagalog on the one hand and languages like English and German on the other might be that Phase 3 processing serves to modulate argument distinctness in the former but not in the latter. This hypothesis, which is admittedly only speculation at present, thus requires testing in future research.

Finally, while the proposal put forward here (Minimality as Distinctness) appears promising in that it can provide a descriptive explanation for a wide range of processing phenomena across languages, it clearly requires further specification and formalisation. Thus, one of the primary goals of future work in this domain will be to quantify the language-specific weightings of individual prominence-related features in order to be able to derive precise predictions about how these features interact to determine the processing choices described in the present paper.

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7 One might argue that the simplest realisation of an event/state of affairs is, in fact, only a verb (at least in languages allowing argument drop). While this is probably true from a structural, sentence-internal perspective, such “verb-only” sentences are typically associated with very highly constraining pragmatic (contextual) requirements. Hence, we would assume that these types of structures are dispreferred as a consequence of phase 3 of processing, in which contextual constraints come into play.

8 In the formulation of the eADM put forward in Bornkessel and Schlesewsky (2006), one of the main consequences of Minimality in Phase 2 of processing was that it led to the assignment of the feature [+agrt] (i.e. it designated the first argument that was encountered to be the argument that agreed with the verb). Given that we no longer assume an independent Minimality principle, one might therefore wonder how agreement processing is now handled. In fact, agreement can also be straightforwardly viewed as a consequence of Distinctness: an argument is assigned the feature [+agrt] when it is highest-ranking in terms of prominence. A single argument therefore again leads to a vacuous fulfilment of the criterion for agreement (for a similar formulation of agreement rules from a theoretical perspective, see Van Valin, 2005).
4. Differences between “Minimality as Distinctness” within the eADM and other approaches

In this final section, we would like to briefly contrast the notion of Minimality (“vacuous Distinctness”) proposed above with other simplicity-based approaches in the literature.

The most basic consequence of the MaD-proposal is that less structure is not always preferable. From the perspective of pure simplicity/minimality approaches, the optimal structure is one without any elements at all (Grimshaw, 1997). By contrast, if Minimality is simply a consequence of the need to be distinct, the optimal structure is one with only a single element of a particular kind (see Footnote 7).

The approach proposed here also differs markedly from the assumptions of generalised simplicity metrics such as Minimal Attachment (Frazier and Fodor, 1978), Minimal Everything (Fodor, 1998; Inoue and Fodor, 1995) and Dependency Locality Theory (Gibson, 1998, 2000). These proposals all share the assumption that minimal structures serve to avoid cognitive costs by minimising the number of elements/relations that must be maintained in working memory. From the perspective of the current approach, however, the number of elements per se is much less important in determining processing costs than the degree of similarity/distinguishability between these elements. The MaD-hypothesis is therefore more strongly in line with proposals that cognitive processing costs during sentence comprehension can be derived with reference to increased similarity-based interference (e.g. Gordon et al., 2001; Lewis and Vasisht, 2005; Lewis et al., 2006; McElree, 2006). However, the notion of Distinctness proposed within the eADM also differs from all of these approaches in that the distinguishability of arguments is defined with reference to hierarchically organised and verb-independent dependency relations. Interference-based processing costs are therefore not only expected at the position of the verb (when the arguments need to be retrieved from memory to allow for full interpretation), but also during the preverbal establishment of argument hierarchies. When the verb is processed, the activation level of a particular argument is therefore expected to be more than a function of the individual elements that were encountered prior to the verb, but also of the argument-argument relations that were constructed before this point. Thus, the status of the argument hierarchy (e.g. in terms of how distinct the arguments are from one another) and word order information also play a crucial role in determining the ease or difficulty of linking the arguments to the verb (for initial evidence in this regard, see Demiral et al., submitted).

In summary, while the present approach shares many of the underlying cognitive motivations of existing interference-based approaches, the data on which it is based also highlight the difficulties that cross-linguistic findings present for such accounts. In addition to the obvious interest that lies in a possible computational implementation of the MaD-approach, one clear objective of future research is therefore to examine in more detail how the interference costs arising from the cross-linguistic application of prominence hierarchies in simple sentences can be related to the types of interference costs that have been established on the basis of findings from complex structures like centre-embeddings.

5. Summary and conclusions

We have argued that a range of language processing phenomena that appear to call for a “minimality” or “least effort” based interpretation are in fact more parsimoniously derived with reference to a principle termed “Distinctness”, which states that the sentential arguments should be as distinct as possible from one with respect to a range of features determining argument “prominence” (e.g. animacy, definiteness, case marking). We began by reviewing empirical evidence that the processing system strives towards minimal interpretations, i.e. interpretations involving the least possible number of dependencies (ideally, intransitive events). This interpretation strategy can explain a range of cross-linguistic findings, including the subject-preference for initial ambiguous arguments. However, a number of further results contradict the idea that the processing system generally endeavours to minimise dependencies: under certain circumstances, two-event readings are preferred over single-event analyses and ditransitive (three-argument) interpretations are preferred over transitive (two-argument) interpretations. In view of these counterexamples to a “pure” minimality-based processing strategy, we proposed that the preference for minimal interpretations should rather be viewed as a special case of a more general Distinctness requirement for arguments: the simplest way to be distinct is to be the only element of a particular kind (e.g. the sole argument in an intransitive relation). When Distinctness cannot be upheld in a sentence with several arguments (e.g. because two arguments are identical with respect to all dimensions of prominence, including case marking), processing preferences switch to a “non-minimal” reading (e.g. to the assumption of two separate events or of a ditransitive event). As the Distinctness principle is independently needed to derive other processing phenomena (e.g. in the domain of word order
permutations), this view of Minimality as vacuous Distinctness (MaD) leads to a significant simplification of the overall processing architecture. Furthermore, as the notion of Distinctness can plausibly be extended beyond the domain of argument interpretation to also apply to basic constituent structuring and the integration of a sentence into the overall discourse, Distinctness is a promising candidate for a meta-principle of the sentence comprehension architecture. This proposal appears attractive from a cognitive perspective, as distinct representations serve to minimise interference and, thereby, cognitive processing costs.

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Appendix A. A brief introduction to event-related brain potentials (ERPs)

Event-related brain potentials (ERPs) are small changes in the spontaneous electrical activity of the brain, which occur in response to sensory or cognitive stimuli and which may be measured non-invasively by means of electrodes.

Fig. A.1. Schematic depiction of the setup of an ERP experiment on language processing (adapted from Rugg and Coles, 1995). The ongoing EEG is recorded while participants read or listen to linguistic stimuli. Critical stimulus-related activity is isolated from the background electrical activity of the brain by means of an averaging procedure, which applies to a set of stimuli (typically 30–40) of the same type. The resulting event-related brain potential, which is shown in the bottom right-hand corner of the figure, consists of a series of negative and positive potential changes. Note that, by convention, negativity is plotted upwards. The x-axis depicts time (in milliseconds or seconds) from critical stimulus onset (which occurs at the vertical bar), while the y-axis depicts voltage in microvolts. ERP components are typically named according to their polarity (N for negativity vs. P for positivity) and latency (an N400, for example, is a negativity with a peak latency of approximately 400 ms relative to critical stimulus onset). ERP comparisons are always relative, meaning that negativities or positivities in a critical condition can only be interpreted relative to a control condition and not in absolute terms (i.e. relative to the zero-line).
applied to the scalp. ERPs provide a very high temporal resolution, which is particularly useful as a means of tracking real time language processing. Furthermore, ERP patterns (‘components’) can be characterised along a number of different dimensions, thus providing a qualitative measure of the different processes involved in language comprehension. These dimensions are: polarity (negative vs. positive), topography (at which electrode sites an effect is visible), latency (the time at which the effect is visible relative to the onset of a critical stimulus), and amplitude (the ‘strength’ of an effect). While a number of language-related ERP components have been identified (cf., for example, Friederici, 2002), we will not introduce these here for the sake of brevity. For a more detailed description of the ERP methodology and how it has been applied to psycholinguistic domains of investigation, the reader is referred to the recent overview presented by Kutas et al. (2006).

The ERP methodology only provides relative measures, i.e. an effect always results from the comparison of a critical condition with a minimally differing control condition. For example, at the position of socks in *He spread the warm bread with socks* in comparison to the position of butter in *He spread the warm bread with butter*, a negativity with a centro-parietal distribution and a maximum at 400 ms post critical word onset (N400) is observable (Kutas and Hillyard, 1980). Thus, in the experiments presented here, we always compare the response to a critical condition with that to a control condition at a particular (critical) position in the sentence.

A schematic illustration of the ERP methodology is shown in Fig. A.1.

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