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Selective impairment of knowledge underlying prenominal adjective order: evidence for the autonomy of grammatical semantics

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Abstract

English speakers have strong preferences for the order in which adjectives can occur before a noun — e.g. *big brown dog* vs. **brown big dog*. These ordering preferences are based on a restricted set of semantic features which include fairly abstract functional distinctions like "descriptive" vs. "classifying" as well as information about adjective categories like "size" vs. "color". Other perceptual and conceptual features of adjective meaning — e.g. particular colors like "brown" vs. "black" —do not influence the syntactic behavior of the words. According to the "grammatically relevant semantic subsystem" hypothesis proposed by Pinker [Pinker S. Learnability and Cognition. Cambridge, MA: MIT Press, 1989], it is reasonable to suppose that the features of adjective meaning that constrain their linear order reside at a different level of mental representation than the features that are invisible to syntax. If this is true, then it is possible that the two components of meaning could be impaired independently of each other by brain damage. This paper reports a series of experiments that confirmed this prediction. Six of 16 brain-damaged subjects failed a test that assessed their knowledge of the semantic principles that determine prenominal adjective order. However, all of the subjects performed within normal limits on a second test that assessed their knowledge of the grammatically irrelevant perceptual and conceptual features of the same adjectives that were used in the first test. In addition, all of the subjects performed well on a third test that assessed their knowledge of the basic syntactic structure of English noun phrases (NPs). Taken together, these results suggest that the brain-damaged subjects who failed the first test have impaired knowledge

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of the grammatically relevant semantic features that influence prenominal adjective order; in contrast, they have well-preserved knowledge of grammatically irrelevant aspects of adjective meaning and of basic elements of NP syntax. This study therefore provides support for the view that there is an independent level of representation in the mind/brain for grammatical semantics.

1. Introduction

A great deal of research in neurolinguistics has been done on disorders of syntactic processing [1]. In addition, a considerable amount of attention has been devoted to disorders of processing word meanings [2–4]. However, virtually no neuropsychological studies have focused directly on the level of mental representation that lies at the interface between syntax and word meaning, namely the level of grammatical semantics [5].

In linguistic theory, there is increasing evidence that the syntactic properties of words are usually constrained by certain very restricted aspects of their meaning [6–18]. A good example involves verbs. The sentence *Sam poured water into the glass* is grammatical, but the sentence **Sam filled water into the glass* is not. The explanation for this difference may be roughly as follows [7,9,19]. The syntactic construction [NPVNP*into*/*onto*NP] is directly associated with the schematic meaning "X causes Y to go to Z", in which the Y entity is construed as the most "affected" one (since it changes location) and usually has a particular manner of motion. In order for a verb to occur in the construction, its meaning must be compatible with that of the construction. Because the verb *pour* specifies that a liquid moves from one location to another in a certain manner (namely in a downward stream via the force of gravity), its meaning is compatible with that of the construction and therefore the verb can freely appear in the construction. On the other hand, because the verb *fill* only indicates that a container changes state in a certain way (namely from not being full to being full) and is completely mute about how this change is accomplished, its meaning is not compatible with that of the construction and this precludes the verb from appearing in the construction. It is especially important to note that only some aspects of the meaning of a verb are relevant to its syntactic behavior. For instance, it is possible for many different motion verbs to occur in the construction described above — e.g. *Sam poured/dripped/dribbled/spilled/sloshed water into the glass*. Each of these verbs specifies that the motion of the water has a particular rate, shape and trajectory, but these subtle perceptual and conceptual features are not what allow the verbs to occur in the construction; rather, what the construction is sensitive to is simply the fact that each verb specifies that the entity changing location is the main "affected" entity and has some characteristic "manner of motion".

Research along these lines has led to what Pinker [7] calls the "grammatically

relevant semantic subsystem'' hypothesis. This view maintains that there is a small set of semantic features that are ''visible'' to grammar insofar as they influence the syntactic behavior of words. Grammatically relevant semantic features include motion, contact, change of state, animate/inanimate, bounded/unbounded, 0/1/2/3-dimensionality and so forth [7,20–22]. Other perceptual and conceptual features are ''invisible'' to grammar and hence do not influence the syntactic behavior of words. Such features include the following: particular manner of motion (e.g. pouring vs. dripping), degree of event realization (e.g. almost vs. just barely), particular shape of entities (e.g. conical vs. with a protrusion)[1], particular color of entities (e.g. red vs. blue) and so forth [23]. In addition to the primary factor of (un)importance to grammar, two other factors are closely tied to the distinction between grammatically relevant and grammatically irrelevant aspects of meaning. First, many semantic features that fall within the grammatically relevant subsystem recur across genetically and geographically unrelated languages with fairly high reliability, whereas grammatically irrelevant perceptual and conceptual features are much more idiosyncratic and crossculturally variable [23]. Second, grammatically relevant semantic features appear to be less salient to consciousness than grammatically irrelevant perceptual and conceptual features, as shown by the fact that very careful linguistic analysis is often required to uncover the semantic motivations behind the seemingly odd syntactic behavior of words.

According to the strong version of Pinker's hypothesis, grammatically relevant and grammatically irrelevant components of meaning are segregated in the mind. If this is true, it is possible that the two components of meaning are mediated by partially distinct neural networks. Therefore, the two components might be selectively impaired independently of each other by brain damage. Recently, a series of experiments was conducted which suggested that grammatically relevant and irrelevant features of verb meaning can be independently disrupted [5]. Specifically, two brain-damaged subjects could distinguish between closely related verbs such as *pour, drip,* and *slosh,* but were defective at making accurate grammaticality judgements about sentences like *Sam poured/*filled water into the glass*[2]. Conversely, another brain-damaged subject exhibited exactly the opposite performance profile. These findings provide neuropsychological support for the ''grammatically relevant subsystem'' hypothesis.

The purpose of this paper is to describe another series of experiments that was designed to test the hypothesis, only this time in the domain of adjectives. English speakers have strong preferences for the order in which adjectives can precede nouns — e.g. *big brown dog* is fine, but **brown big dog* is odd (at least in a neutral context). Analysis of these preferences has shown that they are due primarily to

[1] Some languages do grammaticize shape information in the form of noun classifiers, but such classifiers only specify very schematic features of shape, such as ''long thin objects'' or ''round objects'' [20].

[2] A control experiment indicated that the subjects poor judgement ability was not due to a disorder of syntactic processing or metalinguistic judgement ability, but was instead restricted to the level of grammatical semantics.

rather abstract semantic features, such as whether an adjective has a "specifying" or a "descriptive" function, or whether it encodes a property that is inherent to the kind of object specified by the noun. The "grammatically relevant semantic subsystem" hypothesis predicts that knowledge of these semantic features could be impaired independently of knowledge of various grammatically irrelevant perceptual and conceptual features of adjective meanings. As I will show, the experiments confirmed this prediction. Before presenting the experiments, however, I will first review some of the major linguistic research that has investigated the nature of prenominal adjective order.

2. Semantic constraints on prenominal adjective order

Why is it grammatical to say *the other small inconspicuous carved jade idols* but not **the carved other inconspicuous jade small idols?* A considerable amount of research has addressed this issue from theoretical, experimental and crosslinguistic perspectives [20,24–42]. The most comprehensive analysis of English prenominal adjective order comes from Bache [35,41], whose work is an elaboration of ideas first proposed by Teyssier [25].

In the simplified version of Bache's analysis that I will outline here, there are two main levels of structural and functional organization for adjective order. The first level consists of three syntactic "modification zones" in which adjectives can occur; preceding these zones is a syntactic slot for determiners of various kinds and after them is a slot for the head noun of the NP. Each modification zone can be defined in functional terms: zone 1 is for "specifying" adjectives, zone 2 is for "descriptive" adjectives and zone 3 is for "classifying" adjectives. The zones are shown in Table 1 together with examples.

Descriptive adjectives are "central" adjectives in the sense that they have the

Table 1
Modification zones for adjectives (adapted from Bache and Davidsen-Nielsen [41])

Determiners	Adjectives			Head noun
	1. Specification	2. Description	3. Classification	
the	earliest	important	Aboriginal	carvings
her	own	handsome	naval	officer
the	next	interesting	congressional	procedure
this	particular	informal	linguistic	rule
	many	eager	medical	students
	certain	serious	organic	diseases
the	same	beautiful	Italian	actress

following syntactic and semantic features that are normally considered to be criterial for adjective status:

- They can occur in both attributive prenominal position and predicative position — e.g. *the funny movie, the movie is funny*.
- They can serve as conjoints in linked coordination — e.g. *his ugly and fat opponent*.
- They are gradable and thereby allow comparison by means of *-er* and *-est* suffixes (or *more* and *most* modifiers) and intensification by means of adverbs like *very* and *extremely*.
- They typically enter a binary antonymous semantic system — e.g. *big–small, tall–short*, *good–bad*, *soft–hard*.

Specifying and classifying adjectives, on the other hand, are "peripheral" adjectives insofar as they do not conform to some or all of these criteria. Instead, they have the following properties. According to Bache and Davidsen-Nielsen [41], specifying adjectives "help single out or quantify the referent of the construction in relation to some context — e.g. in *his main reason* and *my former colleague*, the specifying adjectives *main* and *former* have determiner-like properties" (p. 458). In contrast, classifying adjectives "subcategorize the head they modify — e.g. a *medical dictionary* is a special kind of dictionary and *solar energy* is a special kind of energy. Classifying adjectives thus help establish precisely what sort of thing is involved in the expression" (p. 458; see also Warren [42]). It is worth noting that in some contexts, adjectives can shift function — e.g. *wild* is descriptive in *wild party* but classifying in *wild bird*. Bache and Davidsen-Nielsen argue, however, that it is still usually justifiable to regard adjectives as having a default status as either specifying, descriptive, or classifying.

The second level of organization for the order of prenominal adjectives involves positional restrictions within each of the broad modification zones; it is crucial to note, however, that many of these restrictions are just strong tendencies or preferences, as opposed to hard-and-fast rules. Overall, Bache posits 18 distinct adjective slots which are broken down across modification zones as follows (most of the examples were drawn from actual texts by Bache):

- Modification Zone 1: Specification

  Slots:

  – precise and fuzzy ordinal numbers: *first, second, next, final*
  – precise and fuzzy cardinal numbers: *two, four, few, many*
  – compared forms: *older, smaller, finest, most beautiful*
  – others: *only, own, same, other, former, major, main, chief, similar, different, general, specific, certain*

  Examples:

  – ordinal + cardinal: *the first five primaries*
  – cardinal + other: *the two major categories*
  – cardinal + compared: *six smaller children*

- Modification Zone 2: Description
  Slots:
  - evaluative: *good, nice, pretty, wonderful, lovely, bad, horrible, ugly, nasty*
  - underived:
    - size: *big, large, huge, vast, small, tiny, little*
    - length: *long, short*
    - height: *tall, high, low*
    - other: *rough, smooth, hot, cold, hard, soft, heavy, light, wet, dry, young, old*
  - derived:
    - deverbal: *undulating, predictable, quivering*
    - denominal: *hilly, wishful, dusky*

  Examples:
  - evaluative + size: *a terrible small room*
  - evaluative + other: *lovely soft hands*
  - evaluative + denominal: *a horrible, ghoulish enjoyment*
  - size + length: *big, long things*
  - size + height: *big, high cheek bones*
  - size + other: *that big, tough guy*
  - length + height: *long, low sheds*
  - length + other: *long blank periods*
  - deverbal + denominal: *undulating hilly slopes*

- Modification Zone 3: Classification
  Slots:
  - deverbal: *leading, sleeping, internalized, recognized, hypnotizable*
  - time: *daily, annual, nineteenth-century, quarterly*
  - color: *red, green, yellow, blue, white, black*
  - nationality: *English, French, Chinese, Scandinavian*
  - locality: *local, regional, national, Atlanta*
  - denominal: *industrial, presidential, nuclear, woolen, medical, cultural, political*
  - nominal premodifiers: *metal, silk, tourist, airline*

  Examples:
  - deverbal + time: *patched-up nineteenth-century houses*
  - deverbal + nationality: *a retired Indian judge*
  - deverbal + denominal: *internalized linguistic representation*
  - time + denominal: *the annual aquatic contest*
  - color + nationality: *white American men*
  - color + nominal premodifier: *a yellow silk handkerchief*
  - nationality + denominal: *the American political system*

– locality + denominal: *local economic independence*
– denominal + nominal premodifier: *an electronic metal detector*

How is our knowledge of the constraints on prenominal adjective order represented in the mind/brain? Perhaps the most obvious possibility is that it is represented in terms of the semantic and morphological categories that Bache uses to describe the constraints — i.e. the notions of ''specifying'', ''descriptive'' and ''classifying'' for the level of inter-zone organization and notions like ''evaluative'', ''size'', ''color'', ''deverbal'' and ''denominal'' for the level of intra-zone organization. On this view, when a speaker is planning to produce an NP with multiple adjectives, each adjective is labeled as being either ''specifying'', ''descriptive'', or ''classifying'' and is also labeled as belonging to a particular semantic or morphological category of intra-zone relevance. These labels then influence the linear order in which the adjectives are placed.

Another possibility, however, which is not necessarily incompatible with the first but rather adds to it, is that the knowledge may reflect deeper semiotic principles. The order of the three modification zones appears to be iconic, since it roughly mirrors the degree of concreteness or ''nouniness'' of adjectives: classifying adjectives seem to be the most concrete and the nouniest, so it is natural that they are positioned at the right-hand edge of the sequence immediately adjacent to the head noun of the NP; specifying adjectives are the least concrete and the least nouny and accordingly they are positioned at the left-hand edge of the sequence, farthest away from the head noun; finally, descriptive adjectives fall in the middle of the concreteness/nouniness continuum and hence naturally occur in the middle of the adjective sequence[3].

Iconicity may also play a role in the order of adjectives within modification zones, especially within zone 2. This is manifested in at least two ways. First, adjectives that encode objective, inherent, verifiable properties of entities, like *rough*, *hot*, *hard* and *wet*, typically occur closer to the head noun than adjectives that encode subjective, personal, opinion-based properties of entities, like *good*, *bad*, *pretty* and *ugly*; thus the linear order of adjectives mirrors the degree of objectivity of properties [26,34,36]. Second, the concept of (syn)categorematicity appears to be relevant. Basically, this involves the degree to which the interpretation of an adjective is independent of the semantic domain being modified (categorematic) or dependent on that domain (syncategorematic). For instance, *sharp* is a fairly categorematic adjective because its interpretation remains more or less constant regardless of what kind of noun it modifies — e.g. *sharp knife* and *sharp nail* both refer to things that have a particular kind of

[3] This type of iconic order is found in many other parts of grammar — e.g. it is common crosslinguistically for verb aspect markers, which indicate the intrinsic temporal structure of the event, to occur closer to the verb stem than tense markers, which indicate the time of the event in relation to an extrinsic frame of reference [43].

physical configuration. In contrast, *good* is a very syncategorematic adjective because its interpretation depends greatly on the kind of noun it modifies — e.g. *good knife* refers to a knife that cuts well, whereas *good nail* refers to a nail that is suitable for pounding into something. With regard to adjective order, categorematic adjectives typically occur closer to the head noun than syncategorematic adjectives; thus the linear order of adjectives mirrors the degree to which their interpretation is independent of the head noun [20,44,45].

Support for the validity of the two iconic dimensions of objectivity and categorematicity comes from crosslinguistic research. Dixon [34] and Hetzron [36] both demonstrate that there are very strong tendencies for different types of descriptive adjectives to occur in either the same order or in very similar orders across genetically and geographically unrelated languages. Thus, evaluative adjectives almost invariably occur farthest from the head noun, followed by dimensional adjectives (like *long* and *tall*) and then physical property adjectives (like *hot* and *smooth*); color adjectives, which are treated as classifying adjectives by Bache, always occur closer to the head noun than the other types. These findings are remarkable because they suggest that the human mind/brain is somehow predisposed to order adjectives in an iconic manner according to the features of objectivity and categorematicity. However, it is important to note that there are limits to what these features can explain. For instance, it is not clear why size, length and height adjectives tend to occur in precisely that order in English; certainly one would be hard pressed to show (in a noncircular manner) that these adjectives vary in the predicted way with respect to objectivity and categorematicity. Nevertheless, the features do appear to be able to explain many ordering preferences and hence it is conceivable that they constitute part of the knowledge that enables speakers to organize complex adjective sequences in reliable ways.

For purposes of this paper, the most important generalization to draw from the preceding discussion is that only a small, restricted subset of the semantic properties of adjectives are grammatically relevant. To take a straightforward example, the fact that *red*, *green*, *blue* and *yellow* encode different kinds of colors is not relevant to how they get ordered in relation to other adjectives, but the fact that all of them encode some kind of color is relevant. Similarly, the fact that color adjectives encode fairly concrete, objective, categorematic properties of entities is a grammatically relevant semantic feature, even though it is not a feature that comes readily to mind when one thinks of the meanings of color adjectives. If grammatically relevant and grammatically irrelevant aspects of adjective meaning are segregated in the mind/brain, then it is possible that neurological damage could selectively impair one component of meaning, while leaving the other component intact. For instance, knowledge of how color adjectives get ordered might be disrupted, while knowledge of the idiosyncratic differences between various color terms is preserved. The goal of the experiments described below was to test this prediction of the ''grammatically relevant semantic subsystem'' hypothesis.

3. Experiment 1

3.1. Methods

3.1.1. Subjects

Sixteen brain-damaged subjects with exclusively left-hemisphere lesions were selected from the Patient Registry of the University of Iowa's Division of Cognitive Neuroscience. All subjects gave informed consent in accordance with the Human Subjects Committee of the University of Iowa. The lesions were distributed throughout the frontal, parietal, temporal and occipital lobes and some also included subcortical structures such as the basal ganglia. Information about the particular lesion sites of the subjects is provided in Table 2. This information comes from magnetic resonance (MR) data obtained in a 1.5 Tesla scanner with an Spg sequence of thin (1.5 mm) and contiguous T_1 weighted coronal cuts. The neuroimaging data was used to reconstruct each subject's lesion in three dimensions using Brainvox [46,47]. Because grammatical knowledge is generally believed to be mediated by cortical structures within the left perisylvian region, it was hypothesized that lesions within this broad anatomical region would be more likely to disrupt knowledge of prenominal adjective order than lesions that spared it. As shown in Table 2, 10 subjects had intra-perisylvian lesions and the remaining six had extra-perisylvian lesions.

Before participating in the experiments, all subjects had undergone extensive neuropsychological and neuroanatomical investigation according to the standard protocols of the Benton Neuropsychology Laboratory [48]. Although some of the

Table 2
Demographic features of the 16 brain-damaged subjects. The first 10 subjects have lesions that include the left perisylvian cortex and the remaining six subjects have lesions outside the perisylvian region

Subject	Age	Sex	Education	Post-onset	Lesion site (all left-hemisphere)
1962RR	70	M	16	8	frontal, temporal, parietal
1978JB	53	F	12	4	frontal, temporal, parietal
1172JP	88	M	16	12	inferior fronto-parietal
2011SS	32	F	12	4	inferior frontal, insula, post. sup. temporal
1726RO	64	M	12	8	inferior frontal, basal ganglia
2127HW	58	F	13	2	inferior frontal, basal ganglia
1733RK	63	M	12	8	inferior frontal
2078NS	67	M	16	4	middle and inferior frontal
194LP	51	F	12	19	temporo-parietal
615NJ	76	F	12	15	posterior superior temporal
2112JJ	46	M	15	3	lateral orbitofrontal
1848ML	48	M	12	3	temporo-occipital
2061MC	70	F	12	4	temporo-occipital
1621LL	62	F	9	7	temporo-occipital
2170SH	54	M	11	3	anterior inferior temporal
1130JP	53	F	11	13	superior parietal

subjects were aphasic, none of them had aphasia severe enough to prevent understanding instructions or producing coherent verbal responses. Demographic features of the subjects were as follows (Table 2): mean age = 59.7 yr (S.D. = 13.3); mean education = 12.7 yr (S.D. = 2.1); mean years post-onset = 7.3 (S.D. = 5.0); nine subjects were male and nine female; and 15 subjects were right-handed and one (615NJ) left-handed, as measured by the Geschwind–Oldfield Questionnaire.

The brain-damaged subjects were compared with 10 normal control subjects: mean age = 52.4 yr (S.D. = 7.4); mean education = 14.8 yr (S.D. = 3.1); six subjects were male and four female; and all of the subjects were right-handed.

3.1.2. Materials

The subjects were given a test that was designed to assess their knowledge of the semantic constraints on English prenominal adjective order. The test consists of 65 pairs of NPs with each NP having a determiner, two adjectives and a head noun. The two NPs in each pair contain exactly the same lexical items and differ only in the order of the adjectives — e.g. *a big brown dog* vs. **a brown big dog*. The task is to determine which NP sounds more "natural" than the other. That is, subjects do not have to judge whether the NPs are grammatical, but instead have to identify which one would be "preferred" by most native speakers of English. This rating system is appropriate because for many of the pairs of NPs, the dispreferred NP is not really ungrammatical but is simply less natural-sounding than the preferred one. The 65 pairs of NPs are grouped in 13 sets (five pairs per set) and these sets are defined in terms of particular combinations of adjective types. The first three sets focus on the differences between the three broad modification zones:

- zone 1 + zone 2 (e.g. *the last full glass vs. *the full last glass*)
- zone 1 + zone 3 (e.g. *the two Korean girls vs. *the Korean two girls*)
- zone 2 + zone 3 (e.g. *a small local store vs. *a local small store*).

The remaining 10 sets focus on ordering tendencies among descriptive adjectives in zone 2[4]:

- value + size (e.g. *a nice small vase vs. *a small nice vase*)
- value + dimension (e.g. *a good high ceiling vs. *a high good ceiling*)
- value + other (e.g. *a good sharp knife vs. *a sharp good knife*)
- value + color (e.g. *an attractive red dress vs. *a red attractive dress*)
- size + dimension (e.g. *a big long rope* vs. **a long big rope*)
- size + other (e.g. *a large fat cow vs. *a fat large cow*)
- size + color (e.g. *a small brown bird vs. *a brown small bird*)
- dimension + other (e.g. *a short round fencepost vs. *a round short fencepost*)
- dimension + color (e.g. *a tall grey building vs. *a grey tall building*)
- other + color (e.g. *a soft pink sweater vs. *a pink soft sweater*)

[4] The tendency for length adjectives to precede height adjectives was not investigated; instead, these two types of adjectives were collapsed under the general heading "dimensional adjectives".

All 65 pairs of NPs are presented in Appendix A.

In constructing the test, I followed Bache's [35,41] analysis of prenominal adjective order except for one point. I disagree with his placement of color adjectives in zone 3 and believe that there are good reasons to suppose that they belong in the final slot of zone 2 instead. Although there are occasions when color adjectives serve to "define" the kind of entity designated by the head noun (e.g. *red hair, black coffee*), it seems that they usually serve to provide information about "characteristic" properties, like standard descriptive adjectives. Furthermore, although color adjectives do not occur in antonymous relationships, they nevertheless have many other semantic and syntactic features that are typical of "central" descriptive adjectives: they are gradable and hence allow comparison (e.g. *red*, *redder*, *reddest*) and intensification (e.g. *very red*); they can occur in both attributive prenominal position and predicative position (e.g. *the blue shirt*, *the shirt is blue*); and they can serve as conjoints in linked coordination (e.g. *the red and white flag*).

In addition to keeping everything the same in each pair of NPs except the order of adjectives, several other factors were controlled for. First, very few morphologically derived adjectives were used. The only ones were as follows: five for nationality (*Canadian*, *Korean*, *Italian*, *Mexican* and *Chinese*), four for emotion (*beautiful*, *dreadful*, *lovely* and *terrible*) and one for comparison (*finest*). Thus derivational processing requirements were negligible. Second, all head nouns refer to concrete entities. Third, all adjective sequences are "unbroken", i.e. not separated by commas. Finally, in 55 pairs of NPs the determiner is the indefinite article *a* and in the remaining 10 pairs it is the definite article *the*.

3.1.3. Procedure

The subjects were tested individually in a quiet examination room in the Department of Neurology at the University of Iowa. All subjects were given the same pairs of NPs in the same random order. For 32 of the 65 pairs of NPs the correct NP was first and for the other 33 pairs it was second. One practice item was given so as to familiarize the subjects with the nature of the task. The NPs were both read aloud to the subjects and presented to them in written format, so auditory–verbal short-term memory requirements were minimal. In reading the NPs aloud, the examiner always used the same even intonation contour for both the preferred and the dispreferred NP. Subjects' responses were recorded in writing.

3.2. Results and discussion

All of the control subjects performed well on the test, achieving a mean percent correct of 92.0 (range = 85–98%, S.D. = 4.7%). Because their scores were so high and also because the standard deviation was fairly small, a conservative criterion was set for classifying a brain-damaged subject's performance as being defective. Specifically, the subject's overall percent correct had to fall four or more standard deviations below the mean for the normal control subjects, which corresponds to

a score of 74% or lower. Using this system, the 16 brain-damaged subjects were divided into two groups, one unimpaired ($n = 10$) and the other impaired ($n = 6$). The unimpaired group performed only slightly worse than the normal control subjects, with a mean percent correct of 90.2 (range = 82–98%, S.D. = 4.6%) and a mean z-score of -0.5. In contrast, the impaired group performed quite poorly, with a mean percent correct of 69.7 (range = 62–70%, S.D. = 2.2%) and a mean z-score of -4.8.

Four of the six impaired subjects had perisylvian lesions (1962RR, 2011SS, 2127HW and 615NJ). The other two impaired subjects had lesions in the lateral orbitofrontal cortex (2112JJ) and in the superior parietal cortex (1130JP). Among the four subjects with perisylvian lesions, there was no single anatomical area that was commonly affected, although it is worth noting that three had inferior frontal damage and three had posterior superior temporal damage. This partial commonality may not be very significant, however, because many of the unimpaired subjects also had lesions in one or both of the same areas. Thus, no clear brain–behavior relationship emerged from this set of data. While this finding is disappointing, it is not entirely surprising since previous lesion studies of brain-damaged subjects with grammatical impairments have also failed to uncover reliable neural substrates [49,50].

Further analyses were conducted which focused on the two levels of organization for adjective order — organization across the three modification zones (measured by the first three sets of NPs) and organization within zone 2 (measured by the last 10 sets of NPs). On just the NP pairs that assessed

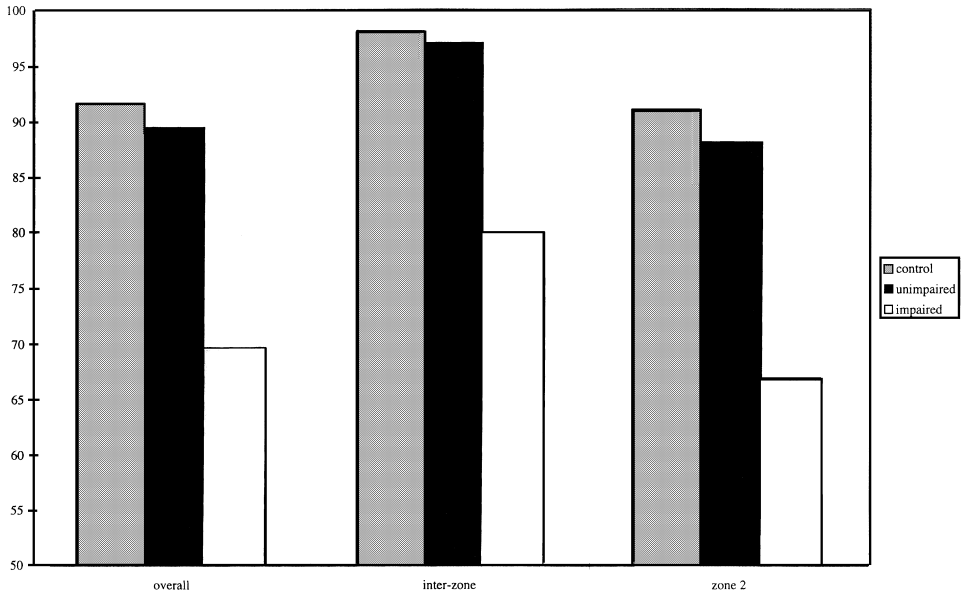

Fig. 1. Overall, inter-zone and zone 2 for control, unimpaired and impaired groups.

knowledge of inter-zone adjective order, the control subjects' mean percent correct was 97.9 (range = 93–100%, S.D. = 3.4%), the unimpaired subjects' was 97.0 (range = 93–100%, S.D. = 3.6%) and the impaired subjects' was 79.7 (range = 53–93%, S.D. = 16.3%). An ANOVA indicated a significant difference ($F(2, 27) = 12.7$, $p < 0.01$), which is clearly due to the impaired subjects. It is important to note, however, that there was considerable variation in the individual performance profiles across the six subjects in the impaired group: three subjects had scores of 93% correct and hence were essentially normal; two had scores of 73% correct and hence were moderately impaired; and one had a score of 53% correct and hence was severely impaired. On the 10 sets of NPs that assessed knowledge of how descriptive adjectives are ordered within zone 2, the scores for all three groups were lower and the difference between the impaired group and the two groups of control and unimpaired subjects was greater. Specifically, the mean percent correct for control subjects was 90.8 (range = 86–98%, S.D. = 6.1%), that for the unimpaired subjects was 88.1 (range = 78–98%, S.D. = 5.7%) and that for the impaired subjects was 66.7 (range = 62–70%, S.D. = 3.3%). An ANOVA revealed a significant difference ($F(2, 27) = 41.5$, $p < 0.01$), confirming the defective performance of the impaired subjects. Fig. 1 summarizes the results by showing the overall, inter-zone and zone 2 scores for the control, unimpaired and impaired groups of subjects.

A closer investigation of the individual performance profiles of the impaired subjects for zone 2 ordering restrictions revealed several interesting differences. These results are shown in Table 3. For the sake of convenience, let us assume that if a subject performed correctly on only two (or fewer) of the five NP pairs representing a particular type of adjective order, this indicates unusual problems

Table 3
Results for individual impaired brain-damaged subjects on 50 pairs of NPs assessing knowledge of zone 2 adjective order restrictions. Each adjective order type is represented by five pairs of NPs. The cells indicate the number of NP pairs for which the subject selected the NP with the correct adjective order

Adjective order type	Impaired subjects					
	2011SS	615NJ	2112JJ	1962RR	2127HW	1130JP
value + size	4	4	3	5	2	4
value + dimension	4	3	3	4	1	4
value + other	4	5	5	3	2	5
value + color	1	3	4	3	3	3
size + dimension	3	1	4	4	4	3
size + other	4	2	2	4	5	2
size + color	3	5	4	3	5	4
dimension + other	3	5	3	0	3	3
dimension + color	3	3	4	2	3	3
other + color	2	4	3	5	4	3
number correct	31/50	35/50	35/50	33/50	32/50	34/50
percent correct	62%	70%	70%	66%	64%	68%

judging that type of order. For the four adjective order types in which "value" precedes some other kind of adjective, the only subjects who had severe trouble were 2011SS and 2127HW. Notice, however, that while 2011SS had difficulty with just the last order type — "value + color" —2127HW had difficulty with the first three types — "value + size", "value + dimension" and "value + other". For the three order types in which "size" precedes some other kind of adjective, three subjects exhibited significant problems — 615NJ, 2112JJ and 1130JP. All three of these subjects had difficulty with the "size + other" type, but 615NJ also had difficulty with the "size + dimension" type. Only one subject — 1962RR — had unusual problems with the order types in which "dimension" precedes some other kind of adjective, and remarkably enough, this subject missed all five of the NP pairs representing the "dimension + other" pattern. Finally, only one subject — 2011SS — had trouble with the "other + color" order type. Thus there was quite a bit of variability with regard to which particular types of zone 2 order patterns were most difficult for the impaired subjects.

Taken together, these results suggest that the impaired subjects have a deficit in their knowledge of the semantic principles underlying prenominal adjective order. However, before drawing such a conclusion it is necessary to explore alternative explanations for the results. In particular, it could be that the impaired subjects have a broader conceptual disturbance that is not restricted to the grammatically relevant semantic features of adjectives but includes other features as well. It is also possible that they have impaired knowledge of the basic syntactic structure of English NPs, or an impaired ability to make metalinguistic acceptability judgements. These alternative explanations are considered in Experiments 2 and 3.

4. Experiment 2

4.1. Methods

4.1.1. Subjects

The same brain-damaged subjects and normal control subjects who participated in Experiment 1 also participated in this study.

4.1.2. Materials

A test was administered that evaluated the subjects' knowledge of the grammatically irrelevant perceptual and conceptual features of the very same descriptive adjectives that were used in the 13 sets of NP pairs in Experiment 1 that focused on zone 2 ordering restrictions. As in Experiment 1, a forced-choice paradigm was used in which the subjects were required to select one of two different answers to a question. In this study, however, the question was not about which of two NPs has a more natural-sounding order of adjectives, but was instead about which of two pictures best represents the basic meaning of a particular adjective. There were a total of 50 adjectives. Each adjective was written at the top of an 8 by 11 inch white page in boldface upper-case 18 point font.

Below the adjective were two pictures aligned horizontally across the page, the left-hand one labeled "A" and the right-hand one labeled "B". One of the two pictures represented the basic meaning of the adjective, while the other picture did not[5]. In half of the items the correct answer was "A" and in the other half it was "B". Whenever possible, the pictures were designed so that the only feature that varied was the property denoted by the adjective. This was done to ensure that the subjects were basing their decisions on the appropriate aspects of the pictures, as opposed to some other cues. Thus for the "value", "size", "dimension" and "color" adjectives, maximally simple line drawings of circles, rectangles and cubes were used. Similar drawings were used for a small number of the "other" adjectives, but for most of these it was necessary to present drawings or photographs of real objects. Excluding the color adjectives, most of the adjectives were organized in antonymous pairs — e.g. *big-little*, *hot-cold*. For these adjective pairs, the same two pictures were used such that when one adjective was presented, one of the pictures was the correct answer and when the other adjective was presented, the other picture was the correct answer; whether the correct answer was "A" or "B" was randomized. All 50 adjectives are listed in Appendix B together with brief descriptions of the pictures associated with each one.

4.1.3. Procedure

As in Experiment 1, the subjects were examined individually in a quiet room and they were given the same items in the same random order. Each adjective was not only presented to the subjects visually, but was also read aloud by the examiner. The subjects were free to respond by either pointing to one of the two pictures or saying "A" or "B". Responses were recorded in writing. A single practice item was provided to familiarize the subjects with the nature of the task.

4.2. Results and discussion

The control subjects made very few mistakes on this test (mean = 99.2%; range = 96–100%, S.D. = 1.6%). All of the brain-damaged subjects also performed extremely well. The mean percent correct for the subjects who were unimpaired on the adjective order test in Experiment 1 was 97.3 (range = 92–100%, S.D. = 3.5%) and that for the subjects who were impaired was 97.7 (range = 92–100%, S.D. = 2.3%).

These results provide evidence that all of the brain-damaged subjects have well-preserved knowledge of the most basic aspects of the idiosyncratic, grammatically irrelevant perceptual and conceptual properties encoded by the descriptive

[5] No attempt was made to explore complex aspects of the meanings of highly syncategorematic adjectives like evaluative and size adjectives; in addition, detailed features of the meanings of dimensional adjectives were not investigated (see Bierwisch and Lang [51] and Stolz [52]). Instead the goal was simply to determine whether the subjects had intact knowledge of the most essential perceptual and conceptual properties encoded by these adjectives.

adjectives used in the test. The fact that the group of subjects who were impaired on the adjective order test in Experiment 1 performed within normal limits on the test of adjective meanings in the present experiment suggests that their disorder is restricted to either (1) the systematic, grammatically relevant semantic features of adjectives, or (2) the ability to process the syntactic structure of NPs or to make metalinguistic judgements about them. The latter possibility was explored in Experiment 3.

5. Experiment 3

5.1. Methods

5.1.1. Subjects

The same brain-damaged subjects and normal control subjects who participated in Experiments 1 and 2 also participated in this study.

5.1.2. Materials

The subjects were given a test that evaluated their ability to make judgements about the syntactic structure of English NPs. As with the adjective order judgement test in Experiment 1, this test contains pairs of NPs that have the same lexical items but different linear orders; here, however, ungrammatical orders are not due to violations of grammatically relevant semantic principles, but rather to violations of purely syntactic rules. There are a total of 15 pairs of NPs, divided into three sets (five pairs per set). The first set was intended to test the knowledge that adjectives (typically) precede rather than follow nouns. Accordingly, the NPs in each pair consist of a single adjective and the head noun, only with opposite orders — e.g. *big field* vs. **field big*. Technically, the ''bad'' NPs really aren't structurally bad since postnominal adjectives can occur in certain very restricted contexts such as the resultative construction — e.g. *He made the field big*. But pilot testing with a small number of control subjects indicated that when people are asked to judge expressions like *field big* in a neutral context, they almost invariably rate them as ungrammatical, undoubtedly because prenominal adjectives are vastly more frequent than postnominal ones. The second set of NPs was intended to test the knowledge that an NP can consist of an adjective followed by another adjective followed by a noun. Hence the NPs in each pair have two adjectives and a noun and the order of lexical items is mirror-reversed — e.g. *sweet warm air* vs. **air warm sweet*. Here the NPs with postnominal adjectives are in fact structurally bad. In addition, it is important to note that the two adjectives are descriptive adjectives of the ''other'' type (in the hierarchy for linear order restrictions) and for this reason their linear order with respect to each other is not semantically constrained but is instead completely flexible — e.g. *sweet warm air* and *warm sweet air* are both fine. Thus the only information relevant to acceptablility judgements is the syntactic category of the lexical items. Finally, the third set of NPs was intended to test the knowledge that an NP can

have the order: determiner > adjective > adjective > noun. The good NP in each pair has this order and the bad NP has the opposite order — e.g. *a cool light rain* vs. **rain light cool a*. Again, in each pair of NPs the two adjectives are of the same type with respect to ordering restrictions. All 15 pairs of NPs are presented in Appendix C.

5.1.3. Procedure

The procedure was essentially the same as in Experiment 1. The subjects were examined individually in a quiet room and they were given the same items in the same random order. For eight of the 15 pairs of NPs the correct NP was first and for the remaining seven pairs it was second. One practice item was given so as to familiarize the subjects with the nature of the task. The NPs were both read aloud to the subjects and presented to them in written format, so auditory–verbal short-term memory requirements were minimal. In reading the NPs aloud, the examiner always used the same even intonation contour for both the grammatical and the ungrammatical NP. Subjects' responses were recorded in writing.

5.2. Results and discussion

As in Experiment 2, all of the subjects performed quite well on the test. The normal control subjects achieved a mean percent correct of 97.3 (range = 87–100%, S.D. = 3.7%); the group of brain-damaged subjects who were unimpaired on the adjective order test in Experiment 1 achieved a mean percent correct of 96.0 (range = 87–100%, S.D. = 4.2%); and the group of brain-damaged subjects who were impaired on that test achieved a mean percent correct of 95.6 (range = 87–100%, S.D. = 5.4%).

These results indicate that all of the subjects have intact knowledge of the basic syntactic structure of English NPs. They also show that all of the subjects are capable of making accurate metalinguistic judgements about the acceptability of linguistic expressions. It is therefore unlikely that the group of brain-damaged subjects who performed poorly on the adjective order test in Experiment 1 did so because of difficulty with syntactic processing or with making metalinguistic acceptability judgements.

6. General discussion

The purpose of the experiments described above was to test the hypothesis that the meanings of adjectives contain two different types of information: (1) a restricted set of semantic features that are visible to grammar and that influence the linear order of adjectives before a noun — e.g. "specifying" vs. "descriptive", or "evaluative" vs. "color"; and (2) an open-ended set of idiosyncratic perceptual and conceptual features that are not visible to grammar and that enable adjectives to encode all kinds of "property" distinctions — e.g. "usual" vs. "unusual", or "red" vs. "green". If these two components of adjective meaning reside at

different levels of mental representation, then it is likely that they are neurally implemented in at least partially distinct brain areas and this in turn predicts that the areas subserving grammatically relevant semantic features of adjectives could be disrupted independently of the areas subserving grammatically irrelevant features. This prediction was confirmed by the experiments, since some of the brain-damaged subjects (6 of 16) exhibited a striking dissociation, such that they performed quite poorly on a judgement test that assessed knowledge of the semantic constraints on prenominal adjective order, but performed quite well on a word–picture matching test that assessed knowledge of the basic meanings (i.e. grammatically irrelevant perceptual and conceptual features) of adjectives. The fact that these subjects performed within normal limits on a separate test requiring detection of purely syntactic violations of NP structure suggests that their failure on the adjective order test cannot be attributed to a disturbance of either syntactic processing or metalinguistic judgement ability.

There are several noteworthy aspects of the performance profiles of the subjects who displayed impaired knowledge of the semantic constraints on prenominal adjective order. One interesting finding is that these subjects performed better on the 15 pairs of NPs that involve ordering constraints on adjectives from different modification zones than on the 50 pairs of NPs that involve ordering constraints on adjectives within zone 2. At the level of group analysis, the subjects were in fact impaired on the inter-zone items, but the mean percent correct for these items (79.7) was considerably higher than the mean percent correct for the zone-2 items (66.7); moreover, at the level of individual subject analysis, only three of the six subjects were actually impaired on the inter-zone items, whereas all six subjects were impaired on the zone-2 items. Thus it appears that judgements of inter-zone order preferences might be slightly easier than judgements of zone-2 order preferences. This view is supported by the finding that the group of normal control subjects as well as the group of unimpaired brain-damaged subjects also performed better on the inter-zone items than on the zone-2 items. What this implies is that mild dissociations can occur even *within* the realm of grammatically relevant semantic features that influence prenominal adjective order. This might reflect differences in the kinds of semantic notions that are relevant to the two levels of organization for adjective order. Constraints on inter-zone order are based on fairly general distinctions like "specifying" vs. "descriptive" vs. "classifying" and possibly also on the iconic dimension of concreteness/nouniness, whereas constraints on zone-2 order are based on more specific distinctions like "evaluative" vs. "size" vs. "color" and possibly also on the iconic dimensions of objectivity and (syn)categorematicity. Perhaps the differential specificity of the two classes of semantic features is somehow responsible for their differential difficulty.

Another interesting finding is that there was quite a bit of variation across the six subjects with regard to which particular sets of zone-2 NP pairs were most difficult to judge. These results provide further evidence that dissociations may be possible *within* the realm of grammatically relevant semantic features that influence prenominal adjective order. For instance, 2127HW had significant trouble with the "value + other" order type but not with the "size + other" order

type, while 1130JP had just the opposite performance profile. It is important, however, to be cautious about inferring "type-specific" deficits from these results, since further research would be necessary to confirm this degree of selectivity. More generally, it is not entirely clear from the present set of data whether the subjects' deficits affect the actual content of grammatically relevant semantic features or instead affect the mechanisms that access and manipulate these features. Despite this indeterminacy, though, the results from Experiments 2 and 3 strongly suggest that the subjects' deficits do not extend to either the level of grammatically irrelevant features of adjective meaning or to the level of NP syntactic structure; instead, the deficits appear to be restricted to the level of grammatically relevant aspects of adjective meaning.

It is perhaps not so surpising that the deficits are restricted in this way. Consider first the finding that none of the subjects were impaired on the test of NP syntax in Experiment 3. Previous research has shown that knowledge of canonical English word order is extremely resistant to disruption by brain damage [53]. Thus the good performance of the subjects on the syntax test is not unusual and actually fits into a more general pattern. Now consider the finding that none of the subjects were impaired on the test of grammatically irrelevant perceptual and conceptual features of adjectives in Experiment 2. The features at issue vary a great deal in content, ranging from evaluative judgements (e.g. *good* vs. *bad*) to abstract spatial features (e.g. *big* vs. *small*), temperature (e.g. *hot* vs. *cold*), texture (e.g. *soft* vs. *hard*) and color (e.g. *red* vs. *green*); moreover, very few instances of each type of adjective were included in the test. It is likely that these features are neurally implemented in widely distributed brain regions that are specialized for particular types of information content [54]. Hence it would be rather strange for a single focal lesion to impair a very large set of these features; rather, one would expect to find deficits that are fairly limited to certain perceptual or conceptual domains. For example, deficits have been reported that are selective for color categories [55].

This study has implications for neurolinguistic research on how language is organized in the brain and also for our general conception of the syntax–semantics interface. For neurolinguistics, the study is important because it provides further evidence for the view that grammatically relevant and irrelevant features of word meaning are mediated by at least partially distinct neural networks [5]. This is a topic that has only just begun to be explored in detail and hopefully more attention will be devoted to it in the near future. With regard to adjective order in particular, Newcombe and Marshall [56,57] conducted some studies many years ago[6] in which they found that brain-damaged subjects with either left- or right-hemisphere lesions performed slightly worse than normal subjects in a task that required immediate recall of sentences containing deviant adjective sequences (e.g. *She has washed plastic red small eight cups*). These findings are intriguing, but the investigators did not go on to directly compare the subjects' knowledge of

[6] I would like to thank John Marshall for pointing these papers out to me.

grammatically relevant and irrelevant features of adjective meaning. Thus the current study is an attempt to break new ground in this domain.

Finally, the study is important for linguistic theory because it provides a completely new form of support for the ''grammatically relevant semantic subsystem'' hypothesis. In the past, the vast majority of argumentation has been based on careful linguistic analyses of the semantic determinants of grammatical phenomena [6–18]. Hence the dissociation reported here between grammatically relevant and irrelevant aspects of adjective meaning constitutes a new piece of convergent evidence from a very different perspective.

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Appendix A. Stimuli for the adjective order test in Experiment 1

There are 65 pairs of NPs organized in 13 sets (five pairs per set) —three sets for inter-zone ordering preferences and 10 sets for zone 2 ordering preferences. The order of NP pairs in the test was random.

Inter-zone ordering preferences			
1	zone 1 + zone 2		
	ordinal + other	*the last full glass*	*the full last glass*
	cardinal + height	*the three tall trees*	*the tall three trees*
	compared + other	*the finest raw oysters*	*the raw finest oysters*
	other + value	*the same good song*	*the good same song*
	other + color	*the other black coat*	*the black other coat*
2	zone 1 + zone 3		
	ordinal + nationality	*the next Chinese woman*	*the Chinese next woman*
	cardinal + nationality	*the two Korean girls*	*the Korean two girls*
	ordinal + location	*the second local parade*	*the local second parade*
	other + location	*the only Chicago newspaper*	*the Chicago only newspaper*
	other + time	*the usual morning ritual*	*the morning usual ritual*
3	zone 2 + zone 3		
	value + nationality	*a beautiful Italian actress*	*an Italian beautiful actress*
	size + nationality	*a big Mexican hat*	*a Mexican big hat*
	other + time	*a heavy midday meal*	*a midday heavy meal*
	size + location	*a small local store*	*a local small store*
	color + nationality	*a blue Canadian flower*	*a Canadian blue flower*

Zone 2 ordering preferences

4	value + size		
		a beautiful gigantic house	*a gigantic beautiful house*
		a good big table	*a big good table*
		a nice small vase	*a small nice vase*
		a nasty little dog	*a little nasty dog*
		a dreadful little car	*a little dreadful car*
5	value + dimension		
		a good long board	*a long good board*
		a nice short skirt	*a short nice skirt*
		a lovely long dress	*a long lovely dress*
		a beautiful tall tree	*a tall beautiful tree*
		a good high ceiling	*a high good ceiling*
6	value + other		
		a good sharp knife	*a sharp good knife*
		a good hard knot	*a hard good knot*
		a nice smooth surface	*a smooth nice surface*
		a beautiful soft blanket	*a soft beautiful blanket*
		a terrible cold dinner	*a cold terrible dinner*
7	value + color		
		a good black suitcase	*a black good suitcase*
		an attractive red dress	*a red attractive dress*
		an ugly yellow car	*a yellow ugly car*
		a bad green pen	*a green bad pen*
		a horrible purple bruise	*a purple horrible bruise*
8	size + dimension		
		a big long rope	*a long big rope*
		a big tall ladder	*a tall big ladder*
		a big high tree-branch	*a high big tree-branch*
		a large tall building	*a tall large building*
		a large high cliff	*a high large cliff*
9	size + other		
		a big raw steak	*a raw big steak*
		a large fat cow	*a fat large cow*
		a small weak boy	*a weak small boy*
		a small light lunch	*a light small lunch*
		a small wet towel	*a wet small towel*
10	size + color		
		a big grey cloud	*a grey big cloud*
		a big red book	*a red big book*
		a little white napkin	*a white little napkin*
		a small brown bird	*a brown small bird*
		a small blue ticket	*a blue small ticket*
11	dimension + other		
		a long heavy table	*a heavy long table*

	a short fat man	*a fat short man*
	a short round fencepost	*a round short fencepost*
	a tall strong man	*a strong tall man*
	a high flat roof	*a flat high roof*
12 dimension + color		
	a long dark road	*a dark long road*
	a short red candle	*a red short candle*
	a short black skirt	*a black short skirt*
	a tall grey building	*a grey tall building*
	a tall silver flagpole	*a silver tall flagpole*
13 other + color		
	a clean brown table	*a brown clean table*
	a wet blue shirt	*a blue wet shirt*
	a heavy black line	*a black heavy line*
	a soft pink sweater	*a pink soft sweater*
	a smooth white surface	*a white smooth surface*

Appendix B. Stimuli for the adjective meaning test in Experiment 2

Most of the adjectives are listed in pairs, although some are listed individually; all of the adjectives are followed by descriptions of the pictures that were associated with them. Each page in the booklet for the experiment showed a single adjective at the top and below it were both pictures — e.g. one page had *beautiful* written at the top and both circles below and another page had *ugly* written at the top and the same two circles below. The order of items in the test was random and so was the position of the correct picture.

Value	
beautiful and *ugly*	pretty multicolored circle; dark smudged circle
lovely and *nasty*	pretty multicolored circle; dark smudged circle
attractive and *dreadful*	pretty multicolored circle; dark smudged circle
good and *bad*	well-drawn circle; badly drawn circle
nice and *terrible*	well-drawn circle; badly drawn circle
Size	
big and *little*	big square; little square
large and *small*	big square; little square
gigantic and *tiny*	big square; little square
Dimension	
tall and *short*	tall cube; short cube
long and *short*	horizontally long cube; horizontally short cube
high	high cube; low cube

Other	
sharp and *blunt*	drawing of a sharp arrow; drawing of a blunt arrow
hard and *soft*	photo of a rock; photo of a blanket
smooth and *rough*	drawing of a smooth 2-D surface; drawing of a rough 2-D surface
cold and *hot*	photo of a bag of ice; photo of a fire
raw	photo of a raw steak; photo of a cooked steak
fat	photo of a fat man; photo of a thin man
strong and *weak*	photo of a big metal chain; photo of a small paper-clip chain
light and *heavy*	photo of a small 5-pound barbell; photo of a big 30-pound barbell
wet	photo of a soaked, dripping paper towel; photo of a dry paper towel
round	circle; square
flat	drawing of a flat 2-D surface; drawing of a bumpy 2-D surface
clean	clean solid-grey circle; smudgy solid-grey circle
full	photo of a glass full of Coke; photo of a glass half-full of Coke
Color	
black	black circle; grey circle
white and *grey*	white circle; grey circle
blue and *purple*	blue circle; purple circle
yellow	yellow circle; chartreuse circle
red and *pink*	red circle; pink circle
green	green circle; chartreuse circle
brown	brown circle; black circle

Appendix C. Stimuli for THE NP syntax test in Experiment 3

There are 15 pairs of NPs organized in three sets (five pairs per set). The order of NP pairs in the test was random.

1	adjective + noun	
	big field	*field big*
	tall man	*man tall*
	heavy box	*box heavy*
	different cat	*cat different*
	green carpet	*carpet green*

2	adjective + adjective + noun	
	warm sweet air	*air sweet warm*
	soft calm eyes	*eyes calm soft*
	harsh thin light	*light thin harsh*
	smart kind woman	*woman kind smart*
	fat round bottle	*bottle round fat*
3.	determiner + adjective + adjective + noun	
	a cool light rain	*rain light cool a*
	a hilly bumpy road	*road bumpy hilly a*
	an interesting likeable person	*person likeable interesting an*
	a natural peaceful expression	*expression peaceful natural a*
	a relaxed confident actor	*actor confident relaxed a*

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