NEURAL SUBSTRATES OF COPREDICATION: WHEN AN UNSTOPPABLE SCAN MEETS AN IMPOSSIBLE OBJECT

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Abstract

This paper reviews a number of studies mapping the neural substrates of abstract and concrete word processing, using them as a guide in proposing a project to map the brain regions implicated in copredication. This is the phenomenon of two apparently incompatible properties being attributed to a single object, creating an "impossible" entity. Licencing conditions on copredication are discussed, and the paper concludes by suggesting some new directions for exploring the brain areas implicated in conceptual representations.

1. Introduction

In a number of publications, Poeppel (2012, 2014) has raised the important concern that there is currently an absence of "linking hypotheses" through which to explore how the primitives of neuroscience (dendrite, cortical column, neuron) form the basis of linguistic computation (concatenation, existential closure, cyclic transfer). This "mapping problem" encompasses what Poeppel calls the "Granularity Mismatch Problem": Linguistics and neuroimaging studies of language operate on objects of different granularity. Correspondingly, the brain sciences cannot succeed in seeking the neural correlates of *syntax* and *phonology* because these are not monolithic concepts, and are much more intricate and modular than 'brute force' neuroimaging often suggests.

Consequently, Poeppel, Boeckx (2010) and others have promoted *computational organology*, which instead proceeds to map the neural correlates of linguistic computations, similar to what Marr (1982) did for vision and, later, what cognitive neuroscientists did for audition. Instead of asking *where is syntax/semantics?*, we should instead ask *where is merge/function application?* To take a model example, Kandel's research into learning in marine snails sought "to translate into neuronal terms ideas that have been proposed at an abstract level by experimental psychologists" (Hawkins & Kandel, 1984: 380). Currently, however, as Schlesewsky and Bornkessel-Schlesewsky (2013: 279) summarise the field, "the only syntactic operation which appears to have possible neurobiological correlates is Merge or something akin to it" (see Murphy, 2015b).

As naturalistic inquiry progresses, the task of the linguist should be to explore the computational properties of mental structures in an effort to employ these principles as the goals of neurobiology, perhaps leading to reduction or unification. Further, any brain scientist concerned with the neural implementation of language should at least understand what language actually is, and not be satisfied with outdated characterisations of syntax and semantics, or indeed of general areas implicated in language use such as Broca's area (Friederici, 2012). This may appear uncontroversial and close to tautology, but a look at the neurolinguistics literature suggests that it is general practice glance at, rather than ponder,

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recent developments in theoretical linguistics (and, for our purposes, natural language semantics).

In the study of I-language (Chomsky, 1986), what Pietroski has termed I-semantics (which, unlike mainstream philosophy of language, does not concern itself with truth-conditions, reference, rigid designators, Twin Earths and other mind-independent constructions) is not yet accompanied by a body of knowledge comparable to that of I-morphology or I-syntax. This may be the goal, but as will be discussed below, even investigation into the neural substrates of basic concrete and abstract word processing has not been sufficiently decomposed – neither formally nor computationally – to permit the development of 'linking hypotheses' between semantic theory and neurobiology. It will be suggested that studies of a particular complex semantic phenomenon, copredication, which (predictably) implicates both concrete and abstract neural processes, may yield insight into how the brain integrates semantic information from distinct conceptual domains.

2. Copredication

Despite a millennium of investigation, what defines a "thing" remains largely obscure. A contribution of modern linguistics to the debate (Chomsky, 2000,; Gotham, 2015) is to revive certain ideas proposed during the Enlightenment, that 'things' do not exist in the physical world (unlike scientific constructs like H_2O), but are rather formed within syntactic structures and the Conceptual-Intentional system (e.g. *water*). The concept BOTTLE, for instance, relies on visual cognition through its shape and colour features, while language uniquely contributes its *functional* properties such as CONTAINER and USED TO MOVE MATERIAL MASSES (McGilvray, 2005: 308).

Exploring the technical distinctions centred on objecthood, Weinreich (1964) distinguished between *contrastive* ambiguity (e.g. river *bank* vs. *bank* the financial institution) and *complementary* ambiguity (e.g. verbal *bank* vs. nominal *bank*). Contrastive ambiguity – the most basic and uninstructive type – occupies the bulk of research in semantics and neurolinguistics.

In his 1995 monograph, Pustejovsky explored copredication, or the problem of two apparently incompatible properties being attributed to a single object. He termed this a case of *logical polysemy*, defined as "a complementary ambiguity where there is no change in lexical category and the multiple senses of the word have overlapping, dependent, or shared meanings" (1995: 8). For instance, in (1), what Pustejovksy calls the "dot objects" of INFORMATION and PHYSICAL OBJECT are attributed simultaneously to the book, creating an "impossible" entity.

(1) a. The Powys book was brilliant but weighed a ton.
    b. John bought an old, heavy, boring history book.

These and other complex types are coherently bound reifications of multiple types. This is one of the reasons why nominalist debates are beside the point, focussing (like Aristotle and other pre-Lockean philosophers) on allegedly metaphysical questions, not cognitive ones. A comparable situation arises in (2), where "delicious" is a predicate which should be applied only to food, and "took forever" should only be applicable to events. Similarly, in (3) the bill is simultaneously conceived of as an abstract monetary amount and a printed piece of paper, while the newspaper in (4) is simultaneously an organisation and a collection of printed pages:

(2) Lunch was delicious but took forever.
(3) He paid the bill and threw it away.
(4) The newspaper I held this morning has gone bust.

Pustejovsky (2001) later proposed a ranking of types distinguishing between natural, artifactual and complex types:

> *Natural*: Application of formal and/or constitutive qualia roles (*lion*, *rock*, *water*)
> *Artifactual*: Adding agentive or telic qualia roles to natural types (*beer*, *knife*, *teacher*)
> *Complex*: Formed from naturals and artifactuals by a product type between the entities, i.e. the dot (*school*, *bank*, *lunch*)

Only complex types yield copredication, as in *book* (INFORMATION•PHYS_OBJ):

> ***book***
> ARGUMENT STRUCTURE = 1[*y*:INFORMATION], 2[*x*:PHYS_OBJ]
> QUALIA = FORM[hold(*x*,*y*)], TELIC[read(*e*,*w*,*x*.*y*)], AGENT[write(*e*,*v*,*x*.*y*)]

Some elements of *book* may be stable across uses, while others may be open to adjustment (see Ludlow, 2014). Note that copredication does not apply well to *all* complex types (e.g. action nominals like *demolished* and *construction*, discussed below), and may in fact apply to some artifactuals, as in *The red wine was opened one hour early* (which involves the senses DRINK and CONTAINER being predicated in the same context). This may be a case of coercion, however, since *wine* is generally assumed to be lexically associated with a simple artifactual type (DRINK) instead of a complex dotted type CONTAINEE•CONTAINER and to license a sense extension to CONTAINER only contextually, as a coercion effect induced by the semantic requirements of the selecting predicate *opened*. So while copredication activates a sense already available in the lexical item, coercion shifts the type in context.

Copredication is a much more complex phenomenon than many accounts over the past two decades have supposed, including those of Pustejovsky (2001). A recent contribution by Gotham (2012) shows that copredication cannot be solved by appealing, as some have done, to coordination reduction, as in "Lunch_1 was delicious but lunch_2 took forever", since copredication occurs in other syntactic structures. Furthermore, how copredication is understood "will have to be explained in any theory" of semantics, Gotham notes (2012: 2), and ultimately by any neurolinguistic theory.

Although generativists in the late 1990s and throughout the last decade have been virtually the only linguists concerned with copredication, the earliest modern account of it was by Postal (1968: 273), in his Epilogue to Jacobs and Robenbaum's early textbook on transformational grammar, though he did not label or explore it. One might argue that it was known to scholastic philosophers as qua predication, where X qua Y has the property P. Modern accounts of type manipulation essentially follow this approach, and view a property and event not as distinct parts of "lunch", but instead see these as the same object under different conceptualisations. This mereological account must be inadequate however, since no one would judge (5) to be correct when faced with two volumes of the same INFORMATION book and a trilogy of three PHYSICAL OBJECT books.

(5) Five books are heavy but easy to understand.

PHYSICAL–INFORMATIONAL composites are thus never counted in determiner phrases involving numerals (i.e. [$_{DP}$[*num*]]). As I argue in Murphy (2015c), perhaps it therefore becomes less correct to say that a given material object is a book than it would be to say that a book can instead be "realised as" – or have as its "host" – a physical medium. These and other examples of copredication are clear cases of where the distinction between classical categories and family-resemblance categories (of the sort adopted by Pinker, 1999) breaks down.

The computations yielding copredication are also subject to particular, and not well understood, constraints (Antunes & Chaves, 2003). While the polysemous label/head appears to determine sense combinations (see Murphy, 2015c for a discussion of the wider semantic effects of labeling), what Copestake and Briscoe (1995) term *Sense Extension* leads to the prohibiting of possible forms of copredication. This involves a base concept and the construction of distinct meanings leading to a form of immediate contradiction not seen with *Constructional Polysemy* (which encompasses the standard copredication seen above). For instance, taking the standard "ham sandwich" case in which a customer's food is used metonymically to refer to them, sense contradictions, and not copredication, result:

(6) a. The ham sandwich is tasty.
b. The ham sandwich left in a blue car.
c. *The ham sandwich was tasty and left in a blue car.

A comparable situation arises when (4) is modified to yield the unacceptable (7), a case yet to be accounted for in the literature.

(7) *The newspaper has gone bust and is covered in biscuit crumbs.

In addition, while the copredication of adjacent senses is permitted, the copredication of "distant" senses yields degraded judgements. A unique conceptual and cultural object, when presented alongside an individual exemplar, yields questionable results as in (8a), but not when it is defined more generally (in this case as a *book*) as in (8b):

(8) a. ??The Bible inspired centuries of love and violence but has a torn page.
b. The book I hold in my hands inspired centuries of love and violence.

Similar results arise with *bank*:

(9) a. *The bank is FTSE-100 listed and used to be a police station.
b. The bank was smashed by protestors during the recession and became less popular.

Other apparent syntactic constraints on copredication can be found by observing how some lexical conceptual structures impose a level of control over a complement. The root √*book*, for instance, does not permit transfer of possession, unlike √*gift*, as the following examples illustrate (Grimshaw, 1990: 97):

(10) a. John's gift to the hospital.
b. *John's book to the hospital.

More generally, lexical ambiguity and polysemy may partly be a consequence of the fact that "the human brain is limited in the number of signs that it can store and quickly retrieve. This number is relatively small compared to the extremely vast number of situations we may encounter and ideas we can entertain about them" (Bouchard, 2013: 49). Further research is required before an adequate account of copredication can be presented, explaining why these judgement contrasts appear to hold, but enough has been uncovered to subject certain aspects

of copredication to empirical inquiry. As a way of prefacing this interdisciplinary project, certain linguists (e.g. Chomsky, 2000, 2012; Gotham, 2012, 2015; Murphy, 2014; Pietroski, 2005) have used logical polysemy to (i) demonstrate the complexity of the lexicon, and (ii) attack various 'externalist' theories in philosophy of language. But these constructions can be used for another purpose, (iii) to explore the neural organisation of concrete, abstract, polysemous and other concepts. The remainder of this paper will discuss ways of achieving this goal.

3. Cartographic perspectives

Copredication is relevant to and has been discussed by both syntacticians and semanticists, and should be of concern to neurolinguists studying the neural correlates of abstract and concrete word processing, though currently is not. At the most general level, amodal theories of concepts in the cognitive sciences hold that linguistic meaning is stored in heteromodal brain cortices (Volta et al., 2014). It has further been well established by brain scanning studies that the semantic lexicon is organised by imageability, and that low-imageability words (*justice*, *heaven*) are harder to retrieve from memory than high-imageability words (*hammer*, *phoenix*). This has been widely termed the "concreteness effect". The pathological conditions of semantic dementia and herpes simplex encephalitis both affect anterior temporal regions and result in the reverse-concreteness effect (or the "abstractness effect"), thus implicating these regions in concrete and abstract word processing. These neuronal activation differences also appear to be increased in aphasic individuals, likely due to an inflated concreteness effect (Sandberg & Kiran, 2014). Empirical, topographic approaches to concept clustering (Troche et al, 2014; Pollock, 2014) also suggest that the conceptual basis for abstract words extends beyond the lexicon, while certain words like *space*, *action* and *modifying* are often judged equally abstract and concrete. However, neither Troche et al. nor Pollock investigated the lexical or conceptual basis of objects defying such strict categorisation, despite their acknowledgement that the boundary itself is often contentious.

Generally speaking, concrete processing produces more extensive activation in a bilateral network of associative areas, such as parietal and pre-frontal cortex, whereas processing of abstract words produces greater activation in the left superior temporal and inferior frontal cortex (Noppeney & Price, 2004; Hoffman et al., 2015). A meta-analysis of activation studies revealed that abstract concepts activate inferior frontal gyrus and middle temporal gyrus, while the processing of concrete concepts led to greater activation in posterior cingulate, precuneus, angular gyrus, fusiform gyrus, and parahippocampal gyrus (Wang et al., 2010). Semantic similarity has been found to affect abstract and concrete word processing, although the effect of association is stronger in abstract than concrete words (Duñabeitia et al., 2009).

A theory developed by Vigliocco in a number of publications (e.g. Vigliocco et al., 2009) holds that this distinction is a result of the different types of information underlying the meaning of abstract and concrete words; predominantly sensory-motor information for concrete words, predominantly affective and linguistic information for abstract words. But these theories have not taken into account the above developments in semantics (along with many others), whereby certain "abstract" concepts do in fact have rich sensory-motor information. Hence we find statements like the following in one of the seminal works of the neural representations of concrete and abstract words:

> [Abstract concepts] seem harder to understand than concrete concepts, which are concepts that have fairly direct sensory referents. Abstract concepts, however, lack such direct sensory referents. (Schwanenflugel et al., 1988: 499)

Activation studies, then, have attributed different neural correlates to the processing of abstract and concrete words. Exploring the processing of copredication could take the form of, for instance, monitoring activity during sentence processing in neurologically-unimpaired subjects. Lexical decision tasks have revealed a significant activation in right anterior temporal cortex for abstract words as opposed to concrete, but again this only begs the question of what areas are involved in copredication (Kiehl et al., 1999). The same applies to recent studies revealing that concrete word processing as compared with abstract word processing is associated with stronger activation of the left extrastriate visual areas, BA18/19 (Adorni & Proverbio, 2012). More relevant to the study of copredication are the findings of common neural networks for abstract and concrete word processing, which include the ventral and lateral portions of the temporal lobe. Following standard accounts in the literature, investigations into copredication should focus on four sites implicated in these tasks: left inferior frontal, bilaterally posterior-superior temporal, and left posterior-inferior parietal.

Two main models exist which have attempted to account for the concreteness effect. The *context availability theory* argues that concrete words are buttressed by larger contextual support (Schwanenflugel & Shoben, 1983; Xiao et al., 2012). The *dual-coding theory* alternatively claims that the processing of abstract nouns relies on verbal code representations of the left hemisphere only, whereas concrete nouns access a second image-based processing system located in the right hemisphere (Paivio, 1991). One relevant question for the current research project is whether image-based processing is employed when processing INFORMATION features of supposedly "concrete" nouns like *book* or *bank*. Many findings are inconsistent with this view, largely because the right hemisphere has been found to be involved more heavily in the processing of abstract words (Kiehl et al., 1999).

It seems that from a semanticist's perspective (though not, unfortunately, a metaphysician's (Hoffman & Rosenkrantz, 2003: 46)) distinctions like "abstract" and "concrete" are useful at a certain level of analysis (like "Wernicke's area") but ultimately fall short of the full picture. Many experimentalists (Pobric et al., 2009) likewise associate imageability (the ability to visually or acoustically represent a concept) with concreteness, which again is a simplification of the actual lexical items under investigation. Abstract emotion words are easily imageable, for instance. There are currently no studies of the imageability of copredication, such as the imageability of bank (INSTITUTION) versus bank (PHYSICAL OBJECT) in (11). Likewise, discussing brain activity in spatial terms is entirely intuitive and quite often accurate, but as Poeppel points out, "localization and spatial mapping are not explanation" (2012: 35). Jackendoff has expressed similar concerns (2002: 22).

(11) a. The bank became less popular during the recession.
b. The bank was smashed by protestors during the recession.

Despite Hinzen and Poeppel's (2011: 1306) confession that "it is somewhat disappointing that practically every cortical region associated with any aspect of language processing has been implicated in semantics", there is a stark lack of research into the neural correlates of this curious semantic phenomenon (although work on the neural representation of object, action and polysemous words is in many ways related, as discussed below). As may be expected with such a "cool phenomenon" (Poeppel, pc.) as copredication, an open question, and one familiar to biolinguistics (Hinzen, 2008), is how much meaning syntax "carves out".

For instance, the RESULT–STATE interpretation of *construction* or *translation* (i.e. "the state of being constructed/translated") seems to be inaccessible to these otherwise copredication-compatible nominals, since copredication "appears to be licensed only under specific syntactic and semantic conditions" (Ježek & Melloni, 2011: 1). Ježek points out that the event structure of *construction* is complex "since it contains a causing process and a (series of) state(s) connected by a temporal relation envisaging precedence and overlap" (2008:12). In (12), the only interpretation available is the one involving a PHYSICAL OBJECT:

(12) Owen Jones admires the construction of that council house.

Returning briefly to the case of *newspaper* in (4) and (7), Pustevjosky (1995: 133) notes that "while the noun *newspaper* is logically polysemous between the organization and the printed information-containing object, the noun *book* refers only to the latter, while the noun *author* makes reference to the "producer" of the book". A journalist simply contributes, rather than brings about, the existence of a newspaper – an observation which could potentially yield interesting stimuli for neuroimaging studies of copredication, as in (13):

(13) Parts of Owen Jones's new book have been printed **in** [PHYS_OBJ]/ **by** [ORGNS/PHYS_OBJ&ORGNS] the local newspaper.

Asher (2011) also observes that with *city* (in fact, with any polity concept), which can have its walls and foundations *demolished* and *re-built* elsewhere by virtue of its abstract dot object (Murphy, 2012), the order of senses seems to play a role in the acceptability of copredication, suggesting that sense combinations may be subject to discourse effects. Reversing the dot objects of (14a) leads to a licensing failure:

(14) a. The city has 500,000 inhabitants and outlawed smoking in bars last year.
b. ?The city outlawed smoking in bars last year and has 500,000 inhabitants.

It is also unclear whether copredication should be ascribed to structures where one of the selectors is located in a modifying (restrictive) subordinate clause, as in (15) (Jacquey, 2001).

(15) The building, which started yesterday, will be very nice.

Neuroimaging studies would allow comparisons to be drawn between these borderline cases, clear cases of copredication and clear cases of non-copredication (which crucially mirror the borderline cases in either semantic interpretation or syntactic structure) to judge whether the same pathways which subserve copredication are involved in the processing of possible copredication in restrictive subordinate clauses.

A concreteness effect has also been revealed in lexical decision when a block of concrete words precede a block of abstract words and when they are mixed, but not when the block of abstract words precede the block of concrete words (Kroll & Merves, 1986). Tolentino and Tokowicz's (2009) ERP investigation into order effects largely corroborates these earlier findings, and so for our purposes the question then becomes whether similar neural activation is produced by the particular ordering of dot object features (INFORMATION before EVENT, etc.). To take a related case, an important difference between action verbs and mental state verbs was found in recent studies; namely, that the contexts of acquisition in which the former occurred were ones in which mental state verbs could not be detected, suggesting that syntactic frames are both necessary and sufficient for acquiring verbs which do not denote observable actions (Tsimpli, 2013: 67). Copredication stimuli could also enhance empirical understanding of event semantics: While a lunch can be both a material object and an event, a

book can only be a material object and an informational entity, not an event (Godard & Jayez, 1993: 169):

(16) a. John began his book at ten and put it away at eleven.
b. *John began his book at ten and didn't stop it till eleven.
(17) a. John began a book that was very thick.
b. *John began a book that took two hours.

Moving on to related imaging topics, Hagoort et al. (2004) measured ERPs and fMRI activation in response to various constructions containing either world knowledge violations or semantic violations and discovered that a response with similar onset latency, topographic distribution and amplitude was found for both kinds of violations in BA45 and BA47. This indicates that these regions were employed when both semantic and world knowledge violations occurred, but the relevant question for our purposes is whether the same regions are involved in the above syntactic deviations from copredication, and whether constructions involving various combinations of (i) copredication, world knowledge access, and semantic integration, or (ii) copredication deviations, world knowledge violations, and semantic violations yield similar neural responses.

There are also small pieces of evidence that representations of action and object words can be based on the same principles. Imagery data implicates left premotor cortex and middle temporal regions in knowledge of actions (Damasio et al., 2001), the same regions which have been implicated in knowledge of artefacts (Moore & Price, 1999), and which consequently may be activated during the processing of dot object activities like reading, as in "Jason's book was heavy [PHYSICAL OBJECT/ARTEFACT] and fascinating [INFORMATION]".

Questions surrounding the N400 effect (Kutas & Hillyard, 1980) may also arise, depending on whether copredication deviations (or simply more exotic cases of copredication) are processed as semantically congruous or anomalous. If they are processed as the latter, then the main regions involved in the predicted N400 effect would be the left posterior and anterior temporal cortex and the left inferior frontal cortex, with the accessing of lexical representations from long-term storage also predictably activating posterior middle temporal cortex (Lau et al., 2008: 922). Friederici et al. (1993) described a negative brain wave over left frontal areas, the left anterior negativity (LAN), which has been observed when words violate the required lexical category ("the conclusion drinks") – a possible response to copredication deviation.

The findings of Kupberg et al. (2003) raise further questions. Their studies examined what happened when the thematic relationship between the verb and its argument was violated ("The box is biting the postman"), and instead of the N400 effect they found a P600 response, which was previously assumed to be sensitive only to syntactic violations and difficulty in syntactic processing. Again, this response may be triggered when subjects process copredication deviations or semantic violations in copredication ("The city which was burned down and re-built across the river howled like a wolf").

It is also an entirely open question whether the brain treats the dot objects of copredication as a case of two words modifying two semantically distinct arguments (e.g. $lunch_1$ and $lunch_2$), as the semanticist's coordination reduction suggests, or whether neural responses are more localised in either of the relevant semantic regions (those subserving "abstract" and "concrete" words), as the mereological account would imply. For instance, data relevant to the former hypothesis would include the activation of left BA45/46, typically linked to the processing of a word semantically associated with another (Friederici, 2000: 129). Cases of copredication involving eventive verbs, denoting causally structured events, rather than

stative verbs with no causal structure, would also be predicted to take longer to process, with lexical decision tasks and self-paced reading studies having confirmed a processing distinction between the two (the reason most likely being that event structures subsume theta roles and hence may "mediate between syntactic knowledge and semantic interpretation" (Gennari & Poeppel, 2003: B27)).

More generally, it would be expected that areas implicated in the processing of sentences, such as the posterior portion of the superior temporal gyrus bilaterally and a cortical area at the midpoint of the superior temporal sulcus in the right hemisphere, are activated during the comprehension of copredication in all its varieties (Friederici, 2000: 130–133). But even with all of these results, we are warned by Adorni and Proverbio in a recent study of the concreteness effect that "neuroimaging studies provide no clear evidence about the neural underpinnings of concrete vs. abstract word processing" (2012: 881). Inquiry into the neural organisation of copredication will likely yield new and hopefully substantial insights not only into the cortical organization of these concrete and abstract concepts, but also into the neural correlates of the above syntactic constraints on copredication, telicity, and other related notions.

Copredication also shares many properties with semantic type mismatch: climbing does not figure in the lexical material of (18), and so in an event-based semantic framework the sentence is thought to involve the insertion of an implicit activity which can mediate between the verb and the otherwise unsuitable object noun phrase, being "coerced" into an event meaning.

(18) The refugees survived the mountain.

Such coercion has been shown to activate a prefrontal midline MEG field, dubbed the anterior midline field (AMF), which is also activated for two distinct types of aspectual coercion (Pylkkänen et al., 2013: 319). Copredication may well activate the AMF, though it more probably implicates areas strongly associated with abstract and concrete word processing. It would furthermore be expected that the semantic shift between different dot objects seen in instances of copredication is reflected during online processing in the activity of neural pathways relevant to the comprehension of abstract and concrete words. The issue becomes more complex with varieties of copredication which go beyond basic dot object types like INFORMATION and PHYSICAL OBJECT and employ agentive, constitutive and hyponymic concepts (and still more abstract notions like telicity or intended design), and the results of neuroimaging studies would predictably mirror this.

In summary, neuroimaging and behavioural studies into copredication processing will very likely enrich understanding of conceptual representations. There remains the possibility that it will also inform and constrain semantic theories of copredication, perhaps similarly to the studies of Shetreet et al., which lent "neurobiological support for the linguistic distinction" between unaccusative and unergative verbs (2010: 2306). Neurobiological investigations into the constraints of copredication processing, in synthesis with studies into lexical access more generally, may well lead to an understanding about why a *book* can be a printed text, a story, a piece of data on a memory stick, but not, for instance, a wall upon which every word of a book has been spray-painted. That is, neurobiological studies could tell us *what the limits of being a book are*.

4. Conclusion

I have argued that brain scientists should be concerned with a particular topic of semantic investigation, copredication, partly because of the current lively debates surrounding the representation of abstract and concrete words, the concreteness effect, acquisition of these concepts, and so on. It should be stressed, however, that at this stage I am not calling for neural investigations into more technical and fine-grained semantic phenomena (or the most elementary computational operations underlying them), and instead see copredication as an excellent way of informing and constraining semantic theory whilst also contributing to ongoing debates in neurolinguistics (although see Murphy, 2015a). If brain scientists are not engaging with linguists at the level of copredication, then there is little hope of them exploring more technical notions and drawing up linking hypotheses between the two still relatively isolated domains.

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