Cognitive Foundations of Linguistic Usage Patterns
Applications of Cognitive Linguistics

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Cognitive Foundations of Linguistic Usage Patterns

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Introduction

Hans-Jörg Schmid and Susanne Handl

1. Background

Significant innovations in theory-building tend to be accompanied by changes in methodology. For example, when generative grammar replaced American structuralism in the 1960s as the leading paradigm in linguistics, performance-based methods were abandoned in favour of introspection. Interestingly, a similar shift did not take place when cognitive linguists started to have a go at the basic assumptions of generativism. This is particularly remarkable in view of the catchword of the usage-based approach, which was introduced to cognitive linguistics by Ron Langacker (1987, 1988) to encapsulate the idea that knowledge of grammar is extracted from the actual use of linguistic structures (rather than implemented on the basis of an innate blueprint). While this would suggest that linguists pursuing a usage-based approach would actually look for relevant evidence in authentic language use, the introspective method continued to dominate cognitive linguistic research for a surprisingly long time. The required methodological changes were much slower in coming than the outpour of theoretical claims – and have in fact not been achieved in some quarters of the cognitive-linguistic community so far.

In recent years, however, the necessary methodological consequences resulting from a serious understanding of the usage-based programme have clearly been recognized. From this perspective, a linguistic approach qualifies as usage-based if, when formulating linguistic hypotheses, it takes a thorough look at the actual use of linguistic structures. In the most extreme versions of this view, usage-based theories of grammar have been replaced by distinctly inductive usage-driven ones. Both usage-based and usage-driven approaches are attractive for cognitive linguistics because they allow conclusions about how lexical, grammatical and pragmatic knowledge finds its way into the minds of the speaker-hearers of a language and comes to be stored there. Thus, by looking into real-life language, cognitive usage-based approaches expect to gain insights into cognitive foundations not only of language use, which has long been the main aim of psycholinguistic research, but also of language structure.
The recent trend towards a usage-based methodology, an important milestone of which is marked by the volume *Usage-based models of language* edited by Michael Barlow and Suzanne Kemmer (2000), manifests itself in a number of different strands. One important impetus has recently come from the empirical work on a usage-based theory of first language acquisition by Michael Tomasello and his team at Leipzig (cf., e.g., Tomasello 2000, 2003; Lieven et al. 2003). In the same period, historical linguistics has seen a move towards usage-based accounts of language change, e.g. in the work of Joan Bybee and Paul Hopper (cf., e.g., Bybee and Hopper 2001; Bybee 2006a, 2006b). Combining the corpus-linguistic methodology with cognitive-linguistic theorizing, linguists such as Dirk Geeraerts and his research group at Leuven (e.g. Tummers, Heylen and Geeraerts 2005), Stefan Gries (e.g. to appear), Hans-Jörg Schmid (2000) and Anatol Stefanowitsch (e.g. Stefanowitsch and Gries 2003, 2006) have tried to tap into the linguistic usage of large populations of speakers by investigating the material collected in computerized corpora.

2. Focus

Attempts to establish plausible links between linguistic data, on the one hand, and assumptions about their cognitive foundations, on the other, can only be convincing to the extent that they rely on observed recurrent linguistic behaviour, no matter whether it is recorded in the form of corpora of authentic language use, studied in linguistic experiments or simulated computationally on the basis of actual usage. For it is only for recurrent patterns of usage that it makes sense to assume that the underlying structure is intrasubjectively stable across time and intersubjectively similar across members of a speech community. Both characteristics are required if a given linguistic form is to be seen as manifesting a stored representation that is part of the ‘grammar’ of a language or variety of language.

Taking this obligation very seriously, the papers in the present volume all aim to bring together observed patterns of linguistic usage with cognitive-linguistic concepts and models. Equally importantly, all contributions have an empirical basis and show a high level of awareness of the potential and limits of the methodology applied. The methods used range from the investigation of corpora and tailor-made samples of authentic language use to linguistic and psycholinguistic experiments as well as computational simulations based on actual usage.
The linguistic phenomena investigated in the contributions run the gamut from the lexico-conceptual and collocational level to morphological and grammatical categories, constructions and pragmatic functions. Cutting across the grouping of the papers into lexical and grammatical studies that divide the volume into two parts (see below, Section 3), two complementary perspectives of language and cognition are represented: in one set of papers, the established methods of psycholinguistic experimentation, quantitative corpus analysis and computational simulation are exploited to demonstrate the viability and increase the plausibility and force of cognitive-linguistic thinking. The papers in the second group test well-known cognitive-linguistic approaches such as conceptual metaphor theory, the theory of idealized cognitive models and construction grammar against authentic data demonstrating their applicability and explanatory potential, but also their limitations. Both groups include papers reaching beyond the scope of traditional cognitive-linguistic topics, e.g. by taking a critical stance of reductionist cognitive thinking.

3. The contributions

As mentioned above, the volume is divided into two parts, each comprising five papers. The papers in the first part focus on lexical patterns and their relations to cognitive processes and cognitive-linguistic concepts. They are ordered according to the complexity of the linguistic elements studied, from individual lexical items to concepts and collocations.

The same principle underlies the arrangement of the papers in the second part. Starting with inflectional morphemes and grammatical categories, the grammatical patterns investigated include argument-structure constructions and valency patterns as well as the pragmatic functions of sentence mood.

In the first contribution on the lexicon, George Dunbar addresses a problem that has a long history in cognitive semantics, viz. the distinction between ambiguous and vague lexemes. While ambiguous lexemes have traditionally been considered to have a number of distinct senses, vague ones are seen to carry one meaning that is interpreted in different ways depending on actual usage contexts. Taking up a proposal by Tuggy (1993), who pleaded for a scalar approach that treats ambiguity and vagueness as two poles of a continuum, Dunbar describes a computational model implementing this continuum, which is based on a connectionist network.
and validated against the lexicographic decisions taken by the corpus-based COBUILD dictionary. Dunbar closes his paper by arguing that the general mechanism underlying his model gives a good account of a number of general cognitive and perceptual phenomena.

The focus of Dylan Glynn’s paper is also a semantic relation, viz. synonymy. Studying the three near-synonyms annoy, bother and hassle denoting slightly different aspects of the concept bother, Glynn emphasizes that semantic investigations must take into account not only the lexicogrammatical frames providing patterns for occurrences of individual lexemes, but also use-related and user-related aspects like registers and regional varieties. His approach is corpus-driven and quantitative, and highly sensitive to the power and limitations of the methods applied. In order to come to grips with the highly multivariate data situation, Glynn uses advanced statistical methods such as correspondence analysis and hierarchical cluster analysis. These multidimensional techniques allow him to map usage patterns that arguably correspond to ways of carving up conceptual space as suggested to speakers of English by the grammar and lexicon of that language.

Olaf Jäkel applies the theory of idealized cognitive models (cf. Lakoff 1987: 113–114 et passim) to the study of public boundary disputes concerning the highly controversial concepts of life and death. His investigation focuses on the entrance boundary of life, with linguistic material taken from the public discourse on embryonic stem cell research going on in both English (United States) and German (Germany) in the years 2000 to 2002. By close scrutiny of the data collected, Jäkel manages to show how scientists and politicians involved in the stem cell debate quarrel over denotational incongruencies, each party trying to dislocate or relocate denotational boundaries to suit their aims. The conceptual basis of this dispute is provided by diverging cognitive models of life, including the conservative model, which sees life as beginning with conception, and the biotechnical model, according to which human life proper does not begin before nidation, a term introduced fairly recently to denote the settling of the foetus in the female womb.

Like Jäkel, Brigitte Nerlich studies usage-patterns in public discourse with the aim of unravelling the conceptual framing of public events. Nerlich looks into press releases and interviews published by scientists as well as the press coverage of key events in science and presents two case studies, one on the alleged breakthrough towards the possibility of ‘cloning’ the first human being in the laboratories of South Korean scientist Woo-Suk
Hwang, and one on the emergence of so-called superbugs heralding the post-antibiotic apocalypse. In her analyses, Nerlich extends conceptual metaphor theory in order to study the politics and ethics of discourse metaphors in authentic contexts. She manages to show how usage-patterns that rely on entrenched conceptual metaphors are deliberately launched and exploited by scientists themselves and by the press to influence public opinion, for example, with the ultimate aim of creating the public hysteria that will force politicians to provide more funding.

Susanne Handl and Eva-Maria Graf introduce an acquisitional aspect into the pattern discussion, relating the contextualist notions of idiom principle and open-choice principle (cf. Sinclair 1991) to the cognitive notions of holistic and analytic language processing (cf. Wray 2002). Drawing on the hypothesis that the quality and evolution of recurring word combinations in different stages of linguistic development provide insights into the anchoring and processing of language in the mind, they classify two essential types of word co-occurrences, i.e. lexical collocations and patterns. Their analysis of these types in children’s and adolescents’ corpora shows that in a phase of predominantly holistic language processing the percentage of lexical collocations is higher, whereas in an analytical phase, speakers produce more patterns, as they have become aware of the separability and combinability of previously unanalyzed linguistic chunks.

The first paper of the second part, authored by Ewa Dąbrowska, moves the interest in language acquisition from the lexicon to grammar. Dąbrowska presents two empirical studies which show that children rely on low-level generalizations when acquiring their first language. One study deals with the inflectional marking of the dative singular in Polish, the other with questions with long-distance dependencies in English (e.g. what do you think you’re doing or who do you think you are). In both cases Dąbrowska reports experimental evidence suggesting that low-level schemas are psychologically more basic and often preferred to the higher-level generalizations proposed in the form of ‘rules’ by generative grammar. What is also striking is that these low-level schemata tend to hinge on prototypical lexical realizations of constructions.

Klaus-Michael Köpcke, Klaus-Uwe Panther and David Zubin argue for a conceptual-pragmatic approach to explaining gender agreement in German. Providing a wealth of attested examples from various sources they adapt Corbett’s (2003) gender agreement hierarchy by replacing Corbett’s formal categories with the conceptual-pragmatic functions of specifying, modifying, predicating and reference-tracking. While grammatical agree-
ment dominates in specifying and modifying contexts, conceptual agree-
ment tends to prevail in uses with reference-tracking function, especially
when other syntactic factors (like high degree of syntactic embeddedness)
and discourse factors (such as narrative concerns) support this choice.

Ulrich Detges tackles a grammatical problem similar to the lexical one
dealt with by Dunbar. The French-language phenomenon which he studies
from both a diachronic and a synchronic point of view traditionally goes by
the name of *imparfait de politesse* and has often been considered a mere
usage variant of the ‘normal’ *imparfait* by many researchers. By means of
an in-depth quantitative and qualitative corpus study, Detges is able to
show that the so-called *imparfait de politesse* actually encompasses two
types of phenomena that should be distinguished, namely one more vari-
able pattern manifesting a range of verbs that invite a metonymic inference
yielding a down-toning effect, and another more specific one consisting of
*je voulais* (‘I wanted’) and a *verbum dicendi* such as *dire* ‘to say’, *parler* ‘to
speak’, *demander* ‘to ask’, *proposer* ‘to propose’ etc. While the first type
retains many aspects of ‘normal’ uses of the *imparfait*, the second one has
become entrenched as a discourse marker with a present-tense meaning
serving a range of specific textual functions. Detges concludes that the
second pattern offers a case of a polysemous meaning of a grammatical
construction, since *je voulais* + *verbum dicendi* is still motivated by the
meaning of the *imparfait*, but too removed for it to be experienced as being
derived from the latter by present-day native speakers of French.

Like Ewa Dąbrowska, Thomas Herbst addresses the nature and degree
of generalizations stored in the minds of native speakers of a language. His
focus lies on a comparison of the predictions made by construction gram-
mar, as represented by Goldberg’s (1995, 2006) argument-structure con-
structions, with those (implicitly made) by European valency models of
grammar. While the former postulates fairly high-level generalizations
assisted by lower-level schemata, descriptions of verbs in terms of their
valency patterns have typically been item-specific, as they often defy gen-
eralizations based on shared meanings. Herbst’s rich data come from di-
verse corpora as well as the *Valency Dictionary of English* (Herbst et al.
2004), which identifies several hundred valency patterns of English verbs,
nouns and adjectives. Herbst concludes by stating that construction gram-
mar is probably better equipped than valency grammar to account for
grammatical creativity (cf., e.g., Goldberg’s by now notorious … *sneezed
the tissue off the table*, 1995: 152). On the other hand, construction gram-
mar still has to find a way of adequately accounting for how the wealth of
item-specific knowledge of grammatical patterns is stored in long-term memory.

**Patric Bach** and **Dietmar Zaefferer** investigate the pragmatic functions of declarative and interrogative sentences. They compare two languages: German, where interrogatives are marked by subject-operator inversion at the beginning of sentences, and Japanese, where interrogatives are marked by a sentence-final interrogative particle (*ka*). Their main concern is how the difference between assertives and interrogatives is processed cognitively and whether it has an effect on the cognitive representations of the contents of the corresponding sentences. These research questions are investigated with original experiments exploiting the so-called Simon effect, i.e., the observation that ipsilateral responses are faster and more accurate than contralateral ones. By systematically varying the place where visual and verbal information was displayed on the computer screen and the side of the keys that informants had to press on the computer keyboard, Bach and Zaefferer were able to isolate the effect of the assertion-question distinction and the effect of the forward-typing (German) and backward-typing (Japanese) language. They present evidence from their tests suggesting that declarative sentences are processed in a richer and more fleshed-out propositional form than interrogatives and that the types of cognitive representations constructed depend on the position of the interrogative marker in the sentence.

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Part I: Lexical patterns
A computational model of the ambiguity-vagueness spectrum

George Dunbar

1. Introduction

The aim of this paper is to show that key properties of an influential analysis of the distinction between ambiguity and vagueness are also properties of a particular kind of neural network-based computation, implying that these are general properties of cognition, not specific ones of the linguistic phenomenon. In the first section of the paper the theoretical issues are introduced, and in the second the computational model is first described, and then applied to the problem.

The concepts of ambiguity and vagueness describe the relationship between a word form and the different interpretations it can be given. For example, the English noun *cup* can be interpreted to mean a particular type of small domestic container with a handle (e.g. *a tea cup*). Alternatively, it can be used to refer to a sports trophy (e.g. *the F.A. cup*). In addition, each of these senses can be used systematically to refer to certain closely linked entities. For example, *cup* can be used to refer to the competition for which the trophy is the prize, as in the phrase *the third round of the F.A. cup*. At a finer grain, within each of these senses, a range of interpretations is possible. For example, domestic drinking cups come in a variety of shapes and sizes, illustrated in 1(a-e).

(1) a. *tea cup* (hand-sized, with a little plinth at the base)
   b. *espresso cup* (smaller, with a flat base)
   c. *breakfast cup* (larger)
   d. *loving cup* (two handles)
   e. *paper cup* (no handle)

All of these interpretations are, let us accept, instances of culturally conventional concepts. By that I mean that they recur in the shared experience of speakers of English. They are not novel concepts that need to be mentally calculated on each occasion of use. Rather, at least in principle, they could
simply be remembered. They are therefore candidate senses for the word form.

When a word form can denote more than one sense, we say that the form is ambiguous. From a linguistic point of view, it has traditionally been considered important to be able to determine whether distinct potential interpretations constitute distinct senses, or whether they are generated from a shared more general, more abstract, sense that covers the different interpretations. Various tests have been used to evaluate this, to try to establish a crisp assessment of whether distinct interpretations are distinct senses.

The core theoretical issue motivating this paper is whether such a crisp distinction can be maintained, and so we will move in Section 1.1 to consider those tests more closely. First, to complete the context, we look at some differences in interpretation that – it is generally agreed – do not arise from lexical ambiguity. A given word form can receive different interpretations also in that it can be applied to various specific objects that differ in irrelevant ways. For example, *cup* can be used to refer to a tea cup decorated with a picture of bluebells or a picture of roses, and the type of flower is not relevant to the interpretation of *cup*. Or, to take an even clearer example, the word *tree* can be applied to trees with different numbers of leaves. It is not anywhere seriously argued that *tree* is ambiguous as to the number of leaves the referent has. In such cases, the noun is said to be vague with respect to this aspect of interpretation. *Tree* is vague as to the number of leaves, and *cup* is vague with respect to the form of surface decoration.

A particular kind of ambiguity has been important in cognitive linguistics and in attempts to differentiate ambiguity and vagueness: polysemy. In cases of polysemy, the ambiguous senses are related in meaning. The two senses of *cup* as a domestic vessel, and a trophy, are related in meaning. Both have a bowl-shaped central part, and both typically have handles. Indeed, it is common for victorious competitors to drink from their trophy. In cases of polysemy, then, it is theoretically possible that there is in fact a single sense consisting of the core shared meaning components rather than two distinct senses. In contrast, for cases where the different interpretations are not related in meaning at all, it is difficult to see what meaningful abstraction could cover both. For example, the English word form *pen* can denote a writing instrument or a small enclosure for livestock. These interpretations are not related in meaning, and this homonym is a clear-cut case of ambiguity.
We can, therefore, identify three broad groups of mappings from one word form to multiple interpretations. There is clear-cut ambiguity, illustrated by homonyms like *pen*, clear-cut vagueness, illustrated by the leafiness of trees, and an interesting set of cases in between these where an analysis in terms of vagueness or ambiguity is possible. It is in relation to these interesting cases that linguists and philosophers have tried to establish criteria to determine whether in a given case we are faced with ambiguity or vagueness.

Evidence that different traditional tests for ambiguity can produce different results for the same lexeme has led cognitive grammarians to the conclusion that there is no fixed boundary between cases of ambiguity and vagueness, with a continuum of polysemy ranging between these poles (Geeraerts 1993; Tuggy 1993). In an influential paper, Tuggy (1993) analysed this continuum using Cognitive Grammar (Langacker 1987). On his account, to summarize briefly, when meanings are related, as in polysemy, they are linked by a schema. At one extreme the schema, the over-arching concept covering both meanings, is “well-entrenched”, but the meanings are not themselves well-entrenched. This represents vagueness. That is, the lexical item corresponding to the over-arching concept is vague with respect to the distinction between the two meanings it covers. At the opposite pole the separate readings of a phonological form are well-entrenched and there is no subsuming schema. This is ambiguity. In between, there can be variation in the salience of the schema or the elaborative distance between schema and instances. In Tuggy’s model there is a parameter that adjusts a threshold for salience, so that forms become effectively ambiguous if there is no subsuming schema whose salience is greater than the current threshold.

This paper presents a computational model that implements Tuggy’s (1993) account using Adaptive Resonance Theory, a type of connectionist model (Carpenter and Grossberg 1987; Dunbar 1999). The model stores concepts as prototypes. When a new instance is encountered, the model compares it to the stored concepts, and selects the most similar one. It then retrieves the prototype for that concept and compares it to the instance. There are two possible outcomes at this stage. If the instance is sufficiently similar, it is assimilated to the existing concept, whose prototype is modified slightly to allow for variation in the new instance. This corresponds to the case of vagueness. The other possible outcome is that the instance is not sufficiently similar. Then the model will set up a new concept, initially with the novel instance as its prototype. This corresponds to ambiguity, with a
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distinct concept being entrenched separately. The computational model contains a parameter termed ‘vigilance’, and it will be shown in Section 2 that manipulating this generates the ambiguity-vagueness spectrum described by Geeraerts (1993) and Tuggy (1993).

1.1. Traditional criteria for ambiguity or vagueness

The English words ball and aunt are often used as illustrations of clear-cut ambiguity and vagueness. Ball can denote an object that is spherical, a toy, or it can denote a formal event at which people dance. It cannot be used to refer, indeterminately, to something that might be either. It is one or the other, an instance of ambiguity. Aunt, on the other hand, can refer to sisters (or sisters-in-law) of a child’s mother or father. Its denotation accommodates the siblings of either parent, so that, for example, the phrase my two aunts can include someone married to my father’s brother, and another married to my mother’s brother, indiscriminately. It is vague in relation to these distinctions. Even when I refer to a particular aunt, when I know that she is, say, my mother’s sister, the word itself does not carry the distinction.

A number of tests have been proposed to differentiate cases of ambiguity and vagueness. If those tests consistently indicated the same diagnostic conclusion for any given word, things would be simpler, but Geeraerts (1993: 237-254) noticed that they often do not. We can illustrate the problem with three of these criteria, the linguistic, logical and definitional criteria.

The linguistic criterion considers the acceptability of crossed readings for anaphoric phrases. The basis for the test is an assumption that an anaphoric term must have the same sense as its antecedent. When there is a mismatch, this generates a feeling termed zeugma. The test works by crossing the two interpretations in question and assessing, metacognitively, whether the crossed interpretation is acceptable. Example (2a) illustrates this with the word ball, and the anaphor at the end of the sentence is awkward to say the least. In contrast, (2b) is fine, no matter whether the respective aunts are linked to John’s mother or father. The logical test assesses whether contradicting, or cancelling, the term can be acceptable. If a term is ambiguous, then one reading can be asserted, and the other coherently denied. Example (3a) shows that one can do this for ball, but (3b) would be considered self-contradictory by a typical native speaker. The definitional criterion examines whether a single definition can be constructed for both
interpretations. If a term is vague, this should be possible. It is difficult to imagine an informative definition covering both senses of ball, whereas it is relatively easy for aunt (parent’s sister or sister-in-law), simply by generalizing from mother or father to parent.

(2) a. John would like to kick a ball and take his wife to one.
   b. John would like to meet one aunt [his father’s sister] and talk to the other [his mother’s sister].

(3) a. The ball that John kicked is not a ball.
   b. My aunt is not an aunt.

For aunt and ball, the three tests are consistent. Ball is ambiguous. Aunt is vague with respect to the distinction between the mother or father’s side of the family. Geeraerts (1993) found, however, that for many words the tests do not give consistent results. For example, the noun dog, which can denote all dogs or specifically male dogs, satisfies the logical test for ambiguity, but passes the linguistic test for vagueness.

1.2. Cognitive grammar model

Tuggy (1993) agreed with Geeraerts, concluding that there is no fixed boundary between cases of ambiguity and vagueness, but rather a continuum of gradable polysemy. Tuggy used the example of paint, which can refer to a range of activities such as painting a portrait, painting a ceiling, and applying makeup, and applied different tests. Tuggy (1993) was able to formulate a general definition covering the range of these uses, thus satisfying the definitional criterion. However, there were ambivalent results with the linguistic test, where acceptability was greater for more similar uses. He constructed example sentences, such as those in (4), and, using his own native speaker judgements evaluated their acceptability. In these judgements, the issue is whether the ‘so has’ form can acceptably cover the second interpretation via anaphoric link to the first. Tuggy found that, for example, (4a) is better than (4b). Similarity of meaning was described in terms of the degree to which components of meaning were shared by the senses. For example, uses would be more similar if the fluid applied was liquid in both cases, less similar if one involved a single colour, the other more than one colour, and so on. Thus, there is greater similarity between the interpretations in (4a) than between those in (4b).
a. I have been painting [a portrait in oils] and so has Jane [a landscape in watercolours].

b. I have been painting [stripes on the road] and so has Jane [a landscape in watercolours].

For *paint*, then, the definitional test suggests that the verb is vague with regard to these distinctions. However, the linguistic test does not give a clear result, but suggests a continuous spectrum, correlated with semantic distance.

Tuggy (1993) used the framework of cognitive grammar (Langacker 1987) to analyse this spectrum of polysemy. Two readings can be related if they can be subsumed by a common schema. Whether the word is vague or ambiguous with respect to those readings will depend on a number of factors, particularly the relative entrenchment of the readings, the entrenchment of the subsuming schema, the degree of elaboration required to instantiate the readings from the schema, and the salience of the schema. For example, the two interpretations of *ball* are well-entrenched, each being well-established independently of the other, and there is no salient common schema subsuming them. These are the characteristics of ambiguity. Conversely, for the interpretations of *aunt* as mother’s and father’s sister, there is a salient schema (parent’s sister), and only a small amount of elaboration is required to instantiate those interpretations from that schema. Thus *aunt* can have a single, vague sense, covering both interpretations.

Tuggy’s key theoretical point is that there is no crisp distinction between ambiguity and vagueness. Rather, there is a spectrum of degrees of unifiability (or, conversely, splitting) of senses. In his account, this gradability is provided for through the gradability of salience and entrenchment, which are related (Tuggy 1993: 280), and the gradability of elaborative distance. The more similar two interpretations are, the shorter the elaborative distance from a common schema potentially can be. Consequently, because degrees of similarity afford degrees of elaborative distance, they allow for degrees of ambiguity within this model. Furthermore, a given schema can be more or less salient as a function of context, leading to different patterns of ambiguity in different contexts. In particular, a schema can only subsume interpretations if its salience exceeds a threshold, and this threshold can vary. Because salience, and the threshold value at which a salient schema becomes relevant, are a matter of degree, there can be degrees of ambiguity. Through these different mechanisms, Tuggy’s model establishes a fuzzy distinction between ambiguity and vagueness and ac-
commodates the gradable and sometimes inconsistent results of applying traditional tests of ambiguity.

2. A computational implementation of Tuggy’s model of the ambiguity spectrum

The remainder of this paper presents a computational model that can produce the pattern of gradable classifications of ambiguity observed by Geeraerts and Tuggy. The model uses a single computational mechanism, Adaptive Resonance Theory, that is believed to have quite general applicability to cognitive processing, and the ambiguity spectrum is generated as a direct result of manipulating a single parameter of the model. The next subsection describes the mechanism, and the following one evaluates it empirically.

2.1. Adaptive Resonance Theory (ART)

ART is a type of connectionist network model, and so to introduce ART, I will first briefly outline the operation of standard feedforward connectionist networks. Such networks are simpler in design, and so will make it easier to introduce relevant terminology. In addition, the distinctive character of an ART network will be easier to perceive through the contrast with feedforward networks.

The simplest feedforward networks are made up of two sets of units, input and output units, with connections running from each input unit to each output unit. Figure 1(a) illustrates a network with five input units and one output unit. The network has five connections, one from each input unit to the output unit. In operation, the network is presented with an input pattern consisting of four numerical values, one for each input unit. These values set the activity of the input units, and the network ‘feeds’ information about this stimulated activity forward along the connections to the output unit.

Each connection also has a numerical value associated with it, termed a weight. These weights influence the way information about activity is transmitted along the connection, by a method that I shall illustrate shortly. Thus, the output unit receives information about the activity of the input units connected to it in a form that is influenced by the connection weights. Let’s illustrate this now, then, with a concrete example. Imagine that the four input units in Figure 1 are ‘feature detectors’ that take the value ‘1’