Semiotic-Conceptual Analysis of a Lexical Field

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Abstract. Semiotic-Conceptual Analysis (SCA) is a mathematical formalisation of semiotics which uses Formal Concept Analysis (FCA) as an underlying formal model of conceptual structures. Previously SCA had only been applied to formal languages. This paper discusses the applicability of SCA to natural languages using the example of the lexical field of "cooking" in English and Maori.

1 Introduction

Semiotic-Conceptual Analysis (SCA) has been introduced by Priss (2017) as a mathematical formalisation of semiotics which uses Formal Concept Analysis (FCA) as a formalisation (Ganter and Wille 1999) of conceptual structures. It has previously been shown how SCA can be applied to the analysis of programming languages and to investigations of why and how certain concepts are more difficult to learn than others. This paper applies SCA to a natural language example and argues that, contrary to purely linguistic analyses, a semiotic perspective that analyses conceptual structures in the form of concept lattices is more promising.

According to SCA, a sign is a triple consisting of a representamen (for example a word or sentence), an interpretation (which can include information about context, situation, speaker, listener and so on) and a denotation which represents a meaning. A condition for signs is that a pair consisting of a representamen and an interpretation uniquely identifies a denotation or, in other words, an interpretation is a partial function that maps representamens onto denotations. In this paper, it is assumed that all denotations are concepts in some conceptual structure. Thus, the notions of "denotation" and "concept" can be used somewhat interchangeably although, strictly, "denotation" is a role whereas "concept" is a type or category. Concepts can be hypothetically constructed whereas, in SCA, denotations must belong to signs that are actually used in communication. With respect to natural languages this implies that the meanings of words are concepts and according to SCA they can be modelled as formal concepts using FCA.

Technically, denotations and concepts are signs as well because they must have representamens, interpretations and denotations themselves, leading to a semiotic chain where signs are parts of signs which are discussed using signs and so on. It is up to a researcher to decide which sets of representamens, denotations and interpretations to use and which to ignore in a particular application and how far to investigate semiotic chains. Using SCA it is feasible to construct denotational conceptual structures (hierarchies, concept lattices or other) and then to investigate how representamens are mapped into these conceptual structures.

The next section provides a brief explanation of the lexical field of cooking in English using a linguistic analysis. Section 3 compares this lexical field in English and Maori using a conceptual analysis. Section 4 then adds a semiotic analysis in the sense of SCA.

2   Linguistic Analysis

Figure 1 shows a reduced neighbourhood lattice of the English and Maori words for cooking. According to Priss and Old (2005) a bilingual neighbourhood lattice can be formed by starting with a word in one language (such as "to cook" in English) then looking up all translations of that word in another language (here Maori), then looking up all the translations of the translations and so. Because the sets grow with each iteration it is useful to constrain this mechanism by only selecting words which occur as translations more than once or by some other means of eliminating homographs. For example, Maori translations of "to boil" include words for how mud "boils" in geothermal hot pools. Such non-food related words have been manually eliminated from Fig. 1. The Norwegian researcher, Helge Dyvik, developed a similar "semantic mirrors method" which was formalised with FCA by Priss and Old (2005). Dyvik's idea was that semantic structures in two languages mirror each other and can be used to jointly construct a thesaurus for each of the languages.
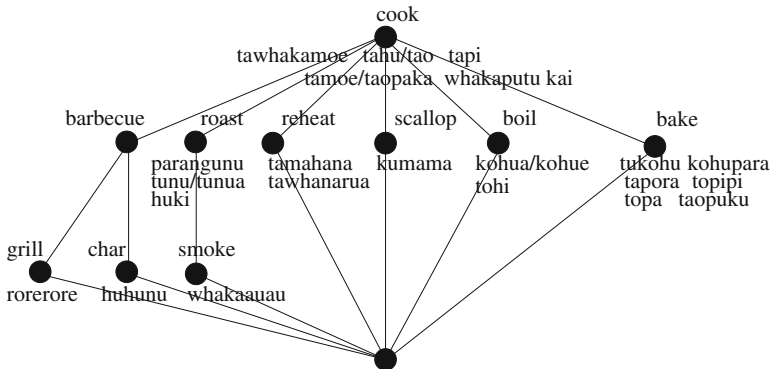

Fig. 1. A neighbourhood lattice for "cooking" words in English and Maori

Unfortunately, the resulting lattice in Fig. 1 is not very interesting. It is mostly just an antichain. The fact that some English words appear to correspond to many Maori words is an indication that the meanings of the Maori words might be distributed in a fairly different manner from the English words which is not obvious from the lattice. While Dyvik successfully detects mirrors comparing English and Norwegian words, this could be because both languages are linguistic and cultural close cousins. Thus a comparison of both demonstrates subtle differences which hint at underlying conceptual structures. Maori and English, however, are both culturally and linguistically far apart. We are arguing in this paper that a primarily linguistic method for deriving semantic information is insufficient if the underlying conceptual structures are far apart. Furthermore, even for languages which are closer related, Priss and Old (2007) observe that bilingual resources (such as corpora or dictionaries) may be inadequate for deriving semantic information if the bilingual resources do not already contain sufficient semantic details. Thus automatic extraction of semantic information from lexical databases that do not already encode semantic information is still a challenge. A hypothesis of SCA is that representamens point to conceptual structures but a significant amount of the information is implicit and not lexicalised. In order to extract semantic information, some sort of "decoding" practice needs to be employed which goes beyond a purely linguistic analysis.

In the 60s and 70s a method of "componential analysis" was developed and applied to lexical fields in order to decode underlying semantic information. An example of this method is Lehrer's (1969) lexical field of the English verbs of "cooking". He identifies a list of semantic features which are either present or absent for each word and which explain the semantic differences between the words. For example, "boiling" involves cooking in a non-fat liquid (e.g. water), contrary to frying which requires a fatty-liquid (e.g. oil). Both grilling and barbecuing employ direct heat, but in barbecuing a special sauce may be used. The result of componential analysis is essentially a formal context with words as formal objects and semantic features as attributes. Lehrer provides such a table in his paper which we have slightly simplified[1]. The corresponding concept lattice is presented in Fig. 2. The reason for colouring some of the nodes is explained further below. The main features for grouping English words of cooking appear to be whether heat is applied directly or indirectly, whether the food is meant to become brown on the surface and whether cooking is achieved with water or fat. Apart from the features that group words, at the lower nodes there is a long list of features that distinguish individual words. For example, cooking in a cream sauce and in a (scallop) shell is a unique characteristic of scalloping.

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[1] We omitted a few of the attributes, for example, the length of cooking time, whether a vigorous action is required and whether it applies to liquids or solids. We omitted some compound cooking verbs and we renamed some of the attributes.
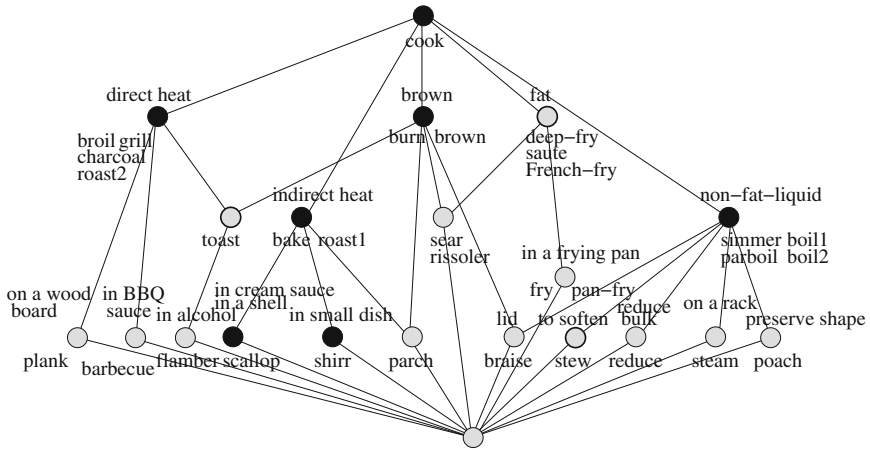
Fig. 2. The lexical field of "cooking" in English

3   Conceptual Analysis

In order to obtain a better understanding of the significance of the semantic features, we decided to compare this English lexical field to Maori again, but this time using semantic features. Polynesian people were isolated from other cultures from the early first millennium (Leach 1981). The Polynesian Maori arrived in New Zealand in the 13th/14th century and lived there in isolation until 1769[2]. Because their contact with foreigners was so recent and because the first Maori language newspapers were already printed in the 1840s, the impact of the contact with foreigners on the Maori language and culture are reasonably well documented. Therefore the Maori language is a good candidate for investigating conceptual differences and the linguistic and cultural changes that occurred after their first contact with "Pakeha" (which is the Maori word for people of European descent).

Although Polynesian people may have once had knowledge of pottery making, they abandoned this practice[3] long before they arrived in New Zealand (Leach 1981). Without pottery which provides heat-proof cooking vessels the most common types of English cooking (i.e., frying in a frying pan or cooking in a pot of water) are impossible. Beaton (2008) describes the six main types of Maori food preparation as: earth oven (hangi) cookery, Polynesian puddings, roasting, boiling, preserving and fermenting. Cooking in a hangi is the most important means of cooking for Maori and is described below. Polynesian puddings resemble bread, but require complicated steps to extract starch from plants, and are also ultimately baked in a hangi. Without heat-proof cooking vessels, boiling

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[2] Abel Tasman's contact with them in 1642 was brief and hostile and did not likely have much, if any, impact on Maori culture.

[3] Leach speculates that the need for pottery making may be connected to growing grains neither of which Polynesian people did.

can only be achieved by placing hot stones into, for example, wooden vessels. It is not, however, possible to cook larger pieces of meat in such a manner and it is not clear whether Maori used boiling for food at all or only for dyeing fibre (Beaton 2008). But at least the concept of boiling in water exists in the Maori language. Preserving and fermenting are also in the list of food preparation styles because, for Maori, this lexical field is more about general food processing. Maori always had to conduct all the steps from obtaining the ingredients from nature to producing the final food product by themselves. This is contrary to an English concept of cooking which mainly refers to the part of the food processing act which happens in one's own kitchen. For Maori, roasting involves broiling, for example, shellfish on hot embers or smaller birds or fish on sticks over an open fire. This is a kind of Maori "fast food" and traditionally was not a favoured means of food preparation (Beaton 2008). Maori preferred to cook their food in a hangi which is an earth oven and is an extreme kind of "slow food". Preparing a hangi involves a large amount of time and labour: digging a hole, collecting (large amounts of) firewood, heating stones, placing food on the stones, pouring water over the stones to produce steam, covering the hole with wet woven mats or sacks, and finally placing earth dug from the hole over the top. The food can be placed in the hangi in vessels to gather the fat or wrapped in leaves for flavour. While the food itself stays in the hangi for 2–3 h the whole process takes a day. A hangi is a communal activity cooked for a larger group of people.

Figure 3 displays a concept lattice of a lexical field of cooking in traditional Maori language. The data collection method for Fig. 3 was simpler than for Fig. 2. We searched for cooking words in several dictionaries[4] and derived attributes from the dictionary definitions. Thus, the Maori data does not have the same detail as the English data. We then compared the English and the Maori lattices. The grey nodes are those for which we did not find a translation in the other language, and the black nodes are those which exist in both languages. Thus, words from either language can serve as representamens for the concepts that are coloured black. The grey nodes with a thicker border in Fig. 2 correspond to the three loanwords which can be found in the modern Maori language. They were derived from English (tiu: to stew, parai: to fry, whakatohi: to toast) after 1769. The comparison of the two languages shows that the general concepts (cooking, broiling, baking, boiling and burning) exist in both languages. For some reason the very specific term of cooking in a small shell exists in both languages as well (kumama and to scallop). It is probably a coincidence that this is practised in both cultures. Both cultures also appear to have a notion of baking something in a small vessel. The remaining two more general types of English cooking (toasting and frying) and a very stereotypical one (stewing) appeared in Maori culture only after contact with Europeans. Because basically all modern Maori are also native English speakers, it is quite likely that other specific English cooking terms (parching, braising, poaching and so on) are simply included as English words if they are mentioned in a Maori language conversation.

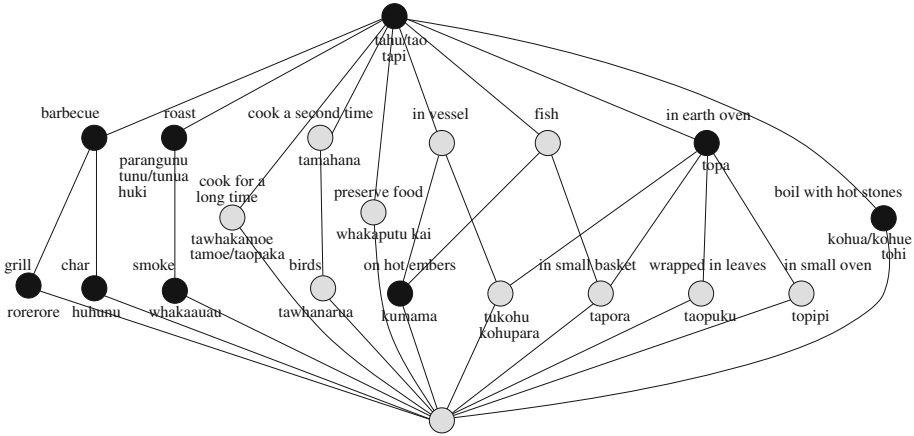[4] Williams (1957) and https://maoridictionary.co.nz.

Fig. 3. The lexical field of "cooking" in Maori

Figure 3 shows that apart from the general words of cooking, boiling and baking (and the scalloping exception) only the Maori words in the subfield of barbecuing and roasting have English expressions. Maori distinctions, with respect to whether fish or birds are cooked or whether something is wrapped in leaves or baskets, have no English counterpart. Although "cooking for a long time" and "cooking a second time" might be expressed in English, in Maori the cooking process is much longer and cooking for a second time may not just be reheating but a required step of the food preparation process. Thus, it is not clear whether these Maori concepts really correspond to English concepts.

Hangis and other Maori food traditions are still practised within modern Maori communities. But while ethnic food (Chinese, Japanese, Italian and Indian) is popular in New Zealand, Maori restaurants are difficult to find apart from a few tourist locations where visitors can book the "whole Maori experience" including greeting ceremony and hangi. The reason for this is most likely, that the Maori "fast food" procedure of roasting something on an open fire does not have a sufficiently distinctive Maori quality. The slow food of a hangi, on the other hand, requires planning ahead for how many people will be eating, and does not allow people to select food from a menu which is then ready half an hour later. There are "oven hangis" (tasteless, according to some Maori) cooked in a modern oven but they still require 2–3 h of baking time. Thus, traditional Maori food is so different that it does not easily fit into a modern restaurant culture. Furthermore, because Maori did not practice large scale agriculture, none of their vegetables apart from their staple, kumara[5], would be available for a mass market. Thus, "hangi" and "kumara" are the main Maori words from the lexical field of cooking which have become loanwords in New Zealand English. In summary, the top concepts of the English lexical field of cooking can be expressed in Maori, but only a few concepts and the subfield of broiling of the Maori lexical

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[5] A kind of sweet potato.

field of cooking can be expressed in English. It appears that English cooking influenced the life of modern Maori much more than vice versa.

4   Semiotic Analysis

The previous two sections describe the lexical field of cooking using linguistic and conceptual analyses. A linguistic analysis starts with words and their relationships to other words. Typical questions for a conceptual analysis focus on a conceptual modelling of the denotational structures. A semiotic analysis considers all three components of signs: representamens, denotations and interpretations. Typical semiotic questions focus on synonymy, polysemy, complexity, efficiency, the mapping of representamen relations, suitability, completeness and usability of signs. Because of the formal modelling with SCA and FCA, these questions become focused and to some degree measurable. The following list provides an overview of the approach:

- *Conceptual efficiency* increases if the total number of attributes in a lattice decreases. As mentioned before, we eliminated several attributes from Lehrer's (1969) original data because the lattice based on the original data had too many concepts which appeared to have no purpose with respect to most representamens.
- *Conceptual complexity* decreases if fewer attributes are needed to identify individual concepts. Lowering complexity tends to involve a decrease of efficiency. For example, in Fig. 2 the concept for "broil" is more complex than "toast" which can only be described by a combination of two attributes ("browning with direct heat").
- *Synonymy* refers to different representamens being attached to the same concept. A high degree of synonymy indicates that the conceptual modelling of the denotations may not be suitable or complete (see below).
- *Polysemy* refers to the same representamen belonging to different formal objects. In Fig. 2 this is indicated by adding a number after the word, such as "roast1" and "roast2". Polysemy is efficient, if it refers to the same representamen used in similar meanings in different concept lattices. Polysemy within a single concept lattice is somewhat acceptable if the words belong to closely related concepts (such as "boil1" and "boil2" in Fig. 2). The fact that the join and meet of "roast1" and "roast2" are the top and bottom concepts can indicate that there are missing attributes in the lattice.
- *Semiotic efficiency* increases if there is a high degree of polysemy (preferably not in one concept lattice but across different concept lattices). More polysemy requires using more interpretations.
- *Semiotic complexity* increases if a large number of interpretations is needed to disambiguate representamens. Figures 2 and 3 each represent an interpretation. But in Fig. 2 additional interpretations are needed to disambiguate "roast" and "boil".
- *Representamen relations* are more relevant for complex expressions such as phrases, sentences or larger texts. It would be possible to investigate word formation but that tends to be of interest mainly for historical analyses.

- *Suitability and completeness of a conceptual model* investigates how well a set of representamens can be described via their denotations within a conceptual model. For example, representamens that are mapped to the top or bottom concept are not very well described by the model. In the examples, in Figs. 2 and 3 only the very general cooking terms are mapped to the top concepts which is as expected. If the English representamens are mapped into the Maori lattice and vice versa, then many concepts are "lexical gaps" because they do not contain a representamen of the other language; furthermore many representamens would be synonyms because they are not sufficiently distinguished. For each representamen a definition can be generated from the lattice. For example, "to scallop" means to apply indirect heat to something cooked in a shell and adding a cream sauce. Such definitions can be compared to dictionary definitions with respect to how well they match.
- *Usability* is mainly relevant for sign systems that are purposefully and deliberately created. Language evolves over time and tends to self-adjust by incorporating new words and changing or forgetting existing words as needed.

The main categories related to cooking appear to be the physical process of cooking (e.g. using a frying pan), the intended result (e.g. brown) and the type of food that is cooked (e.g. type of animal). Some of the relationships between the attributes are causally related and not really of a linguistic nature. It would be of interest to compare the lattices in Figs. 2 and 3 to lattices derived from a more carefully designed formal ontology, but that is left for future research.

5   Conclusion

From an SCA view, representamens (e.g. words or phrases) are mapped onto denotations (which exist as conceptual structures) by interpretations. Interpretations can occur at different levels of granularity: corresponding to the utterances of one person in one specific context, or one person in general or to a group of people or a language. In this paper three main interpretations are considered: modern English, traditional Maori and modern Maori language. A purely linguistic analysis that compares translations from English into Maori and vice versa does not appear to provide detailed semantic insights. But if conceptual structures are constructed using some kind of method of decoding, then it is possible to show how representamens can be mapped into these conceptual structures. Using SCA questions about the quality of the representamens compared to the underlying denotational structures can be specified and investigated.

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