

The Role of Cardinality in Metonymic Extensions to Nouns

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Abstract

Meaning shifting phenomena such as metonymy have recently attracted increasing interest of researchers. Though these phenomena have been addressed by a variety of computational methods, the impacts of cardinalities of metonymically related items have been widely ignored in all of them. Motivated by this lack of analysis, we have developed a method for representing expectations and knowledge about the cardinalities of metonymically related entities and for exploiting this information to build logical forms expressing metonymic relations, the entities related, and their cardinalities as precisely as possible. The representation of lexically motivated knowledge is realized as an enhancement to Pustejovsky's Generative Lexicon, and the process of building logical forms takes into account overwriting of default information and mismatch of cardinality requirements. Our method enables a precise attachment of sentence complements, and it provides better prerequisites for reference resolution in the context of metonymic expressions than previous approaches.

1 Introduction

Meaning shifting phenomena such as metonymy have recently attracted increasing interest of researchers. Computational methods addressing these phenomena aim at inferring implicitly represented relations, predicting meaning shifts of nouns or verbs, expressing restrictions on these meaning shifts in dependency of context- or language-specific factors, and facilitating reference resolution. Measurements to achieve these issues include representation of default knowledge, and various sorts of dedicated inference methods and constructive procedures. However, the entities in the texts examined almost always appear in singular form so that issues of cardinality of metonymically related items have been widely ignored by the approaches undertaken so far.

Motivated by this lack of analysis, we have examined sentences taken from the literature about metonymic phenomena, and we have modified them by varying cardinalities of the items appearing explicitly or implicitly, to analyze effects of these alternations. The results have inspired us to undertake extensions to other techniques, such as lexical representations, to build increasingly explicit versions of logical forms, and to formulate conditions on pronominal accessibility. The insights gained are

likely to improve analysis methods for metonymic expressions, especially for relating contextual specifications to the appropriate entity, and for supporting reference resolution to entities related implicitly.

This paper is organized as follows. First, we review major computational approaches to metonymy. Then we illustrate the phenomena investigated by a number of typical examples. We continue by elaborating techniques to deal with these phenomena, that is, an enhancement to entries in the Generative Lexicon, and a procedure for building a logical form that appropriately represents relevant aspects of metonymic expressions. Finally, we discuss impacts of our analysis on pronominal resolution.

2 Approaches to Metonymy

Metonymy belongs to a variety of natural language phenomena that contribute to expressing information in an effective and economic way. All these phenomena involve what has been termed '*transfers of meaning*' by (Nunberg, 1995), i.e., the meaning of some constituent does not correspond to what can usually be expected according to the syntactic and semantic environment. Metonymy, or semantic coercion, is usually defined as a figure of speech in which the speaker is "*using one entity to refer to*

another that is related to it" (Lakoff and Johnson 1980). For example, in the utterance "The ham sandwich is waiting for his check", it is not literally the ham sandwich, which wants to pay, but the person who ordered it.

Motivations to address metonymy include both theoretical insights and practical applications (cf. (MACDOW 1992) and the natural language database interface TEAM (Grosz et al. 1987)). Computational approaches are mostly concerned with inferring implicitly expressed metonymic relations in English texts – (Fass 1991), Hobbs (Hobbs et al. 1993) (Lakoff and Johnson 1980), (Nunberg 1993, 1995), (Pustejovsky 1991), and (Wilks 1975) are prominent representatives. Some analyses also consider French (Kayser 1988), (Pustejovsky and, Bouillon 1995) and German (Horacek 1996).

In his program *met**, (Fass 1991) makes use of formal definitions of several kinds of metonymic relations; *met** also allows chaining metonymic relations in order to fill in implicitly expressed knowledge. Sowa's *conceptual graphs* (Sowa 1992) are used for inserting an unknown relation between a concept of the type expected and the concept appearing on the surface, which is later filled on the basis of world knowledge accessible to the system. The TACITUS system (Hobbs, Martin 1987) uses similar methods for dealing with metonymy and for interpreting noun-noun components, which are considered special cases of reference resolution – that approach, which is also described in (Hobbs et al. 1993), treats interpretation as a uniform abduction process to 'find the best explanation for the observables'. These approaches work nicely for analyzing utterances of the kind considered by inserting a plausible relation to remove a constraint violation, and they have similar and characteristic properties:

- The conditions expressing when leaving a metonymic relation implicit or not is possible are too unconstrained to cover a larger number of examples in several languages.
- The entities involved, the real and the literal referent, always appear in singular form.

There are only two approaches which in some aspects deviate from this characterization:

- Pustejovsky's Generative Lexicon (Pustejovsky 1991) addresses the first aspect. He proposes a *Theory of Qualia* within a

Generative Lexicon, which enables the explanation of systematic polysemy. Applying type coercion enables one to arrive at cases of ordinary metonymy which can be grounded in terms of the semantics of lexemes, as well as at word senses which Pustejovsky has termed *logical metonymy*, like the *reading* of a book in the sentence "Mary enjoyed the book". Enhancing the semantic representation of a noun within such contexts is done by exploiting prototypical knowledge derived from AGENTIVE or TELIC roles of the lexical entry for 'book', which are prominent roles in the Qualia Structure of lexical entries for nouns. The accuracy of the theory has been extended by the incorporation of restrictions on the productivity of lexemes. Particularities of the Qualia Structure of nouns regulate the acceptability or unacceptability of leaving a metonymic relation implicit in context of the words engaged (McDonald, Busa 1994, Pustejovsky, Bouillon 1995).

- (Stallard 1993) indirectly addresses the second aspect by taking into account scoping relations and consequences for pronominal reference. He has introduced a distinction between *referential* and *predicative* metonymy, depending on whether the actual or the literal argument is accessible for subsequent pronominal reference. This distinction manifests itself in different scope relations that hold between the actual and the literal argument in the corresponding logical forms. Though we do not agree with his usage of scoping and the resulting strict distinction of pronominal accessibility, Stallard's approach to build logical forms has inspired our techniques.

Though neither Pustejovsky's nor Stallard's approach address the role of cardinalities, we show that both of them can be extended accordingly: the Generative Lexicon can be augmented to represent knowledge about cardinality information associated with the semantics of nominals, and techniques similar to those used by Stallard can be set up for building logical forms with more precise cardinality specifications of the metonymically related entities. But before we expose these methods in detail, we prepare the ground for this enterprise by discussing a set of sentences illustrating the phenomena we intend to investigate.

3 Phenomena Investigated

For a number of metonymic relations, such as PRODUCER for PRODUCT ('I bought a *Ford*') and ARTIST for ARTWORK ('He plays *Beethoven*'), cardinalities are never a problem because the literal referents are expressed as proper names. Similar considerations apply to the eventualities involved in logical metonymy. For other metonymic relations, especially PART for WHOLE and ORGANIZATION for MEMBER, a number of complications may arise due to the cardinality of the items involved in a metonymic expression, as the following examples demonstrate. Let us start with two contrastive sentences (1) and (2), taken from (Hobbs et al. 1993), and (Lakoff and Johnson 1980), respectively (an earlier version of the subsequent analysis is available in (Horacek 1994)):

- (1) The ham sandwich is waiting for his check.
- (2) The Boston office called.

Following Stallard, (1) is interpreted as an example of *referential* reading, while (2) as an example of *predicative* reading: (1) can be rephrased more explicitly by *The man_x who has eaten a ham sandwich_y is waiting for his_x check*, while (2) in a similar way gets expanded to *The Boston office_x represented by one of its_x employees_y called*. These reformulations suggest that *the man* in (1) and *the Boston office* in (2) have wider scope in Stallard's representation than *the ham sandwich* in (1) and *the employee* in (2), which predicts pronominal accessibility in (1a) and (2b), as opposed to (1b) and (2a). We challenge this analysis in its strict sense, but we agree with it insofar as pronominal references as in (1b) or (2a) are rare, but quite common in sentences such as (1a) and (2b).

- (1) The ham sandwich is waiting for his check.
 - (1a) He is getting impatient.
 - (1b) It is 2 \$.
- * (1c) They are getting impatient.
- (2) The Boston office called.
 - (2a) He was angry.
 - (2b) It is our head quarter.
 - (2c) They want us to organize a meeting.

Apart from this difference, there do not seem to be further complications in these sentences: all referents involved are in singular form, as are the metonymic extensions. Since cardinalities of the entities involved are identical, conditions about pronominal reference depend primarily on pragmatic factors, which make references such as (1a) and (2b) more common than those

in (1b) and (2a). However, more complications than the analysis made so far has shown arise, when variations of cardinality in sentence (1) (see sentences (3) to (6) and their follow-ups), and variation of circumstances in sentence (2) (see the follow-ups of sentences (7) and (8)) are considered. For dishes made of animal ('the mussels'), additional complications may arise through interference between animals and persons as pronominal referents. Because we want to study the effects of cardinality variations per se, we avoid examples of this sort.

- (3) The pizzas are waiting for their checks.
- ? (3a) He/she is getting impatient.
- (3b) They are getting impatient.
- (4) The fruit dumplings want(s) to pay.
- (4') The fruit dumplings is waiting for his/her check.
 - (4a) He/she is getting impatient.
 - (4'') The fruit dumplings are waiting for their check(s).
 - (4b) They are getting impatient.
 - (4''') Die Fruchtknödel warten auf ihre Rechnung.
- (5) The meat plate want(s) to pay.
- (5') The meat plate are waiting for their check(s).
 - (5a) They are getting impatient.
 - (5'') The meat plate is waiting for his/her check.
 - (5b) He/she is getting impatient.
 - (5''') Die Schlachtplatte wartet auf ihre Rechnung.
- (6) Table 7 want(s) to pay.
- (6') Table 7 are waiting for their check(s).
 - (6a) They are getting impatient.
 - (6'') Table 7 is waiting for his/her check.
 - (6b) He/she is getting impatient.
 - (6''') Tisch 7 wartet auf seine Rechnung.

These sentences demonstrate that both intra-((1) and (3)) and intersentential ((1a) and (3b)) pronominal reference work fine, if the literal referents (here, various sorts of food) and the real referents (here, the persons) agree in number. Otherwise, a variety of complications arise in intrasentential reference, which also include cross-language differences, as the German sentences (4''') to (6''') as opposed to the English sentences (4') to (6') and (4'') to (6'') demonstrate. In these sentences, a fundamental difference manifests itself in the way how metonymic expressions are syntactically embedded in these languages. In English, it is the *intended* referent that determines verb agreement and pronominal reference in the same sentence. That is, the singular or plural form of the verb

in (4' to (6') and (4'') to (6'') indicates the cardinality of the intended referent, which may deviate from the cardinalities of the literal referents in each of these sentences. In (5'), the cardinality of the intended referent naturally differs from the number of the literal referent, assuming the meat plate is known as a dish for more than one person. For the fruit dumplings, situations with single (4') as well as with multiple intended referents (4'') are possible, because the expression 'fruit dumplings' is ambiguous in the sense that it can refer to one plate of dumplings to be eaten by a single person, or to several plates, each for another person. Moreover, sentences (6') and (6'') illustrate a case similar to sentences (4') and (4''). As a tendency, a single intended referent would be the default interpretation for the metonymic use of 'fruit dumplings', while 'table' seems to be more neutral with respect to the number of persons sharing it. As with the verb agreement, also the possessive pronouns are always agreed in gender and number with the intended referent in English. In contrast to that, the verb and possessive pronouns in German appear in strict agreement with the literal referents in the corresponding sentences (4''') to (6'''). Altogether, English sentences of this sort are more conclusive by making cardinalities and, in case of singular, also gender of the intended referent explicit, while the German sentences are ambiguous in these respects.

Unlike with intrasentential reference, intersentential pronominal reference with number features deviating from the referent that is pronominally accessible intrasententially is possible also in German under a variety of circumstances. These include default expectations about the cardinality of the real referents (see (4a) and (5b) as two complementary cases), and may perhaps be considered felicitous in other cases (see (5a)), similarly to (3a). The remaining case, as exemplified by sentence (4b), is felicitous for similar reasons as the different cases (4') and (4''). Finally, sentences (6') to (6b) constitute further pieces of evidence that default expectations about the cardinality of metonymically related entities (here, persons as eaters of kinds of food) play a certain role as to whether pronominal reference to metonymic expressions is felicitous or not, but not in a strict sense. In addition, (6b) is probably more common than (6a) as a default, due to the pragmatics of paying and plausibilities about table sharing, especially about food sharing according to reasonably assumed food quantities, seem to influence felicity in a subtle, hardly generalizable way in these sorts of sentences. For a member of a group as in (3b) (one of the pizza

eaters), the pragmatics of paying (a single person on behalf of several ones) may even license the use of the singular form as in (3a). However, a somehow chained metonymic reference to a group as in (1c) (to which the eater of the ham sandwich belongs) is certainly not possible.

- (7) The Boston office is represented in the business meeting.
- ? (7a) He/she is an expert in marketing.
- (7b) They are experts in marketing.
- (7c) They always send someone to important meetings.
- (8) The Boston office will meet for an excursion on Friday.
- * (8a) He/she likes to walk.
- (8b) They will make a lunch break at 2 pm.
- (8c) They like to organize social events.

In contrast to the examples discussed so far, sentences in the next group ((2), (7), (8), and their follow-ups) involve slightly harder restrictions. These are, however, no cross-language differences, because all references in these sentences are intersentential. The example sentences demonstrate certain complications in metonymic uses of 'office' in contrast to metonymic uses of 'sandwich', which originate from the differences in the underlying relations between food and the persons eating it, as opposed to the office and the caller who is related in a more indirect or perhaps more pronounced way to the office than persons are to the food they eat. Plural pronominal references as in sentences (7b), (7c), (8b) and (8c) are felicitous, but there is a difference between the sets of entities the plural pronouns refer to. While in (7c) and (8c), the pronouns refer to the *entire set* of employees of the Boston office, they more plausibly refer to the *representatives* in the meeting in (7b) and to the *excursion participants* in (8b). In any case, these examples indicate an additional demand on the treatment of cardinalities and referential accessibility of metonymic expressions: a distinction is to be made between the entities referred to metonymically (here: employees of the Boston office), and those of its member involved in the event expressed by the sentence (here: the meeting and the excursion). For the restaurant scenario, these sets of persons are mostly identical except to those cases where one person out of a group of persons eating together and referred to metonymically is the one who intends to pay.

- (9) Which airlines serve diet food from Boston to New York?
- (9a) In the first class?

food(x)	sandwich(x)	pizza(x)
CONST = {food ingredients}	CONST = {ham, bread, .. }	CONST = {dough, tomato, ... }
FORMAL = eatable(x)	FORMAL = eatable(x)	FORMAL = eatable(x)
TELIC = eat(e ^T ,y,x)	TELIC = eat(e ^T ,y,x)	TELIC = eat(e ^T ,y,x)
AGENTIVE = cook(e ^T ,z,x)	AGENTIVE = prepare(e ^T ,z,x)	AGENTIVE = bake(e ^T ,z,x)

Figure 1: Some 'standard' examples of Qualia Structures, for the nouns 'food', 'sandwich', and 'pizza'

As a further aspect of metonymic expressions, the last set of examples demonstrates chaining of metonymic relations and the relevance of each set of items involved for the associated analysis. In sentence (9), the airlines are the literal, and the persons the real referents. However, relating these two entities directly by an employment relation is problematic, since it is impossible to connect the locality information (from Boston to New York) and the first class restriction to either of them. Linking this information to the airline would decontextualize the serving process, and linking it to the persons would make the serving process independent of the context of a flight and the person's working for the airline. Therefore, it is more appropriate to elaborate the relation between the airlines and their employees to include the implicitly referred flights explicitly. These flights, of course, are the items that are first class and go from Boston to New York. Note, that linking the locality context properly is essential for setting up correct database requests, at least for requests to databases not restricted to flights only.

4 Expressing Lexical Knowledge

In order to capture distinctions between the varying interpretations of metonymic expressions illustrated in the previous section,

knowledge about the lexical items involved plays a crucial role. For adequately expressing this knowledge, we make use of entries in the Generative lexicon (see Figure 1). Since the information represented therein is insufficient for reasoning about cardinalities, we extend the entries in the Generative lexicon, prominently the TELIC role, by quantifier specifications. In the original form, the entities involved (typically, the lexical item itself and some related entity) are implicitly quantified, and a typed event variable is used (an event may be a state (S), a process (P), or a transition (T)). A similar exploitation of taxonomic knowledge in terms of cardinality restrictions has been exploited for scope disambiguation in (Fliegner 1988).

In the extended form (see Figures 2 and 3), we introduce explicit quantifiers, and we optionally add restrictors to variables referred to by events predicates. In addition, the scoping of quantifiers allows the derivation of cardinalities – see the entries for FRUIT-DUMPLING and MEAT-PLATE, as contrasting examples. We distinguish several types of quantifiers to cover the cases elaborated in the previous section, in addition to the standard quantifiers EXIST and WH (the first two constitute default information, and the others express definitional restrictions):

fruit-dumpling(x)	meat-plate(x)	table(x)
CONST = {dough, fruit, ... }	CONST = {pork, beef, .. }	CONST = {legs, plate, ... }
FORMAL = eatable(x)	FORMAL = eatable(x)	FORMAL = physobj(x)
TELIC = (DEFSINGLE y (DEFMULTIPLE x (eat(e ^T ,y,x))))	TELIC = (DEFSINGLE x (DEFMULTIPLE y (eat(e ^T ,y,x))))	TELIC = (DEFSINGLE E x (DEFMULTIPLE y (sit-at(e ^S ,y,x))))
AGENTIVE = cook(e ^T ,z,x)	AGENTIVE = prepare(e ^T ,z,x)	AGENTIVE = build(e ^T ,z,x)

Figure 2: Some 'extended' examples of Qualia Structures, for special food sorts and for 'table'

- DEFSINGLE for a single object
- DEFMULTIPLE for multiple objects
- SINGLE for a single object
- MULTIPLE for a multiple objects

Figures 2 and 3 show entries in the Generative Lexicon with extended TELIC roles. In principle, the same extensions also apply to the AGENTIVE roles, but we do not elaborate these extensions because we do not make use of these roles for our current purpose. Figure 2, for example, shows that some sorts of food are associated with different expectations about how many persons typically eat them. Fruit dumplings appear as sets (quantified by DEFMULTIPLE), to be eaten as a dish by a single person (quantified by DEFSINGLE). In contrast to the fruit dumplings, cardinality relations are inverted for the meat plate. Similar, but weaker default assumptions hold for a table in a restaurant.

In contrast to the restaurant scenario, cardinality relations are less vague and associated with defaults for elementary relations in organizations. Each office, and airlines in particular, are supposed to employ a set of persons larger than one, and each person is working for one organization only, at least in his/her individual activities (hence, the quantifiers SINGLE and MULTIPLE in the lexical entries shown in Figure 3). Similarly, each flight carries some set of people, each of which participates in one flight only (at the same time).

The knowledge contained in these lexicon entries can be used for building logical forms representing metonymic expressions of the kind discussed in section 3. The event predicates in the TELIC roles (and, less frequently, in the AGENTIVE roles) are exploited to infer the

relation involved, which works similarly to other approaches. Moreover, the new quantification specification yields the otherwise missing source of information to build an explicit logical form with cardinality specifications from concise surface expressions in a precise manner.

5 Building Logical Forms

Based on entries in the Generative Lexicon and on the context given by a sentence to be interpreted, appropriate logical forms can be built that represent semantic relations involved more explicitly than this is the case with previous approaches. These logical forms take into account sorts of the entities involved and sorts of case frame slots in which these entities appear, syntactic information about number, and default expectations or semantic restrictions about the cardinality of these entities, the latter aspect being a new feature in our approach. In a nutshell, metonymic extensions are tried according to specifications found in the lexicon, as long as the sort of an NP and the sort of the referring case role are incompatible. In addition, agreement between syntactic number and semantic cardinality specifications is achieved, which may require overwriting defaults or introducing a new set of entities as a subset of those already introduced. In concrete, logical forms are built by pursuing the procedure sketched in Figure 4, with step 2a performing metonymic extensions, and step 2c performing a final extension in case of a cardinality mismatch. In the following, we illustrate the procedure by some examples. Consider the sentence

- (4) The fruit dumplings wants to pay.

office(x)	airline(x)	flight(x)
CONST = {employees, ... }	CONST = {planes, office, .. }	CONST = {place, source, ... }
FORMAL = organization(x)	FORMAL = organization(x)	FORMAL = location-change(x)
TELIC = (SINGLE x (MULTIPLE y PERSON (work(e ^P , y, x))))	TELIC = (SINGLE x (MULTIPLE y FLIGHT (organize (e ^T , y, x))))	TELIC = (SINGLE x (DEFMULTIPLE y PERSON (carry(e ^T , y, x))))
AGENTIVE = establish(e ^T , z, x)	AGENTIVE = found(e ^T , z, x)	AGENTIVE = organize(e ^T , z, x)

Figure 3: Some 'extended' examples of Qualia Structures, for the nouns 'office', 'airline', and 'flight'

1. *Build an initial logical form from the surface expression.*

The representation is composed as an expression of the form $(Q_E x_E S_E \langle P \rangle)$, with

x_E being the variable whose representation is to be extended

(initially equal to x , denoting the literal referent),

Q_E being its quantifier, and S_E its sort

(initially equal to Q and S , which are associated with the literal referent), and

$\langle P \rangle$ being an eventually structured representation of the sentence predicate and its modifiers.

Moreover, the conflicting restrictions are stored. Let

S_R be the sort required within the referring case frame, and

Q_R the quantifier representing the associated case slot restrictions.

2. *Extend the meaning of noun phrases where a sortal incompatibility occurs.*

2a. *Build a metonymically extended expression through consultation of lexical knowledge.*

Merge the partial expression $(Q_E x_E S_E \langle P \rangle)$ with the extended representation found in the lexical entry for S_E (typically under the TELIC role), which structurally yields

$(Q_1 x_1 S_1 (\text{AND } \langle P_1 \rangle (Q_2 x_2 S_2 \langle P_2 \rangle)))$ – that is, the structure taken from the lexicon, with

$Q_1 = Q_E, x_1 = x_E, S_1 = S_E$, and $Q_2 = Q_N, x_2 = x_N, S_2 = S_N$,

if the referent with the same sort as x_E has wider scope in the lexicon entry, or

$Q_2 = Q_E, x_2 = x_E, S_2 = S_E$, and $Q_1 = Q_N, x_1 = x_N, S_1 = S_N$,

if the referent with the same sort as x_E has narrower scope in the lexicon entry.

$\langle P \rangle$ is partitioned according to sortal compatibility of its components, as follows

if $x_1 = x_E$

then $\langle P_1 \rangle$ contains parts that refer to x_E and are sortally compatible with S_E ,

else $\langle P_2 \rangle$ contains parts that refer to x_E and are sortally compatible with S_E .

Similarly, the remaining parts of $\langle P \rangle$ become $\langle P_2 \rangle$, if $x_1 = x_E$, and $\langle P_1 \rangle$ otherwise.

2b. *Test the compatibility of the newly inserted sort with the restrictions to be met.*

If S_N ($S_N = S_2$, if $S_1 = S_E$, and $S_N = S_1$ otherwise) is again incompatible with S_R ,

then repeat step 2a with x_N, S_N, Q_N and $\langle P_N \rangle$ as x_E, S_E, Q_E and $\langle P \rangle$, respectively

(x_N, Q_N and $\langle P_N \rangle$ have the same index as S_N);

else Q_N is overwritten by Q_R if Q_N is a default quantifier compatible with Q_R .

2c. *Test the cardinality compatibility of the newly inserted sort with the restrictions to be met.*

If S_N is compatible with S_R , but Q_N is incompatible with Q_R ,

then the expression is expanded as under 2a, by a MEMBER relation between x_E and x_N .

If not the whole set of entities bound to x_E participates in the eventuality,

then an expansion is performed with a SUBSET relation instead of a MEMBER relation.

Figure 4: The procedure for building logical forms with extended metonymic relations

The initial logical form directly built from the surface expression simply is

(MULTIPLE x FRUIT-DUMPLING
(WANT-PAY x))

which contains a sortal incompatibility.
Making use of the lexical entry for 'fruit

dumplings' and expanding the expression according to the TELIC role (see Figure 2) yields

(SINGLE y PERSON
(MULTIPLE x FRUIT-DUMPLING
(AND (EAT y x)
(WANT-PAY y))))

- More referents than just the real and the literal referent may be introduced, either through chained metonymic extensions or through membership/subset insertions.
- An additional inserted referent may provide a proper place to relate sentence complements (e.g., locality information to flights rather than to airlines or to persons).

Note, that there is a scoping difference in the expressions underlying the phrases 'one and the same person eating several fruit dumplings' and 'several persons sharing a meat plate' (the default interpretations), which is in contrast to the approach by (Stallard 1993). Moreover, the additional referents may not only improve the basis for complement attachment, but also for pronoun resolution. Both aspects are briefly discussed in the next section.

6 Impacts on Reference Resolution

Empirically supported by the considerable number of examples discussed in section 3, our approach is able to explain more pronominal references to metonymic expressions than others. This achievement is based on the following factors we have examined:

- Reference to literal and intended referents is possible in an increasing number of cases.
- Pronominal reference in plural form may have as antecedents distinguished sets of entities that are associated with a metonymic expression.
- There are cross-language differences between German and English in the treatment of intersentential pronominal reference.

In order to express scoping relations among sets properly, the logical forms representing metonymic expressions with entities of cardinality greater than one must deviate from Stallard's methods. According to (Stallard 1993), pronominal reference to literal and real referents is regulated by their scope, which distinguishes referential from predicative kinds of metonymy. Unfortunately, this realization of metonymic extension is incompatible with the common use of scoping. However, we believe that Stallard's distinction is in some sense artificial, because the felicity of pronominal reference seems to be more complex and influenced by other factors than scoping. For example, the sentence 'the

ham sandwich is waiting for his check' can be followed by some information useful to a novice waiter: 'It costs 2\$.' Moreover, the message 'The Boston office called' can be followed by the remark 'He spoke angrily' in some plausible contexts. Hence, it does not seem to be referential inaccessibility which makes many similar examples sound odd, but the rare occurrence and the eventual low coherence in neutral contexts. For example, it is usually of minor interest whether the person calling on behalf of the Boston office is angry himself; it is the attitude of the responsible representatives at the office that is usually more interesting, since this is usually considered an influential factor regarding the content of the message.

Given these pieces of evidence, reference resolution is essentially supported by the explicit logical form built through our techniques, and it is additionally guided as follows:

Intrasentential reference

Possessive pronouns always relate to the intended referent, which is accessible through the logical form. Since possessive pronouns in the same sentence agree in gender and number with the real referent in English, while they agree with the literal referent in German, only English sentences contain additional information about cardinality and gender of the intended referent. For example, the sentence 'the fruit dumplings is waiting for his check' carries the additional implication that there is one male person who wants to pay.

Intersentential reference

Reference through personal pronouns is possible to the literal and to the real referent, and to referents of the same sort but with possibly different cardinality as the real referent. Thus, all entities involved in a metonymic expression in its appearance in the explicit logical form are potential antecedents, except to some internal elements of a metonymic chain, so that a dialog memory should be maintained accordingly. For example, following the sentence 'The Boston office called', pronominal reference is possible to the office (the literal referent), to the caller (the real referent), and to the people at the office (differing from the caller by number only). However, 'the flights' appearing in the extended logical form representing the sentence 'Which airlines serve diet food from New York to Boston?' are not pronominally accessible.

7 Conclusion

In this paper, we have presented an approach to deal with cardinality aspects of metonymic extensions to nouns. We have discussed a variety of constellations with pronominal references to implicitly related items, sometimes associated with subtle conditions, including cross-language differences between English and German. In order to build explicit logical forms with cardinality specifications, we have extended entries in Pustejovsky's Generative Lexicon by default quantifier specifications, and we have described methods for exploiting these entries accordingly: Metonymic extensions are introduced on the basis of events represented in the roles of the Qualia structure, and member or subset relations are introduced on the basis of the associated quantifier specification. Our method for building explicit logical forms challenges Stallard's distinction of predicative and referential readings of metonymic expressions: it produces different scopings that reflect proper quantifier dominance relations rather than pronominal accessibility conditions, and it allows for additional cases of pronominal reference. In addition, our method enables a more precise attachment of contextual specifications to related entities, and it yields a better basis for reference resolution to metonymically related entities.

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