

António Branco (Ed.)

LNAI 4410

# Anaphora: Analysis, Algorithms and Applications

6th Discourse Anaphora and Anaphor Resolution Colloquium, DAARC 2007  
Lagos, Portugal, March 2007  
Selected Papers

 Springer

Lecture Notes in Artificial Intelligence 4410

Edited by J. G. Carbonell and J. Siekmann

Subseries of Lecture Notes in Computer Science

António Branco (Ed.)

# Anaphora: Analysis, Algorithms and Applications

6th Discourse Anaphora and Anaphor Resolution  
Colloquium, DAARC 2007

Lagos, Portugal, March 29-30, 2007

Selected Papers

Series Editors

Jaime G. Carbonell, Carnegie Mellon University, Pittsburgh, PA, USA  
Jörg Siekmann, University of Saarland, Saarbrücken, Germany

Volume Editor

António Branco  
Universidade de Lisboa, Faculdade de Ciências  
Departamento de Informática Campo Grande  
1749-016 Lisboa, Portugal  
E-mail: antonio.branco@di.fc.ul.pt

Library of Congress Control Number: 2007922631

CR Subject Classification (1998): I.2.7, I.2, I.7, F.4.3, H.5.2, H.3

LNCS Sublibrary: SL 7 – Artificial Intelligence

ISSN            0302-9743  
ISBN-10        3-540-71411-1 Springer Berlin Heidelberg New York  
ISBN-13        978-3-540-71411-8 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable to prosecution under the German Copyright Law.

Springer is a part of Springer Science+Business Media

[springer.com](http://springer.com)

© Springer-Verlag Berlin Heidelberg 2007  
Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India  
Printed on acid-free paper    SPIN: 12035274    06/3142    5 4 3 2 1 0

# Preface

Anaphora is a central topic in the study of natural language and has long been the object of research in a wide range of disciplines in the area of cognitive science, such as artificial intelligence and human language technology, theoretical, corpus and computational linguistics, philosophy of language, psycholinguistics and cognitive psychology. The correct interpretation of anaphora has played an increasingly vital role in real-world natural language processing applications including machine translation, automatic abstracting, information extraction and question answering. Given the challenges its complexity poses to scientific inquiry and technological progress, anaphora has been one of the most productive topics of multi- and inter-disciplinary research, and has enjoyed increased interest and attention in recent years.

The cutting-edge results reported in the papers collected in the present volume address all these aspects. They are a selection of the best papers presented at the sixth edition of DAARC.

The Discourse Anaphora and Anaphor Resolution Colloquia (DAARC) have emerged as the major regular forum for presentation and discussion of the best research results in this area. Initiated in 1996 at Lancaster University and taken over in 2002 by the University of Lisbon, the DAARC series established itself as a specialized and competitive forum for the presentation of the latest results on anaphora. The series is unique in that it covers this research subject from a variety of multidisciplinary perspectives, while keeping a strong focus on automatic anaphora resolution and its applications.

The program of the sixth DAARC was selected from 60 initial submissions. It included 24 oral presentations and 15 posters from over 70 authors coming from 18 countries: Australia, Belgium, Czech Republic, Denmark, France, Germany, Israel, Italy, Japan, Norway, Poland, Portugal, Russia, Spain, The Netherlands, Turkey, UK and the USA. The submissions were anonymized and submitted to a selection process by which each received three evaluation reports by experts from the Program Committee.

The program also included two invited presentations, by Ruslan Mitkov and his team, from the University of Wolverhampton, and by Jos van Berkum, from the University of Amsterdam.

The articles in the present volume grew out of one of the invited talks, by Ruslan Mitkov *et al.*, and of 12 regular papers presented at DAARC. They are fully fledged versions of the submissions that got the best reviewing reports from the Program Committee.

On behalf of the Organization Committee, I would like to thank all the authors who contributed with their papers to the present volume and all the colleagues in the Program Committee for their generous and kind help in the reviewing process of DAARC, and in particular, of the papers included in the

present volume. Without them neither this colloquium nor the present volume would have been possible.

Last but not least, my warm thanks also go to my colleagues in the Organization Committee of the colloquium, Tony McEneary, Ruslan Mitkov and Fátima Silva.

Lisbon, January 2007

António Branco

# Organization

The sixth DAARC colloquium was organized by the University of Lisbon, Faculty of Sciences, Department of Informatics.

## Organization Committee

António Branco, University of Lisbon, Portugal  
Tony McEnery, Lancaster University, UK  
Ruslan Mitkov, University of Wolverhampton, UK  
Fátima Silva, University of Oporto, Portugal

## Program Committee

Mijail Alexandrov-Kabadjov, University of Essex, UK  
Mira Ariel, Tel Aviv University, Israel  
Sergey Avrutin, OTS, The Netherlands  
Amit Bagga, Ask.com, USA  
Patricio Martinez Barco, University of Alicante, Spain  
Peter Bosch, University of Osnabrück, Germany  
António Branco, University of Lisbon, Portugal  
Donna Byron, Ohio State University, USA  
Francis Cornish, University of Toulouse-Le Mirail, France  
Dan Cristea, University of Iasi, Romania  
Robert Dale, Macquarie University, Australia  
Richard Evans, University of Wolverhampton, UK  
Martin Everaert, OTS, The Netherlands  
Lyn Frazier, University of Massachusetts, Amherst, USA  
Claire Gardent, CNRS/Loria, France  
Rafael Muñoz Guillena, University of Alicante, Spain  
Jeanette Gundel, University of Minnesota, USA  
Sanda Harabagiu, University of Texas at Dallas, USA  
Lars Hellan, Norwegian University of Science and Technology, Norway  
Erhard Hinrichs, University of Tübingen, German  
Graeme Hirst, University of Toronto, Canada  
Yan Huang, University of Reading, UK  
Andrew Kehler, University of California San Diego, USA  
Andrej Kibrik, Russian Academy of Sciences, Russia  
Emiel Kraemer, Tilburg University, The Netherlands  
Shalom Lappin, King's College, UK  
Tony McEnery, Lancaster University, UK  
Ruslan Mitkov, University of Wolverhampton, UK

## VIII Organization

Jill Nickerson, Ab Initio Software Corp, USA

Constantin Orasan, University of Wolverhampton, UK

Maria Mercedes Piñango, Yale University, USA

Georgiana Puscasu, University of Wolverhampton, UK

Costanza Navarretta, CST, Denmark

Massimo Poesio, University of Essex, UK

Eric Reuland, OTS, The Netherlands

Jeffrey Runner, University of Rochester, USA

Antonio Fernandez Rodriguez, University of Alicante, Spain

Tony Sanford, Glasgow University, UK

Frédérique Segond, Xerox Research Centre Europe, France

Roland Stuckardt, University of Frankfurt am Main, Germany

Joel Tetreault, University of Rochester, USA

Renata Vieira, Unisinos, Brazil



# Table of Contents

## Human Processing and Performance

Nuclear Accent Placement and Other Prosodic Parameters as Cues to Pronoun Resolution . . . . .	1
<i>Ekaterina Jasinskaja, Ulrike Kölsch, and Jörg Mayer</i>	
Empirically Assessing Effects of the Right Frontier Constraint . . . . .	15
<i>Anke Holler and Lisa Irmen</i>	
Pronoun Resolution and the Influence of Syntactic and Semantic Information on Discourse Prominence . . . . .	28
<i>Ralph Rose</i>	

## Language Analysis and Representation

Anaphora Resolution as Equality by Default . . . . .	44
<i>Ariel Cohen</i>	
Null Subjects Are Reflexives, Not Pronouns . . . . .	59
<i>Antônio Branco</i>	
Using Very Large Parsed Corpora and Judgment Data to Classify Verb Reflexivity . . . . .	77
<i>Erik-Jan Smits, Petra Hendriks, and Jennifer Spender</i>	
An Empirical Investigation of the Relation Between Coreference and Quotations: Can a Pronoun Located in Quotations Find Its Referent? . . . . .	94
<i>Shana Watters and Jeanette Gundel</i>	

## Resolution Methodology and Algorithms

Applying Backpropagation Networks to Anaphor Resolution . . . . .	107
<i>Roland Stuckardt</i>	
Improving Coreference Resolution Using Bridging Reference Resolution and Automatically Acquired Synonyms . . . . .	125
<i>Ryohei Sasano, Daisuke Kawahara, and Sadao Kurohashi</i>	
Evaluating Hybrid Versus Data-Driven Coreference Resolution . . . . .	137
<i>Iris Hendrickx, Veronique Hoste, and Walter Daelemans</i>	

## Computational Systems and Applications

Automatic Anaphora Resolution for Norwegian (ARN) . . . . .	151
<i>Gordana Ilić Holen</i>	
“Who Are We Talking About?” Tracking the Referent in a Question Answering Series . . . . .	167
<i>Matteo Negri and Milen Kouylekov</i>	
Anaphora Resolution: To What Extent Does It Help NLP Applications? . . . . .	179
<i>Ruslan Mitkov, Richard Evans, Constantin Orăsan, Le An Ha, and Viktor Pekar</i>	
<b>Author Index</b> . . . . .	191

# Nuclear Accent Placement and Other Prosodic Parameters as Cues to Pronoun Resolution\*

Ekaterina Jasinskaja, Ulrike Kölsch, and Jörg Mayer

University of Potsdam  
Institut für Linguistik, SFB 632,  
Karl-Liebknecht-Straße 24-25, 14476 Golm, Germany  
{jasinsk,ukoelsch}@uni-potsdam.de, mayer@ling.uni-potsdam.de

This paper investigates the influence of prosody on the interpretation of anaphoric pronouns, concentrating especially on the effect of nuclear accent placement. It is well-known that accented and unaccented pronouns generally have different resolution preferences, but it is less obvious that pronoun interpretation can be affected by almost any manipulation of the accentual pattern of the sentence in which the pronoun occurs, even by a manipulation that does not involve the pronoun. However, the latter follows from theories of accentuation such as [1] and in this paper we present experimental support for this prediction. Our results corroborate the view that the influence of accent on pronoun resolution should be derived from a general theory of focus interpretation, rather than from rules defined specifically for accents occurring on pronouns.

We start in Section 1 by presenting some background on accentuation and its impact on pronoun resolution. Since accent is a way of signaling contrast, and contrast in turn can be viewed as a rhetorical relation, constraints on pronoun resolution that result from rhetorical structure should be taken into account as well, which is done in Section 2. Section 2 also introduces hypotheses related to other prosodic parameters (pitch range and pause duration) which are known to be able to convey aspects of rhetorical structure. Finally, Section 3 describes our experiment, and Section 4 discusses the results.

## 1 Accent Placement and Pronoun Resolution

It is well-known that accentuation affects the resolution preferences of anaphoric pronouns. In particular, the effect of accenting the pronoun itself has been studied quite extensively and is illustrated by the following example (coindexing indicates coreference relations):

---

\* We are indebted to Elke Kasimir for making her implementation of Schwarzschild's OT constraints system [1] available for deriving our hypotheses; and to Robin Hörnig for advice on the statistical analysis. Many thanks also go to Martin Neumann, Norman Schenk and Marcus Thienert. This research was funded by the German Research Community (DFG) as part of the Collaborative Research Center *Information Structure* (SFB 632).

- (1) a. Paul<sub>i</sub> called Jim<sub>k</sub> a Republican.  
       Then he<sub>i</sub> insulted him<sub>k</sub>.  
    b. Paul<sub>i</sub> called Jim<sub>k</sub> a Republican.  
       Then HE<sub>k</sub> insulted HIM<sub>i</sub>.

Recent studies have argued that there is nothing special about the role of accent when placed on a pronoun; rather, the effects of accent on pronoun resolution should be derived from a general theory of accentuation and focus semantics [1,2]. In particular, it is proposed that certain accentual patterns, including those that involve accented pronouns, require the presence of a *contrasting alternative* in the context or a possibility to accommodate such an alternative [3,4,5]. A contrasting alternative in this case is a constituent (often, a clause) that differs from the clause in question only in the focused ( $\approx$  accented) subconstituent(s). Thus in (1b), the accents on the pronouns and the absence of accent on the verb *insulted* are licensed only if the sentence is taken to contrast with the preceding sentence *Paul called Jim a Republican*; this implies that (a) HE must be contrasted with, i.e. distinct from, *Paul* (hence HE  $\mapsto$  Jim), (b) HIM must be contrasted with, i.e. distinct from, *Jim* (hence HIM  $\mapsto$  Paul), and (c) *insulted*, since it is deaccented, must be viewed as “parallel” to *called a Republican*, so that calling someone a Republican has to be accommodated as a kind of insult.

Most of the existing theoretical analyses of accented/stressed pronouns, notably [6] and [4], seem to treat accent as an independent property of the pronoun.<sup>1</sup> However, theories of accent placement such as [7] or [1] suggest that the decision to accent or deaccent a pronoun is not independent from the decision to accent or deaccent other constituents in the sentence. Thus, for instance, placing no accent on the pronouns in the second sentence of (1a) means almost automatically that the verb *insulted* must be accented. In this paper we present further support for the idea that the dependence of pronoun resolution on accentuation is a by-product of the general functioning of prosodic focus as a contrast-signaling device; however, unlike the previous studies, we would like to emphasise the importance of the overall accentual pattern of a sentence. That is, it does not only matter whether the pronoun is accented or not, but as predicted by Schwarzschild [1], any occurrence of an accent in the sentence, as well as any occurrence of deaccenting is potentially relevant for determining an antecedent. We present below the results of an experiment which show that this prediction is indeed borne out. There is a well-known asymmetry between nuclear and pre-nuclear accents in marking given information, and we will

---

<sup>1</sup> This approach makes it look as if the opposition of stressed and unstressed pronouns behaves like the opposition of strong and weak pronouns, e.g. *it* vs. *that* in English, *er* vs. *der* in German. The latter indeed applies specifically to pronouns, in that the strong/weak pairs often have to be defined in the lexicon, rather than following a productive pattern, whereas accentuation is completely productive in languages like English and German, and is not restricted to pronouns. Although the choice between a strong and a weak pronominal form might not be completely independent from stress, the oppositions are *a priori* distinct and a uniform analysis should be empirically justified.

therefore follow Venditti et al. [8] in restricting our attention to the placement of *nuclear* accents—the most prominent, and usually the last, accent in a prosodic phrase.

To illustrate the prediction in question, consider the German example in (2) as well as its English translation in (3):

- (2) a. Johann hat die Möhren geschnitten.  
*Johann has the carrots cut*  
 b. Marek hat indes die Kartoffeln geschält.  
*Marek has meanwhile the potatoes peeled*  
 c. Außerdem hat er die Kartoffeln geschnitten.  
*besides has he the potatoes cut*
- (3) a. Johann cut the carrots.  
 b. Meanwhile, Marek peeled the potatoes.  
 c. Besides, he cut the potatoes.

The most natural interpretation of the pronoun *er* ‘he’ in (2c)/(3c) is *Marek*, the only male individual mentioned in the immediately preceding sentence, while the most natural pronunciation of (2c) is with a nuclear accent on the verb *geschnitten* ‘cut’, indicated by small caps in (4), with the direct object *die Kartoffeln* ‘the potatoes’ deaccented.

- (4) Außerdem hat er die Kartoffeln GESCHNITTEN  
*besides has he the potatoes cut*

This pattern is explained straightforwardly if we assume that only the previous sentence is relevant for establishing the contrast relation. In that case, the transitive relation *He/Marek X-ed the potatoes* is given, while the verb *geschnitten* ‘cut’ is contrasted with *geschält* ‘peeled,’ so the verb is narrowly focused and receives the nuclear accent. However, if both context sentences (2a) and (2b) are taken into account, the question arises, with which of them (2c) should be contrasted. This choice is essential for determining the accentual pattern, and as it turns out, it interacts in a crucial way with the choice of antecedent for the pronoun.

Suppose, as before, that *er* ‘he’ in (2c) refers to *Marek*, but (2c) is contrasted with (2a). Then the verb *geschnitten* ‘cut’ is given, but its arguments are contrasted: *er/Marek* with *Johann* and the potatoes with the carrots. So a contrast/givenness-based theory predicts accents on *er* and *Kartoffeln*, cf. (5a). Now suppose that the pronoun refers to the antecedent farther away—*Johann*. If (2c) is contrasted with (2b), the sentences differ in who did what to the potatoes, so accents are expected on the pronoun *er/Johann*, contrasting with *Marek*, and *geschnitten* ‘cut,’ contrasting with *geschält* ‘peeled,’ cf. (5b). If, in turn, (2c) is contrasted with (2a), the open proposition *He/Johann cut X* is given and only the objects of cutting, the potatoes and the carrots, are contrasted. Therefore, we predict an accent on *Kartoffeln* ‘potatoes,’ cf. (5c), whereas the pronoun receives no accent.

- (5) a. Außerdem hat ER [Marek] die KARTOFFELN geschnitten  
*besides has he the potatoes cut*
- b. Außerdem hat ER [Johann] die Kartoffeln GESCHNITTEN  
*besides has he the potatoes cut*
- c. Außerdem hat er [Johann] die KARTOFFELN geschnitten  
*besides has he the potatoes cut*

This short sketch shows that theories of accent placement based on the notions of contrast and givenness such as [5] and [1] predict a rather complex interplay between pronoun resolution possibilities and accentuation patterns. Since coreference relations play a role in identifying the parallel part of the contrasting clauses, the choice of pronoun antecedent does not only determine whether the pronoun should be accented or not, but also imposes constraints on which other parts of the sentence may be accented. Conversely, one would expect that in discourses like (2) the shift of accent between the direct object and the verb in (2c) should correlate with a change of antecedent for the pronoun *er* ‘he.’ This study concentrates specifically on the contrast between (4) and (5c) where the pronoun remains unaccented in both versions. Here, the nuclear accent on *geschnitten* ‘cut’ is expected to correlate with the resolution of *er* ‘he’ to *Marek*. Resolution to *Johann* would, of course, be dispreferred due to distance considerations, however a nuclear accent on *Kartoffeln* should favour this suboptimal resolution. Testing this hypothesis is the main goal of the experiment presented below, but first a few words on some further corollaries of this hypothesis.

## 2 On the Role of Discourse Structure

If the above theory is correct, then placement of accent can influence which part of the context a current sentence is contrasted with. Thinking of contrast as a rhetorical relation, along the lines of Mann & Thompson [9] or Asher & Lascarides [10], accent placement can thus affect the *attachment site* of the current sentence in the discourse structure: with the accentual pattern in (4) the sentence is attached with a contrast relation to the immediately preceding sentence; with the accent on the direct object as in (5c), the sentence is attached higher up in the discourse structure, to a sentence that is farther away. In other words, the latter case is an instance of *discourse pop*.

The present work is part of a larger study on prosody as a cue to discourse structure. There is a substantial body of research on discourse prosody (see e.g. [11,12,13,14,15,16,17,18]) showing that pitch range—the fundamental frequency span between the realizations of high and low tones—is higher at the beginning of a discourse unit (e.g. a paragraph) and lower at its end. A switch from one discourse unit to another (topic shift, or discourse pop) is therefore associated with a perceptible reset of pitch range back to higher and larger F0 span. Similarly, discourse pops correlate with relatively longer pauses between utterances [19,20].

Furthermore, it is well-known that the hierarchical organisation of discourse (global topic structure) affects anaphora resolution. Although, in general, referents mentioned in more recent sentences tend to be more accessible for pronominal

reference, a discourse pop can change this. If a less recent antecedent is related to a more global discourse topic, it can become more salient when that topic is reactivated after the pop. A more recent antecedent, on the other hand, can become less salient, if it is only locally important in the discourse segment just closed off.<sup>2</sup> Consequently, prosodic features signaling a discourse pop are expected to facilitate resolution of pronouns to less recent antecedents, which is supported by our previous experimental studies [29,30].

Applying these findings to example (2) above, one would expect that a pitch reset in the last sentence, as well as a long pause before it, should favour high attachment to (2a) with corresponding resolution of *er* ‘he’ to *Johann*. Lack of pitch reset and normal pause length before (2c) should correlate with low attachment to (2b) and resolution of *er* ‘he’ to *Marek*. In our present experiment the effects of accentuation and global prosodic parameters were studied simultaneously, as we were interested in possible interactions between different prosodic devices signaling discourse attachment.

### 3 Experiment

#### 3.1 Method

**Discourses:** For the purposes of the experiment we constructed 40 discourses, each of which consisted of a set of 3 sentences similar to (2), and in which the last sentence could be understood as contrasting with either the first or the second sentence, depending on the interpretation of the pronoun. The potential antecedents were proper names referring to male or female humans (either both male or both female), and always constituted the grammatical subject of the sentence, occurring in sentence-initial preverbal position. Sentence 2 was related to sentence 1 by a discourse adverbial that appeared immediately after the finite verb, cf. *indes* ‘meanwhile’ in (2b). The target sentences started with a discourse adverbial, cf. *außerdem* ‘besides’ in (2c), while the ambiguous pronoun *er* ‘he’ or *sie* ‘she,’ which was also the grammatical subject, immediately followed the finite verb. We wanted to avoid placing the target pronoun in the absolute sentence-initial position so that the first prenuclear pitch accent could precede it thus enabling the listener to appreciate the pitch range of the utterance before he or she interpreted the pronoun. The nuclear accent in turn always occurred after the target pronoun.

As with (2), all the experimental discourses were designed in such a way that shifting the nuclear accent from one constituent to another in the target sentence would indicate contrast with the first or the second sentence of the context. It should be noted, though, that there is an asymmetry between the accentual patterns in (4) and (5c). The nuclear accent on the transitive verb as in (4)

<sup>2</sup> This generalisation has been expressed in various forms as the Right Frontier Constraint [21,10], the stack model [22], the cache model [23], the veins theory [24], the rhetorical distance theory [25], among others, and has been empirically substantiated by e.g. [26,27,28].

indicates more or less unambiguously that the verb bears *narrow focus*; that is, the sentence could only be used felicitously as an answer to a question like *What did he do to the potatoes?* or be uttered in a context where the potatoes are given, e.g. if it is contrasted with a sentence that explicitly mentions the potatoes. In contrast, the accent on the direct object in (5c) is ambiguous between narrow focus on *Kartoffeln* ‘potatoes’ and broad focus on the VP or the whole sentence (cf. e.g. [7,31]). Thus (5c) can answer both a question like *What did he cut?* and questions like *What did he do?* or *What happened?* Similarly, it can be contrasted with a sentence that only differs from (5c) in the referent of the direct object, e.g. (2a), or with one where, for instance, the whole VP is different: *A: Johann hat die Pfanne gewaschen. B: Nein, er hat [die Kartoffeln geschnitten]<sub>FOC</sub>*. ‘A: John washed the frying pan. B: No, he cut the potatoes.’ Finally, a transitive sentence with a nuclear accent on the direct object need not be involved in a contrast relation at all and can be uttered “out of the blue,” hence this accentual pattern is often called the *default* or the *neutral* pattern.

In order to prevent a confound between the neutral vs. non-neutral accentual pattern distinction and the factor under investigation—contrast with sentence 1 vs. contrast with sentence 2—we made sure that our materials were balanced with respect to whether the “neutral” pattern supported attachment to sentence 1 or 2. To achieve this, half of the discourses were like (2), in that the neutral pattern appeared in the ‘contrast with sentence 1’ condition, whereas in the other half this was reversed, in that the neutral pattern appeared in the ‘contrast with sentence 2’ condition. An example of the latter is a discourse like (6) below, cf. the English translation in (7). Here the neutral pattern with the nuclear accent on the direct object *Garten* ‘garden’ in (6c) appeared in the ‘contrast with sentence 2’ condition, whereas the marked pattern with the nuclear accent on the verb *gemalt* ‘painted’ was expected to trigger contrast with sentence 1.

- (6) a. Dirk hat den Garten fotografiert.  
       *Dirk has the garden photographed*  
 b. Franz hat solange       den Teich gemalt.  
       *Franz has in that time the pond painted*  
 c. Dann hat er den Garten gemalt.  
       *Then has he the garden painted*
- (7) a. Dirk took some photos of the garden.  
 b. During that Franz painted the pond.  
 c. Then he painted the garden.

The syntactic functions of the constituents involved in the accent shift manipulation were varied. There were 12 discourses like (2) and (6) where the nuclear accent was shifted between the (monotransitive) main verb and the direct object. In 8 discourses the accent was shifted between the first and the second object



of a ditransitive verb, e.g. *hat Benno ein BUCH geschenkt* ‘gave Benno a BOOK’ vs. *hat BENNO ein Buch geschenkt* ‘gave BENNO a book,’ in (8)/(9).

- (8) a. Martha hat Niklas ein Buch überreicht.  
*Martha has Niklas a book presented*  
 b. Leonie hat dann Benno eine DVD beschert.  
*Leonie has then Benno a DVD presented*  
 c. Außerdem hat sie Benno ein Buch geschenkt.  
*apart from that has she Benno a book presented*
- (9) a. Martha gave Niklas a book (as a present).  
 b. Then Leonie gave Benno a DVD.  
 c. Apart from that she gave Benno a book.

There were 8 discourses in which the accent shift manipulation concerned the direct object of a (mono)transitive verb and a PP- or adverbial modifier of the verb, e.g. *HEUTE ein Seminar versäumt* ‘missed a class TODAY’ vs. *heute ein SEMINAR versäumt* ‘missed a CLASS today.’ In 2 cases the accent was shifted between a head noun and its PP argument: *ein BUCH über Napoleon* ‘a BOOK about Napoleon’ vs. *ein Buch über NAPOLEON* ‘a book about NAPOLEON’; in 4 cases between an NP and its PP modifier: *ein REGAL aus Nussbaum* ‘a SHELF of walnut wood’ vs. *ein Regal aus NUSSBAUM* ‘a shelf of WALNUT wood’. Finally, 6 discourses were like (10)/(11) in which the accent was shifted between an NP and its adjectival modifier: *mit einer blonden AMERIKANERIN* ‘with a blond AMERICAN’ vs. *mit einer BLONDEN Amerikanerin* ‘with a BLOND American.’

- (10) a. Björn tanzte mit einer rothaarigen Amerikaner-in.  
*Björn danced with a.FEM red-haired American-FEM*  
 b. Maik tanzte übrigens mit einer blonden Schwed-in.  
*Maik danced by the way with a.FEM blond Swede-FEM*  
 c. Vorher tanzte er mit einer blonden Amerikaner-in.  
*Before that danced he with a.FEM blond American-FEM*
- (11) a. Björn danced with a red-haired American.  
 b. By the way, Maik danced with a blond Swede.  
 c. Before that, he danced with a blond American.

In the 28 discourses in which the main verb was not involved in the accent shift manipulation, it was important that the verb be part of the background, i.e. that it constitute the parallel (non-contrasting) part of the contrasting sentences. As a result, the verb had to be repeated in all three sentences in a set, e.g. *tanzte* ‘danced’ in (10), which often led to rather unnatural discourses. To avoid this, in 21 of these 28 discourses, the second and third occurrences of the verb were replaced by synonyms or near-synonyms as in (8) above, where the

verbs *überreichen*, *bescheren* and *schenken* all describe an act of giving a present to someone.<sup>3</sup>

Finally, 42 distractor discourses were constructed. As with the experimental discourses, these consisted of a set of three sentences and mentioned multiple human referents, but varied as to whether or not they contained contrast relations, and as to whether or not the pronouns in sentence 2 or 3 resolved unambiguously on the basis of number and gender features.

Each discourse (experimental or distractor) was accompanied by a *who?*-question of the form in (12) *Who cut the potatoes?* In the experimental items the question was derived from sentence 3 in order to reveal the hearer’s interpretation of the pronoun. In distractors, the question addressed any of the three sentences.

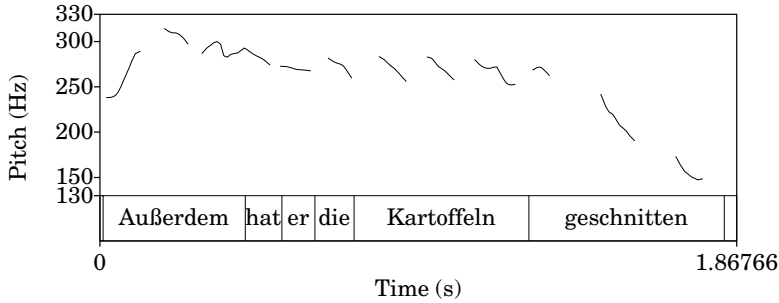
- (12) Wer hat die Kartoffeln geschnitten?  
*Who has the potatoes cut*

**Audio Materials:** All materials were recorded in an anechoic chamber. The sentences were read by one female speaker in randomised order (i.e. not in the context of the respective discourses), aiming at producing constant pitch range and intensity values. The third sentence of each experimental discourse was recorded in two versions corresponding to the two nuclear accent placements, cf. Figs. 1 and 2.

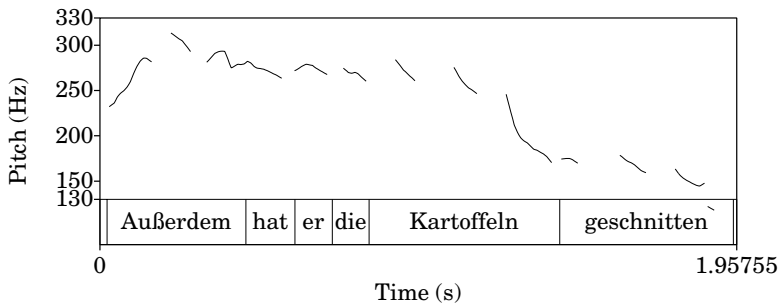
The sentences were resynthesised and the discourses put together using uniform pitch range and pause duration values following the methodology of Mayer et al. [30]. All signal processing was done using PRAAT [32].

Pitch range was defined as the range between the highest intonationally relevant high tone (HT) and the lowest relevant low tone (LT) within one phrase (sentence). Relevant tones were labeled manually in the original recordings and corresponded usually to high or low tonal targets of pitch accents. For pitch range manipulations, 3 different ranges were defined: normal, compressed and expanded. We determined the normal pitch range of the female speaker as ranging from 150 Hz (baseline) to 270 Hz (topline). Using standard expansion and compression ratios, the expanded pitch range of the speaker was set to 150 Hz baseline and 310 Hz topline and the compressed range to 140 Hz baseline and 250 Hz topline. The first and the second sentence of each discourse were assigned an expanded and a normal range, respectively. Each accentual realization of sentence 3 of the experimental discourses (cf. Figs. 1 and 2) was resynthesised in two versions: once with a compressed pitch range corresponding to the continuity condition and once with an expanded pitch range for the discourse pop condition. Third sentences of distractor discourses were assigned one of the pitch range values (expanded or compressed) on a random basis. Based on the original

<sup>3</sup> Either all the three verbs in a discourse were the same like in (10) or all three were distinct synonyms like in (8). Our intuition was that if the verb of the target sentence were synonymous with the verb of one of the context sentences, but literally repeated that of the other, this could have created a bias for attachment to the sentence that contained the literal repetition.



**Fig. 1.** Pitch track for (4). The falling nuclear accent occurs on *geschnitten* ‘cut’.

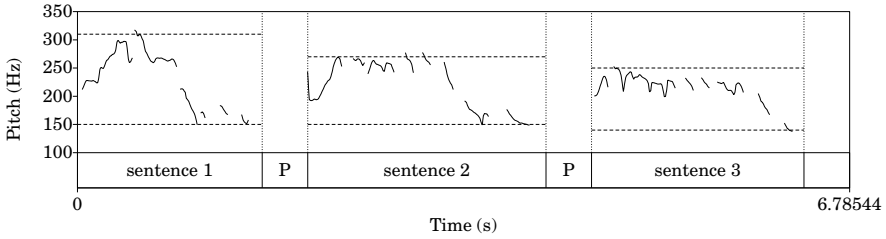


**Fig. 2.** Pitch track for (5c). The falling nuclear accent occurs on *Kartoffeln* ‘potatoes’.

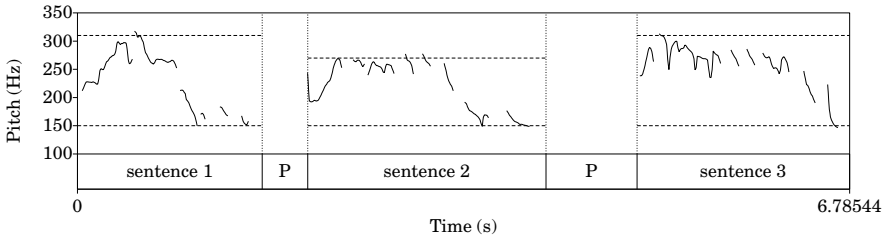
HT and LT and the target range values, the pitch contour of each sentence was shifted so that the LT was set to the target baseline and multiplied so that the HT reached the target topline.

The original discourses were re-created by concatenating the resynthesised sentences with intervening pauses (intervals of zero amplitude). The standard pause length was set to 400 ms. However, in the discourse pop condition an extra long pause of 800 ms was inserted before the last sentence. Figures 3 and 4 show the resynthesised and the reconcatenated realizations of (2) in the continuity and the discourse pop conditions, respectively (the accentual realization of sentence 3 is as in (4), cf. Fig. 1). The horizontal dashed lines indicate the top- and the baselines of the resynthesised sentences. Notice that in the continuity condition (Fig. 3) the pitch range “declines” from the beginning towards the end of the discourse, whereas in the discourse pop condition (Fig. 4) a pitch reset occurs in sentence 3.

In sum, each discourse appeared in four versions corresponding to the four experimental conditions resulting from a 2 by 2 design with accent placement and global prosody (GP) as factors: (1) accent placement in sentence 3 as contrasted with sentence 1 vs. sentence 2; and (2) pitch range of sentence 3 and pause duration before sentence 3 signaling discourse pop vs. discourse continuity.



**Fig. 3.** Prosodic realization of (2) in the continuity condition: the pause between sentence 2 and 3 has standard length (400 ms); sentence 3 has a compressed pitch range



**Fig. 4.** Prosodic realization of (2) in the discourse pop condition: the pause between sentence 2 and 3 is long (800 ms); sentence 3 has an expanded pitch range

The final questions were spoken by a male speaker and were appended to the sequences after a silent interval of 1500 ms with the original unmanipulated question intonation.

**Procedure:** The experimental items were divided into four counterbalanced lists that contained only one version of each item, and mixed with the distractor items. The items were presented in a randomised order. After listening to each item only once, the participants had to answer the questions orally; no choice lists of possible answers were provided. The responses were recorded and classified as indicating resolution to the referent introduced in the first sentence (R1) or the second sentence (R2) or as “incorrect resolution”. The response was classified as incorrect if it showed resolution to a referent other than R1 or R2, or if the subject refused to give a definite answer (e.g. by saying *I don’t know*).

### 3.2 Subjects

53 subjects took part in the experiment, all of whom were undergraduate students of linguistics and native speakers of German, and were either paid or received credit for participation. The data of 13 subjects were excluded from the analysis since they failed to give an answer or gave an absurd answer to the test question three or more times. The data of the remaining 40 participants (10 per list) were subjected to statistical analysis.