02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Julia B Hirschberg

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☒ U.S. Citizen ☐ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

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PI/PD Name: Ani Nenkova

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race: (Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status: (Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☐ Permanent Resident ☒ Other non-U.S. Citizen

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Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:
Not Listed

REVIEWERS NOT TO INCLUDE:
Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 04-23

NSF 06-572 **11/02/06**

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376000511

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IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Columbia University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0027078000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

2960 Broadway
NEW YORK, NY 10027-6902

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
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☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

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TITLE OF PROPOSED PROJECT **RI: Collaborative Research: Speaking More Like You: Lexical, Acoustic/Prosodic, and Discourse Entrainment for Spoken Dialogue Systems**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **488,198**	**36** months	**06/01/07**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

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☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.5) IACUC App. Date _____
☒ HUMAN SUBJECTS (GPG II.D.6)
Exemption Subsection _____ or IRB App. Date **03/01/04**
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)
_____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
computer science

PI/PD POSTAL ADDRESS

New York, NY 10027
United States

PI/PD FAX NUMBER
212-666-0140

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Julia B Hirschberg**	**PhD**	**1985**	**212-939-7114**	**julia@cs.columbia.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Appendix D of the Grant Proposal Guide.

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ''Disclosure of Lobbying Activities,'' in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Beth H Israel**		**05/03/05**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
212-854-6851	**bhi1@columbia.edu**	**212-854-2738**

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COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 04-23

NSF 06-572 **11/02/06**

FOR NSF USE ONLY

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954558914

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☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

University of Pennsylvania

AWARDEE ORGANIZATION CODE (IF KNOWN)

0033787000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

University of Pennsylvania
Research Services
Philadelphia, PA. 191046205

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS

☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **RI:Collaborative Research: Speaking More Like You: Lexical, Acoustic/Prosodic, and Discourse Entrainment for Spoken Dialogue Systems**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ **325,000**	**36** months	**09/01/07**	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.A)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
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☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)

PI/PD DEPARTMENT
Computer and Information Science

PI/PD FAX NUMBER
215-573-7759

PI/PD POSTAL ADDRESS
Research Services
3451 Walnut St, P221 Franklin
Philadelphia, PA 191046205
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Ani Nenkova**	**PhD**	**2006**	**215-898-7293**	**anenkova@stanford.edu**
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

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By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

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NAME		

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RI: Collaborative Research: Speaking More Like You: Lexical, Acoustic/Prosodic, and Discourse Entrainment for Spoken Dialogue Systems

When people speak with others, they often ENTRAIN to their conversational partner, adopting the partner's word choice or changing their speaking rate to match the partner's more closely. While much is known about LEXICAL ENTRAINMENT, other aspects of entrainment have received less attention. Intonational contour, pitch accent, phrasing rate, pitch range, loudness, production of laughter, turn-taking and backchanneling behaviors, ways of signaling discourse structure or hedging one's statements are all areas in which entrainment may occur in dialogue, but they have been little studied in this regard. Even forms of entrainment that **have** been identified have not yet influenced response generation in Spoken Dialogue Systems. While proposals have been made that systems could improve speech recognition accuracy by taking advantage of users' preference for re-using words from system prompts in their responses, no system today entrains to its **users'** speech. We will investigate lexical, acoustic/prosodic, and discourse-level entrainment in two large corpora of spontaneous dialogues. We will examine **how** such entrainment occurs as well as **which features** are entrained. We will evaluate the results of our analyses in perception experiments and in a response generation system for a Spoken Dialogue System.

Intellectual Merit: To our knowledge, our research represents the first corpus-based study of speaker entrainment to conversational partners in lexical, acoustic/prosodic, and discourse-level features. The entrainment models we develop and test will make it possible for SDS to entrain to users, as opposed to users to SDS. Our perception studies will inform research on dialogue systems as to which types of speaker entrainment are most important to model and how they can be realized to promote dialogue naturalness, efficiency, and efficacy. Our findings will also impact research on Natural Language Generation by identifying additional conversational-partner dependent constraints on the choice of lexical items and their spoken realization.

Researchers' Qualifications: The PIs are well qualified for this research: PI Hirschberg has over 20 years of experience studying the acoustic/prosodic and discourse-level phenomena which we will now examine for speaker entrainment in dialogue. She also has conducted extensive research on Spoken Dialogue Systems. PI Nenkova has recently completed her dissertation on the generation of referring expressions in summarization. She has conducted postdoctoral researchon prosodic variation in dialogue on the Switchboard Corpus at Stanford. Both PIs have extensive experience designing and conducting perception and production studies on text and speech and evaluating their results; e.g., PI Nenkova is an inventor of the PYRAMID method of summarization evaluation.

Broader Impact: While the study of entrainment is important to our understanding of human communicative behavior, it is also of major practical importance to the future of Spoken Dialogue Systems. Our research will support an important new dimension in dialogue systems, the notion that systems should adapt their behavior to users, rather than vice versa. Given that intelligent systems are becoming more and more popular in daily life and activities, such a capability is important for improving the human-machine experience for average users as well as for users who differ significantly from the majority population in terms of cultural or language background or age. Also, as a by-product of our research, we will make two richly annotated corpora available to the Natural Language Processing (NLP) and speech communities to allow others to participate in future research on spoken dialogue. Our results will be disseminated through papers presented at speech and NLP conferences.

Broadening Participation: The PIs are committed to broadening the participation of under-represented groups in Computer Science and will use this research collaboration to that end. Women and minority students at both institutions — at the undergraduate, master's and PhD levels — will be recruited to participate in this research. PI Hirschberg has mentored women undergraduate interns at Bell Labs and AT&T Labs, three of whom have received CS PhDs, and regularly includes women MS and undergraduates in research projects, including an REU student in 2006. She serves on three university committees for recruitment/retention of a more diverse faculty and advises two women's student organizations and Barnard CS majors. PI Nenkova was president of WICS 2002–05 and the founder of WICSE, an organization of women engineering students at Columbia, receiving a departmental award for extraordinary service in 2005.

Key Words: entrainment; prosody; Spoken Dialogue Systems; Natural Language Generation.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

	Total No. of Pages	Page No.* (Optional)*
Cover Sheet for Proposal to the National Science Foundation		
Project Summary (not to exceed 1 page)		
Table of Contents	1	
Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) **(Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**	0	
References Cited		
Biographical Sketches (Not to exceed 2 pages each)	2	
Budget (Plus up to 3 pages of budget justification)	5	
Current and Pending Support	1	
Facilities, Equipment and Other Resources	1	
Special Information/Supplementary Documentation	0	
Appendix (List below.) **(Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)**		
Appendix Items:		

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

D.1 Introduction

When people engage in conversation, they adapt the way they speak to the speaking style of their conversational partner. For example, they may alter their SPEAKING RATE to speak faster, if the person they are speaking with speaks faster than they do. Or they may adopt a certain way of describing something based upon the way their conversational partner describes it, negotiating a common description, particularly for items that may be unfamiliar to them. For example one speaker might describe a picture of a weaving loom as "*the thing that looks like a harpsichord*," and the other might refer to this object later as "*the harpsichord-looking thing*." This phenomenon is known in the literature as ENTRAINMENT, ACCOMMODATION, ADAPTATION, or ALIGNMENT. We will refer to it below as ENTRAINMENT for simplicity's sake.

While there is considerable experimental evidence for LEXICAL ENTRAINMENT and some evidence of adaptation of speaking rate in natural speech, much less is known about other types of speech entrainment and little corpus-based work has been done. We propose a systematic examination of lexical, acoustic/prosodic and discourse-level entrainment in two corpora of spontaneous speech. Our goal is to identify evidence of which ***types*** of entrainment occur in spontaneous dialogue, to determine ***how*** they occur, and to evaluate whether these entrainment phenomena ***should*** and ***can*** be incorporated successfully into Spoken Dialogue Systems (SDS) to improve their naturalness and usefulness.

In this study, we will examine how people adapt to their conversational partners in acoustic/prosodic and discourse dimensions, as well as in their lexical and syntactic decisions. We will examine speakers' lexical content and spoken realization of referring expressions; their pitch, amplitude and timing variation; their choice of intonational contours, pitch accents and phrasing decisions; their turn-taking behaviors; the way they mark topic shift; the way statements are 'hedged'; and their use of laughter and audible sighs. Our study will be based on two corpora: the Columbia Games Corpus, a large corpus of spontaneous dialogues produced by subjects playing a collaborative computer game, which has been annotated for a range of acoustic, prosodic and discourse features; and a subset of the Switchboard Corpus, which also has been annotated for some of the same phenomena.

While there have been many studies of entrainment in human-human dialogue and some studies of user entrainment to systems in SDS, we still know little about how important this entrainment is to human-human or to human-machine dialogue, particularly non-lexical entrainment. So we will test our corpus-based findings with a set of perception and production studies designed to determine: 1) Which types of entrainment do indeed make a difference in SDS in perceived naturalness and in measures of dialogue efficiency and success? 2) Can current SDS technologies support the types of entrainment our studies find to be effective in these regards? To date, SDS researchers and developers have seen evidence of speaker entrainment primarily as means to influence ***users*** to adopt particular speaking styles and vocabulary, so that recognition systems might be able to recognize user input more accurately. However, little attention has been paid to how or whether ***systems*** should entrain to their users in SDS. We believe that systems themselves will be more successful conversational partners for a wider population of potential users if, like humans, they attempt to entrain to users communicative styles.

Below we describe previous work on entrainment (Section D.2). We then describe the corpora we will analyze (Section D.3) to discover evidence for different types of entrainment and how they are realized in spontaneous dialogue. Our research plan is outlined in D.5 and our evaluation plan in Section D.6. We relate the proposed research to our previous NSF-funded

work in Section D.7. In Section D.8 we explain the scientific contribution of our work and discuss the implications of the study in a broader social context. In Section D.9 we describe our plans for coordinating this collaborative study between Columbia University and the University of Pennsylvania.

D.2 Previous Studies

Studies of entrainment in human-human and human-machine dialogue have largely taken place in the laboratory and have generally focused on lexical entrainment. However, some studies have confirmed these findings in analyses of speech corpora and a few studies in both laboratory and non-laboratory settings have explored the way speakers adapt to their conversational partner's syntax, rhythm and speaking rate, loudness, pitch range, voice quality and general style. We briefly survey this literature, as well as some literature in Natural Language Generation which is pertinent to our study of how lexical entrainment might influence response generation in SDS.

D.2.1 Lexical Entrainment Influential work by a number of psychologists [38, 25, 16, 11, 13, 12, 44] convincingly demonstrates the existence of lexical entrainment as speakers negotiate how to refer to items in discourse. Brennan and Clark [13] term the result of this negotiation the CONCEPTUAL PACT and explore its characteristics in numerous experiments. In particular, they find that speakers often continue to use longer descriptions for discourse entities in subsequent mentions than would be necessary in order to uniquely identify the referent (e.g. they might continue to refer to a car as "*the funny yellow car*," even when no other cars are in view) when they have already agreed upon such a pact. They do find that speakers sometimes abandon such pacts and propose potential reasons for this. In further work, Metzing and Brennan [44] showed that deliberately violating conceptual pacts could cause partners difficulty in locating the intended discourse entities. And Brennan [12] also reports on experiments demonstrating that speakers will adopt the terminology of partners thought to be computer systems just as readily as with partners known to be human. Fais and Loken-Kim [24], however, found that lexical accommodation varies by interaction modality, when subjects spoke over a phone or interacted through a multimodal interface. In actual human-computer interactions, Gustafson et al. [29] confirmed that users tended to adapt to the terminology of system responses in general, using verbs in system prompts more frequently, for example, than other synonyms. Levelt and Kelter [41] discovered priming effects for syntactic constructions as well as lexical items in laboratory experiments and similar findings are reported by Reitter et al. [51] in corpus-based work.

Such findings have motivated attempts to improve speech recognition accuracy in SDS by designing system prompts which will prime user responses using words can be recognized more accurately or simply conditioning the language model on the lexical items in system prompts [29, 55, 59]. However, there have been remarkably few (e.g. [47, 48]) proposals that systems should instead entrain to their users, despite evidence that the ability to adapt may be critical for successful dialogue; for example, experts have been shown to adopt a user's incorrect terminology in a computer repair exchange, in order to facilitate understanding [48].

D.2.2 Acoustic and Prosodic Entrainment Acoustic/prosodic entrainment has to date produced fewer clear findings. The most convincing of these have involved entrainment of speaking rate. While some research on rate adaptation has focused on speakers' ability to ***track*** another speaker's rhythm when instructed to in speech cycling and synchronous speech experiments [18, 19], studies more relevant to natural dialogue have shown that speakers ***do*** adapt to

the speaking rate of others, whether the partner is an artificial voice or another human adult or a child [54, 28, 6]. Sherblom and La Riviere [54] also found evidence for entrainment of utterance length and vocal jitter, while Coulston [17] found that children adapted their amplitude to synthetic speech from an animated character. Other studies of bearing upon possible acoustic and prosodic entrainment have documented 5-year-olds using a different pitch range when talking to 3-year-olds [53] and other children adapting their response latencies to those of an animated agent partner [22]. However, there is no large body of objective or experimental evidence for entrainment for most acoustic and prosodic features in natural speech, despite the fact that entrainment in features such as rate and amplitude could prove to be as useful as lexical entrainment from the system perspective in SDS systems: systems could modify their own system's rate, for example, to encourage speakers to produce more easily recognized speech [34].

D.2.3 Discourse Level Entrainment More general studies of entrainment in multiple dimensions and in discourse-level behavior have been primarily descriptive in nature, including Azuma's [2] account of Emperor Hirohito of Japan adapting his 'speech patterns' to those of country people in lower social status when he visited the countryside after World War II, and a longitudinal study by Roth [52] of two CO-TEACHERS which found that one of the teaching partners adopted catch phrases from the other and entrained to both the other teacher's and the students' pitch and amplitude when speaking with them. More usefully for SDS, perhaps, Breazeal [9] reports that in human-robot interactions people entrain to "the tempo of [the robot's] vocal turn-taking utterances" so that the number of interruptions and awkward pauses diminish over time. When the robot is communicating affective intent, there is evidence of entrainment by subjects in body posture, head tilt and facial expression as well.

D.2.4 Entrainment and NL Generation Research on Natural Language Generation for SDS has lagged far behind research in recognition and understanding for such systems, although the generation of referring expressions (GRE) has been a topic of significant interest for other generation and summarization research. The basic parameters of the GRE task are clear: how can we describe a discourse entity so that the listener can identify it, among other distractor entities, without including unnecessary information that would slow down communication? Current GRE algorithms are deterministic in nature [20, 21, 40, 56], while the entrainment literature cited above (Section D.2.1) suggests that the proper form of reference to an entity is likely to be ***negotiated*** between the conversational partners. Moreover, algorithms for GRE have focused on the production of initial references to a discourse entity only but SDS must generate appropriate subsequent references as well.

Recently, Viethen and Dale [61] have compared the productions of several existing algorithms for GRE with actual human productions, finding numerous mismatches between the two. Human subjects included more information than was necessary to uniquely disambiguate the referent (confirming [14]). Indeed, subjects often produced different descriptions of the same object at different times, which current deterministic algorithms cannot do. None of the GRE algorithms could generate any of the relational descriptions produced by people; compare one GRE algorithm's "*the drawer above the drawer above the drawer above the pink drawer*" with a human's "*the orange drawer above the blue drawer*." However, some proposals have been made that GRE research should be influenced by findings on lexical entrainment [37, 31, 23], although these studies have focused on the representations that would be needed to support entrainment-influenced GRE algorithms. Generally, the lack of suitable corpora has so far prevented the generation community from refining their models. And since most

generation research is done on text, few spoken language corpora have been examined with respect to spoken GRE. In Section D.3 we describe several such corpora which might be used for this purpose.

D.3 The Games Corpus

The Columbia Games Corpus is a collection of 12 spontaneous task-oriented dyadic conversations elicited from native speakers of Standard American English (SAE) for a study of the intonational realization of GIVEN (old, previously-mentioned) vs. NEW information [49]. Thirteen subjects (six female, seven male) participated in the study in October 2004. Eleven of the subjects participated in two sessions on different days, each time with a different partner.

D.3.1 Design of the Corpus Subjects were paid to play a series of computer games requiring verbal communication between partners to achieve a joint goal of identifying and moving images on the screen. Participants sat facing each other in a soundproof booth with a curtain hanging between them, so that all communication would be by voice. Each subject was recorded on a separate channel to a DAT recorder using a Crown head-mounted close-talking microphone. All games were played on separate laptops whose screens were not visible to the other player. All keystrokes were captured and have been synchronized with the speech recordings and with the items appearing on the screen at the time.

The games involved tasks of increasing complexity in terms of the coordination necessary between the partners. For each game, a different set of objects appeared on each player's screen; successful completion of the game required players to describe and discuss the objects; they received points for each successfully completed subtask. In some games (CARDS), players saw cards with one to three objects on them; the objects were chosen so that at least one possible description was largely sonorant (e.g. *loom, M&M, mailman*), for ease of subsequent intonational analysis. Objects were of two sizes (small or large) and various colors. In other games (OBJECTS), only the objects themselves appeared on the screen. In each session, subjects were asked to play three versions of two different Cards Games and three versions of an Objects Game; these are described below. The order in which objects appeared on the screen was manipulated so that the same object reappeared at different intervals during the game, and the number of GIVEN objects on the screen at any time was varied systematically. Subjects were told that their goal was to accumulate as many points over the entire session as possible, since they would be paid additional money for each point they earned. Subjects spoke with one another quite spontaneously throughout the tasks. Sample screens for the various game types are shown in Figure D.1

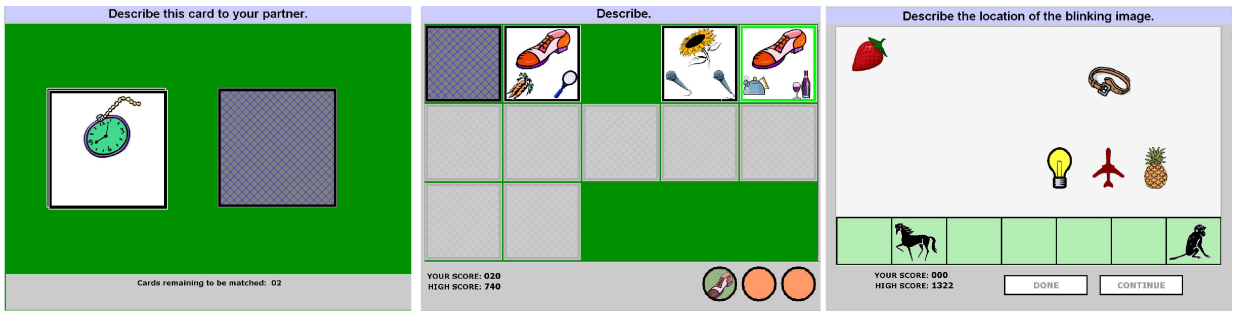

Figure D.1: Sample Screens from the Columbia Games Corpus.

In the first type of Cards game, each player's screen displayed a pile of 9 to 12 cards. Player 1 was asked to describe the top card on her pile, while Player 2 was asked to search through ***his*** pile to find the same card, clicking a button to indicate success. This process was repeated until all cards in Player 1's deck were matched. In the second type of Cards game, each player saw a board of 15 cards on the screen, all initially face down. As the game began, the first card on one player's (the DESCRIBER's) board was automatically turned face up. The Describer was told to describe this card to the other player (the SEARCHER), who was to find a similar card from the cards on his board. If the Searcher could find a card depicting one or more of the objects described by the Describer, the players could decide whether to declare a match and thus receive points proportional to the numbers of objects matched on the cards. At most three cards were visible to each player at any time, with earlier cards being automatically turned face down. Players switched roles after each card was described and the process continued until all cards had been described. Subjects were given additional opportunities to earn points, based on other characteristics of the matched cards, to make the game more interesting and to encourage discussion.

In the final game type (Objects games), each player's laptop displayed a gameboard with 5-7 objects. Both players saw the same set of objects at the same position on the screen, except for one (the TARGET). For the DESCRIBER, the target appeared in a random location among other objects on the screen. For the FOLLOWER, the target appeared at the bottom of the screen. The Describer was instructed to describe the position of the target on her screen so that the Follower could move his representation to the same location on his own. After players negotiated their best location match, they were awarded 1-100 points based on how well the Follower's target location matched the Describer's. The game proceeded through 14 tasks, with Describer and Follower alternating roles with each new task.

D.3.2 Annotation Twelve sessions, totalling 9h 8m of dialogue were recorded, of which 1h 14m correspond to the first type of Cards game, 3h 35m to the second, and 4h 19m to the Objects game. On average, the first Cards game took 2m 3s, the second, 5m 58s, and the Objects game, 7m 12s, averaging 45m 39s of dialogue per session. Each session was downsampled to 16K. All files in the corpus were orthographically transcribed and words were aligned by hand by trained annotators in a ToBI [57, 4, 39] orthographic tier using Praat [8] to manipulate waveforms. Certain non-word vocalizations, including laughs, coughs and breaths, were marked in a ToBI miscellaneous tier, together with speech disfluencies and self repairs. The corpus contains 2241 unique words, with 73,844 words in total. It is currently being intonationally transcribed using the ToBI conventions; 6h 2m of speakers from the Objects games has been annotated to date. Pitch, energy and duration information has been extracted for the entire corpus automatically, using Praat.

The corpus is also being labeled for additional phenomena, including CUE (discourse) and NON-CUE (literal) use of some DISCOURSE MARKERS, TURN-TAKING behavior, and the form and function of all questions. All lexical items potentially indicating agreement, (e.g. *alright, gotcha, huh, mm-hm, okay, right, uh-huh, yeah, yep, yes, yup*) have been labeled by three annotators, who separately determined whether each item was used to indicate acknowledgment/agreement, to mark the beginning or ending of a discourse segment, to indicate both acknowledgement/agreement and discourse segmentation, to backchannel, to stall in order to keep the floor, to check the interlocutor's state, to signal the completion of a task, or as a literal modifier.

Turn exchanges in the Objects games have been manually classified into seven categories,

following [3]. These were: SMOOTH SWITCHES, OVERLAPS, BUTTING-INS, INTERRUPTIONS with and without overlap, and BACKCHANNELS with and without overlap. There are approximately 2100 speaker turns in the Objects games and 1700 in the Cards games. All manuals for these annotations are available at `http://www.cs.columbia.edu/~agus/games-project/`.

D.3.2.1 The Switchboard Corpus

While we will develop our models of entrainment from our analyses of the Games Corpus, we will test our models on another corpus, to see if our findings generalize beyond task-based dialogues. For this purpose we will examine the Switchboard corpus [26], a collection of recordings of telephone conversations on a set of pre-assigned topics, such as favorite types of music or the new roles of women in society. The corpus as a whole has been orthographically transcribed, and a subset of 12 conversations (14,555 words) has been richly annotated with linguistic information such as pitch prominence, dialog acts (e.g. hedge, question, agreement, statement), the given/new status of referents, and ANIMACY [15, 45].

D.4 Pilot Studies

In the corpora described above (Section D.3), we have found evidence of entrainment of various types. Below we present some examples which illustrate several types of entrainment in the Games and Switchboard corpora and which motivate our future research.

D.4.1 Lexical Entrainment The Games Corpus is rich in examples of lexical entrainment, which occurs particularly when subjects described ambiguous pictures. For example, a picture of a loom came to be identified in one conversation as *the harpsichord*; in others, a lily eventually became *the orchid* and a Menorah was identifed as *the Jewish candelabra*). Also, when a picture included multiple features, e.g. *a large blue rhinoceros*, where one of more features might turn out to be salient in future contexts, we find many negotiations of conceptual pacts. The fact that most speakers played with two different partners in different sessions but viewing the same objects is especially useful for our study, since it will allow us to compare different entrainment opportunities for all such subjects. For example, in the first session for Subjects S11 and S10, S11 introduces the term *extraterrestrial* to refer to a picture most other users labeled *the alien*, and S10 accepts and re-uses this description:

S11: *okay in the middle of the card I have an **extraterrestrial** figure*
...
S11: *okay middle of the card I have the **extraterrestrial***

A few minutes later, they both confirm this conceptual pact:

S10: *I've got the blue lion with the **extraterrestrial** on the lower right*
S11: *okay I have the **extraterrestrial** now and then I have the eye at the bottom right corner*
S10: *my **extraterrestrial**'s gone*

In later sessions with other partners, both S10 and S11 introduce the same term again for the same picture. However, in each case their new partners reject this term for the more common description *the alien*. Interestingly, both S10 and S11 immediately agree to this new description and use it during the remainder of the session, e.g.

S03: *okay I have a blue lion and then the **extraterrestrial** at the lower right corner*
S11: *mm # I'll pass # I have the **alien** with an eye in the lower right corner*
S03: *um # I have # just the **alien** so I guess I'll match that*

and

S10: *yes now I've got that **extraterrestrial** with the yellow lion and the money*

...
S12: *now I have the blue lion in the center with our little **alien** buddy in the right hand corner*
S10: *with the **alien** buddy so I'm gonna match him with the single blue lion # okay # I've got our **alien** with the eye in the corner*

We also find in the Switchboard Corpus that the negotiation of a conceptual pact appears to have interesting acoustic and prosodic correlates; such features have, to our knowledge, not been studied before. For example, in the following conversation on the changing role of women in modern society, Speaker A compares the raising of children at home by the mother to the alternative of organized paid child care. Throughout the segment below, the speakers introduce multiple 'negotiable' referring expressions with some amount of disfluency (in the example, filled pauses are orthographically noted, '.' indicates that the previous word is accented, and ':' indicates that the previous word has NUCLEAR STRESS, i.e., is the most prominent accent in its intonational phrase.)

A_1: *And I also. wonder. about the children: that are being. brought up: in: the uh uh day: care centers:.*
A_2: *I guess: we'll have to see: another generation: to see. what differences. a child. being brought: up you: know in a kind. of a: uh community: rather. than a home:.*
B_3: *I have. not. to be honest: had. much experience: with children: in that situation:.*
B_4: *I guess: my experience: is is just: with what we: did and: and so they didn't: really go through the child: care route*
B_5: *I don't: know. whether: there will be: an increased: amount. of of surrogacy: that we see: I just. don't know:*
A_6: *What. do you mean:?*
B_7: *Uh: deliberate. childbirth: by surrogate. mother:*
A_8: *Oh: yeah:*
B_9: *Sort of rent-a-mom. to be: you: know*
B_{10}: *There might: be a kind. of a deliberate: uh uh. a professional: mother: a- person:*
A_{11}: *A nanny: sort: of*
B_{12}: *(I can en)Vision: more women deliberately: raising children: either. in surrogacy: or: or. as a professional nanny: nanny. as you: put it uh:*
B_{13}: *Maybe. we'll. see a growth. in that: where someone. makes. a career: out of say: taking. care of five. or six. children: as opposed to day care:*
B_{14}: *It would be. a sort of day: care but it would be more. of a family setting:*
A_{15}: *And then you might. have more. control: over uh the the morals: that they would be. taught: rather than: in like a classroom. or a day. care center:*
A_{16}: *I know the day. care centers. are not. cheap: either:*

In A_1, speaker A appears uncertain about how to describe the alternative to raising children at home: his first mention of *day care centers* is preceded by two filled pauses. The hesitation is also marked by increased prominence of the preposition *in*, which, were this production fluent, would be unlikely to have been accented. In the following utterance, A_2, we see that speaker A has still not determined how best to refer to the concept of child-raising outside the home and suggests another possible reference, "*a child. being brought: up you: know in a kind of a: uh community*." Again, the whole expression is marked by hesitations and unusual prominence assignment; a filled pause precedes the final noun. Speaker B at first seems no clearer on how to describe this concept, explicitly noting that he has little experience "*with children in that situation*" (B_3). In B_4 he proposes *child care* and in B_{13} *day care* as alternatives. In

A_{15}, A accepts the latter term, and now there is no disfluency or hesitation.

A similar reference negotiation process happens in the same conversation with the discussion of surrogate mothers. The first mention of the concept is in B_5, where speaker B is disfluent before introducing the term (repeating *of*) Speaker A explicitly questions the meaning of this term in A_6. B's reply in B_7 is preceded by a filled pause and his additional clarifications in B_9 and B_{10}, and B_{12} are marked by hesitations, hedges (*sort of*), filled pauses and other fillers (*you know*, fragments and repetitions, as is speaker A's suggestion of another term — "*a nanny: sort: of*" in A_{11}. In B_{12} speaker B accepts the final suggestion, explicitly acknowledging that he is accepting the conceptual pact.

We will further study the possible relationship between incomplete conceptual pacts and disfluencies and hesitation in dialogue. The possibility of direct relationship between the two has significant bearing on SDS development: if systems are not able to entrain to the user's terminology, users might themselves become more disfluent in subsequent utterances, making them harder for the system to understand. In Section D.5 we will describe in more detail how we will analyze lexical entrainment in our corpora.

D.4.2 Acoustic and Prosodic Entrainment We also noticed in the Games Corpus that some subjects do appear to adapt their speaking style to that of their interlocutor's in terms of their speaking rate, their choice of intonational contour and their mean and maximum pitch. Some initial analyses of rate and pitch, comparing subject productions with each of the two conversational partners they spoke with, gives preliminary indications that a given subject's productions vary in our data to approach those of the partner. Figure D.2 shows the mean speaking rate of each subject in their two sessions (connected with solid lines) compared to the mean rate of each of the subject's two partners (connected with dashed lines).

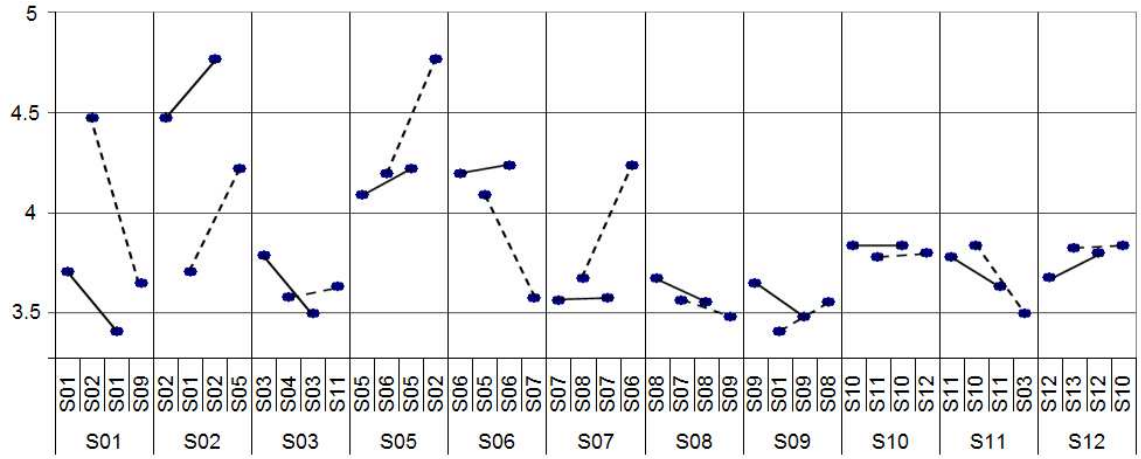

Figure D.2: Mean Speaking Rate (in words/sec) by Speaker Compared to Partners

While mean speaking rate across an entire session is a crude measure of potential entrainment to rate, Figure D.2 ***does*** show some promising evidence of this, insofar as half of our speakers show some evidence of rate entrainment: When subjects converse with speakers with a faster rate, their own rate is faster than when they converse with speakers with a slower rate. For example, when S01 speaks with S02, his rate is faster than when he speaks with S09. S02, S05, S08, S10 and S11 exhibit this pattern, while S03's rate appears already very close to both of his partners, and S07 and S12 are more difficult to analyze at this level. Only two sub-

jects, S06 and S09 exhibit the opposite tendency, increasing their speaking rate with a slower speaking partner.

It is more difficult to examine pitch in this simple manner because mean pitch varies with gender. However, we see less evidence of entrainment in this feature than we do in speaking rate, if we examine only those subjects whose partners were only male or only female. Only 2 of the five with matched partners raised and lowered their own overall pitch when speaking with partners with a higher or lower mean. And only one of these was among those subjects who adapted to the partners' speaking rate. For maximum pitch over the session, only one speaker appeared to have been influenced by their conversational partner. However, interestingly, that speaker shows evidence of entrainment to her partners in both speaking rate and mean pitch.

Clearly, entrainment is not best measured in terms of simple measures over long stretches of conversation. It seems likely that acoustic and prosodic adaptation, like lexical entrainment, is a more local or perhaps a cumulative phenomenon. However, these simple analyses do suggest that some amount of measurable acoustic/prosodic entrainment occurs in the Games corpus and that their may be interesting individual differences not previously examined in the entrainment literature. Only one of our speakers adapted to her partners in all three of the dimensions examined here, at least by our initial metrics. A fuller study of these and other potential entrainment phenomena will be necessary to test whether speakers entrain to others differently — some in one dimension and some in another — or whether some forms of entrainment are more prevalent than others.

D.5 Research Plan

In Section D.4 we described some preliminary investigations on potential areas of entrainment in the Columbia Games Corpus and the Switchboard Corpus. We have found indications that there is lexical entrainment in both corpora and also acoustic/prosodic entrainment in the Columbia Games Corpus, as discussed in Section D.4. We have also seen indications in both corpora that lexical entrainment is accompanied by a number of different disfluency and hedging behaviors, as speakers negotiate a conceptual pact among themselves. In this section we outline our plans to study these phenomena in both corpora. Our proposed research focuses on entrainment in the lexical, acoustic, prosodic and discourse domains, to pursue the questions raised in Section D.4. In Section D.6 we detail our planned approach to building, refining and testing models for the entrainment types we describe below.

D.5.1 Lexical Entrainment: Referring Expressions and Prominence As noted in Section D.2, the presence of lexical entrainment in human-human communication has been well documented in the psycholinguistic literature, but current algorithms for the generation of referring expressions (GRE) do not even attempt to incorporate a model of entrainment into the generation process. In fact, little work has been done on the generation of subsequent mentions at all. The proposed work will lead to a computational model of lexical entrainment that we plan to incorporate into an improved GRE algorithm, leading to better automatic generation of text.

Recent studies have shown that GRE algorithms are not able to mimic human productions [61]. However, suggestions for the improvement of such algorithms have primarily been based on preplanned text, rather than spoken dialogue. For example, Krahmer and Theune [40] found in preference experiments that subjects reading pairs of sentences preferred the omission of previously mentioned properties when a discourse entity was mentioned in both sentences; they also preferred that a uniquely identifiable entity be mentioned using a pronoun, rather than a full noun phrase. Krahmer and Theune conclude that referring ex-

pressions are tentative; once they have been established, only the core part of the description should be used. However, as noted in Section D.2, [13] found that, in conversational data, speakers often continue to use longer descriptions for discourse entities than would be necessary to uniquely identify the referent. This finding would suggest a different approach then for the generation of referring expressions in dialogue.

Moreover, traditional generation algorithms (most notably Dale and Reiter's INCREMENTAL ALGORITHM) [21] claim that there is a preferred order in which people order mentioned properties (size-shape-color, e.g. "*the big round brown X*"). In Siddharthan and Copestake's [56] GRE algorithm, it is assumed that there is no fixed hierarchy of attribute types, but that speakers pick out attributes that are distinctive ***in context***. Neither approach allows for the influence of Brennan and Clark's [13] conceptual pacts.

Referring expressions in dialogue may also exhibit entrainment in their acoustic and prosodic realization. Typically in non-pronominal subsequent reference to discourse entities in monologue or dialogue, some or all of these previously uttered (given) elements within the NP will be made less prominent, or DEACCENTED. Predicting which items in the NP will be deaccented has long been the subject of study, particularly for text-to-speech systems [36, 46, 10]. However, the possibility that in dialogue such speaker decisions might themselves be influenced by the productions of the conversational partner has not yet been examined.

Our proposed research on lexical entrainment will address the deficiencies of current generation algorithms in both the lexical choices and acoustic/prosodic realization of referring expressions in dialogue. From a statistical analysis of speaker's generation of referring expressions in the Games and Switchboard corpora, we will develop a unified framework for reference generation including both first and subsequent mention in dialogue, based on an analysis of the orthographic, prosodic and given/new annotations we have for the Games and Switchboard corpora. In these corpora we will identify patterns of human behavior with respect to the form and content of subsequent mentions and compare patterns exhibited by each speaker with his conversational partner(s) to examine the extent to which lexical and acoustic/prosodic entrainment explains speakers' decisions on referring expression. For the Games corpus we also have information on the visual context in which discourse entities are discussed, so we can test how a model of mutual salience may explain collaborative decisions on referring expressions. Since all speakers saw the same set of objects, but some saw them in the same order and some in different orders, we should also be able to investigate how different referring expressions are used for the same entity, in different contexts and by different speakers, We will integrate this mutual salience model into procedures for automatic prosody prediction.

D.5.2 Acoustic/Prosodic Entrainment As noted in Section D.2, there is some evidence in the experimental and descriptive literature that speakers adapt to their conversational partners, changing their own acoustic/prosodic parameters, such as speaking rate, pitch range and intensity/loudness, to come closer to those of their conversational partners. However, to date there has been little corpus-based quantitative investigation of these phenomena in spontaneous human-human dialogues.

In Section D.4 we describe some simple experiments that show evidence of possible entrainment in speaking rate and pitch variation in the Games Corpus. We will pursue these investigations in detail and also study potential entrainment of simple binary prominence decisions (i.e. Do speakers tend to adapt to their partner's accent rate?), phrasing behavior, variation in pitch range, intensity/loudness, speaking rate and duration of pauses. We will

study these phenomena in both the Games and Switchboard corpora to determine which of these basic acoustic/prosodic parameters are subject to adaptation.

We will also investigate the adaptation that may occur in dialogue speakers' choice of tonal prosodic features such as choice of pitch contour, pitch accent and phrase endings in the Games Corpus; as noted in Section D.3, this corpus is currently being labeled in the ToBI scheme. Certain intonational contours are used to express particular pragmatic goals, but the same contour can have more than one pragmatic meaning [32]. There is also evidence that usage patterns for particular contours are speaker-dependent [33]. It is possible that speakers may adapt to other speakers' style of intonational variation in order to express similar pragmatic purposes, to communicate pragmatic information more successfully. Alternatively, intonational entrainment may arise as more of a priming effect, with speakers entraining upon their partner's propensity to employ one contour or another, or one type of pitch accent or phrasal ending, without regard to subtle pragmatic distinctions. We will be able to investigate this too in the Games Corpus, which is currently being labeled for the form and function of questions, to see whether questions with the same form and function are realized with different contours by different speakers and whether entrainment occurs in contour use over a conversation.

D.5.3 Discourse Structuring Entrainment Dialogue is rich in other phenomena for which entrainment to one's conversational partner may be investigated. In particular, explicit discourse markers such as cue phrases, backchannels and signals for turn-taking co-ordination are all important structuring devices which make spontaneous communication possible. For this reason it is important for successful communication that the speakers achieve a mutual agreement on the use of discourse structuring expressions. Turn-taking behavior, in particular, has been shown to be both speaker-dependent and dependent upon cultural background [58]. Beattie's [3] study of the turn-taking behaviors of Margaret Thatcher and James Callaghan, for example, demonstrates significant differences in propensity to interrupt and ability to hold the floor when another speaker barges in, which he attributes to differences in behaviors associated with yielding a turn. We will investigate whether speakers adapt to their partner's turn-taking and turn-yielding behaviors over the course of a dialogue session in the Games Corpus, which has been labeled for turn-taking behaviors using a Beattie-inspired model.

Similarly, we will address the use of cue phrases, backchannels and hedges, as well as the generation of laughter and audible breaths across speakers. Do speakers entrain to another speaker's propensity to use particular cue phrases over others, such as *okay* instead of *yeah* or *right*? Do they tend to adopt their partner's backchanneling style, either in choice of lexical item or in latency before backchanneling? Does one speaker adopt another's hedging behavior — become more or less cautious in assertions — when the latter's strategy differs from his or her own in terms of lexical choice or frequency of hedges? Does a speaker's use and style of laughter differ when conversing with different conversational partners? Does a speaker's use of audible breaths, e.g. as a turn-taking signal vary when interacting with different speakers? While a subset of cue phrases, all backchannels, laughter and audible breaths are already labeled for much of the Games Corpus, the study of hedging behavior will require additional annotation.

D.5.4 Entrainment and Spoken Dialogue Systems Our ultimate goal in examining entrainment in the Games and Switchboard corpora is to incorporate our findings into a fuller model of entrainment for SDSs. However, to determine whether the entrainment we find in natural dialogue *should* be incorporated into SDSs, we must first determine that this addition will

indeed improve the quality of SDS interactions. If so, we must then test the feasibility both of recognizing user behaviors for systems to entrain on and of producing system responses that are so entrained, given the state of current speech analysis, recognition and synthesis technology.

D.6 Testing and Evaluation

Because of the complexity of the entrainment phenomenon and the diversity of types of entrainment we are examining, we propose a suite of evaluation scenarios to help us classify the kinds of entrainment that can be detected in human interaction and their respective significance. Our corpus-based analyses described in Section D.5 will provide a set of parameters for which we have evidence of entrainment from human-human data. Three very important questions arise next:

1. **What makes a difference?** Of the entrainment types that we have identified in the corpus-based study, which ones actually contribute to improving dialogue naturalness and effectiveness? It is possible that humans entrain to other humans in ways that may not influence the efficacy or perceived quality of communication in measurable ways. We will use perception experiments to identify which types of entrainment lead to a perceived difference in dialogue 'success' in these areas.

2. **What is the best model?** We need a computational model for the entrainment types identified as important for dialogue quality. In order to find the best models and to compare their effectiveness with simpler baselines, we will test how well they fit held-out human-human dialogues. How do our models predict real human productions?

3. **Can the best models be integrated in current spoken dialogue systems?** Given the best models identified in the reproduction of human dialogue experiments, we next need to assess the feasibility of integrating these models into real SDSs. Some of the models may be too computationally intensive to be incorporated into real SDS. Others might demand access to information about human partners that is not reliably capturable using current speech analysis tools, or the ability to modify system outputs in ways that cannot be achieved effectively given current language generation technologies. This third round of experiments will establish how much of our findings ***can*** be incorporated into SDSs, given the current status of speech technology, and which models would pose challenges that would require future technological development.

D.6.1 Perception Study: Prerecorded Interaction In order to identify which types of entrainment correlate with improvement in dialogue quality, we will run perception studies in which subjects are asked to rate the naturalness of a set of simulated conversations between a human speaker and a dialogue agent. The utterances corresponding to the human speaker will be natural productions extracted from the Games Corpus, while those corresponding to the agent will be generated with a text-to-speech (TTS) system under several conditions. Note that in all experiments we will use one of the Festival [7], Cepstral [1], or IBM [30] TTS systems, all of which are available at Columbia, for system output.

In the agent's utterances, we will systematically vary acoustic, prosodic and lexical features that have been identified in our corpus study as possible parameters for entrainment. The agent's response will be generated under three conditions, simulating either (1) an entrainment behavior with respect to the feature being studied, (2) the lack of entrainment (neutral

with respect to what an entrainment model would predict), or (3) an 'anti-entrainment' variant of the feature, in which the feature changes in a direction opposite to the one predicted by entrainment. Subjects will be asked to rate the naturalness of each conversation condition using a 1-5 Likert scale. These ratings will provide evidence of which types of entrainment improve the naturalness of conversations.

D.6.2 Perception Study: Wizard-of-Oz Experiments The purpose of this evaluation will be the same as the experiment described in Section D.6.1, but the experimental design will simulate a setting closer to real SDSs. In this experiment, subjects will perform a series of collaborative tasks using a computer-based dialogue agent, controlled by one of the experimenters.

In an initial calibration phase, each subject will be asked to describe a set of objects to the agent. The subject's speech will be recorded and a set of lexical, acoustic/prosodic and discourse-level parameters will be measured from the speech. The subject will be given a set of distractor tasks to perform while the measurements are being made. These measurements will be used to modify parameters of the TTS system in one of three ways, as in the perception study above: to simulate entrainment, lack of entrainment, or anti-entrainment. The subject will then be asked to perform a set of short, collaborative tasks with the dialogue agent (e.g. a modified version of the Objects game). Since these tasks will be specified in advance, we can predict a small set of appropriate responses for each of them. The Wizard can then rapidly select appropriate agent responses by button click from a pool of responses automatically generated with the appropriate parameter settings for the desired entrainment condition, to avoid any unusual response latency that might be incurred by typing in to the TTS system. Each subject will be tested in all three conditions during different stages of the experiment, balancing order of condition and task across subjects.

Subject performance on the tasks will be measured in terms of time to task completion and quality of task completion. At the end of each task, the subject will be asked to perform a series of subjective ratings of system performance, testing the naturalness of the conversation.

D.6.3 Model Validation: Reproducing Human Decisions Our initial perception studies (Sections D.6.1 and D.6.2) will identify parameters that can be entrained to other speakers and that lead to improvement in the efficacy, efficiency and perceived naturalness of dialogue interaction. The next question to address is: Can we build an automatic model that ***predicts*** human entrainment behavior? For example, if our perception experiments demonstrate that speaking rate and referring expression entrainment ***do*** lead to more natural conversations, then the next issue is how to compute appropriate speaking rates and referring expressions. The off-line experiments outlined in this section will test the fit between our models and actual human productions.

First, we will divide the Games and Switchboard corpora into training and test sets. For each utterance in the test set, we will compute the probability of its realization using first a general model and then an entrainment model trained on training data for that corpus. For example, the general model would predict a speaking rate conditioned only on the current speaker, such as the average speaking rate for that speaker over the entire conversation (R_a). The entrainment model might predict a different speaking rate (R_e), conditioned on the conversational partner's rate as well as the current speaker's, perhaps varying as a function of time over the conversation. We can then compare which of R_a and R_e is closer to the speaking rate actually produced by the speaker in each test utterance.

Similarly, models for lexical entrainment can be tested by generating a reference at time T_1, first using a standard GRE algorithm and then using an entrainment-driven procedure

sensitive to the prior context. The automatically produced expressions under each condition can be compared to the actual productions in the dialogue. Success here will be measured by the number of referring expressions used in the actual dialogue that are faithfully reproduced by each algorithm. This approach has been successfully used in evaluating first references in text newspaper articles [56]. Such an evaluation paradigm will allow us to compare different possible models of entrainment and choose those that best fit the human data.

D.6.4 Spoken Dialogue System The next step in our evaluation will be to integrate the best performing models identified in Section D.6.3 into a fully functioning SDS. The purpose of this experiment is to discover which of our models can operate in real time with current speech technologies. We will perform experiments similar to those described in Section D.6.2, but this time in a simple but fully automated SDS, without participation from a human operator. We plan to implement this experiment using components of the CMU ***Let's Go*** [50] system, which Alan Black (see attached letter) will make available to us for this purpose.

D.7 Results of Previous NSF Research

In previous NSF-sponsored research we have examined the acoustic, prosodic and lexical characteristics of deceptive speech (NSF IIS-0328295), finding that an automatically trained system performs considerably better than human judges (67% accuracy vs. a human mean of 55%). We have also experimented with automatic identification of student state (certainness, uncertainty, anger and frustration) and detecting and classifying question-bearing turns in spoken tutoring systems as to form and function using acoustic, prosodic and lexical information (NSF IIS-0328295). Here we are able to detect whether or not a student is confident in her responses with 76% accuracy, a 15.8% relative improvement over a baseline always predicting certainness [42]. We are also able to detect turns that include a question with 80% accuracy [43, 60]. Our goal is to emulate the behavior of human tutors, who respond differently to students based on the confidence they display — when they are wrong as well as when they are right — and whose answers are also conditioned on the form *and* the function of student questions, which are quite frequent in our corpus. studying the relationship between prosodic variation across languages (Mandarin and English) in order to develop methods of training second-language learners of languages whose prosodic systems may be quite different from their first language (IIS-HLC 0534568).

We have also investigated the role of prosodic variation in spoken dialogue systems, focusing on how GIVEN information is produced in comparison with NEW information (NSF IIS-0307905). In [34] we examined two potential uses of DOWNSTEPPED contours in Standard American English (e.g., H*H* L- L% in the ToBI system [57, 4, 5]) which have been hypothesized in the literature, the marking of discourse structure and the marking of given information. Examining the Boston Directions Corpus of read and spontaneous speech [35], we found evidence that downstepped contours, ***do*** appear to serve at least these two functions. In [27] we presented complementary findings on how speakers use pitch, intensity (loudness) and pause to distinguish between given and new information in the same corpus. Most interestingly, we found that speakers' productions of given vs. new information in both spontaneous and read speech differ significantly according to whether the information is realized as a noun or a verb: given verbs are uttered with higher intensity than new verbs, while the opposite tendency is observed for nouns. We also found considerable individual differences in the realization of given vs. new information in general.

D.8 Conclusions and Broader Impact

Speaker entrainment is an important aspect of human-human communication. However, our understanding of the full range of entrainment features is still in its infancy. We propose a study of many varieties of speaker entrainment in spoken dialogue for the purpose of improving the naturalness, efficiency and efficacy of SDSs and expanding their population of use. We have examined evidence of entrainment in the experimental literature and in the existing corpus-based studies to motivate the features we will examine (Section D.2). We have conducted a set of preliminary analyses of simple lexical and acoustic/prosodic features in two corpora, the Columbia Games Corpus and the Switchboard Corpus, which show some indications of entrainment to motivate our further study (Section D.4). We have outlined a research plan for this further analysis (Section D.5). We have described a plan for multiple evaluations of our results (Section D.6) to determine not only which features ***should*** be incorporated into SDS, but also to determine ***whether*** such incorporation is technologically feasible.

Intellectual Merit Most uses of entrainment in SDS to date have examined how speakers can be entrained to a system. We propose instead that systems should be capable of entraining to their users. In this respect, our findings will provide guidance on which features systems can and should be able to entrain upon and how this entrainment should and can be modeled. In the course of our work, we will produce richer annotations (orthographic, intonational, discourse-level) of several existing corpora, the Columbia Games Corpus and a subset of the Switchboard Corpus, which will be made available to the speech and language community for research. This data will increase the amount of annotated spontaneous dialogue material available for research on SDS significantly. We will disseminate our results widely through the presentation of papers at major speech and NLP conferences.

Broader Impacts The broader impacts of our work fall into two categories: 1) Our work will support a new approach to SDS interactions — speaker entrainment by the system, to make such systems more useful and natural to a larger portion of the population; 2) We also will make research in computer science and speech technologies more accessible by students from diverse backgrounds and at different stages in their education.

It has long been noted that people speak differently when they speak with children, foreigners and the elderly, to facilitate communication. So, SDS should also adapt to the lexical, acoustic/prosodic and discourse styles of such users as well as to the styles of the general adult native-speaker population. We also believe that language teaching itself should benefit from our findings about entrainment in American culture. Behaviors such as tolerance for overlapping speech (interruption), for example, differ significantly between cultures [58]; yet such behaviors are rarely taught to second language learners.

Student participation from women and minorities at graduate and undergraduate levels will be actively sought at both Columbia and the University of Pennsylvania. In particular, new GRAs will be funded under this grant at both institutions for this research, with women and minority candidates specially recruited at both. The PI and co-PI have both been very active in the recruitment and retention of women in computer science, serving on numerous diversity committees whose aim is to increase the participation of women in engineering and the sciences, advising student groups and organizing activities such as panels, invited talks and workshops at Columbia to enhance women's ability to succeed in the engineering sciences. Numerous women undergraduates and graduate students have worked on NSF-sponsored and other research projects at Columbia, including 3 women master's students in 2005-6 and a woman REU in Summer 2006.

D.9 Coordination Plan

PI Julia Hirschberg, with primary expertise in speech science and technology, will lead the project at Columbia University. Co-PI Ani Nenkova, with primary expertise in text-based generation, will lead the University of Pennsylvania part of the collaboration. This cross-university collaboration between researchers with expertise in text and speech processing will also contribute to bringing the two communities closer together, by engaging students at both universities who will share research experience from both perspectives.

PI Hirschberg will have primary responsibility for supervising the analysis and modeling of spoken phenomena, including the study of acoustic/prosodic entrainment, and the turn-taking and backchanneling aspects of discourse-level entrainment. Co-PI Nenkova will bear major responsibility for supervising the analysis of lexical entrainment and the creation of algorithms for generating referring expressions based upon this, and for the studies of hedging behavior and cue phrase entrainment. However, to maximize the educational potential of this collaboration, students from both Columbia and Penn will be encouraged to work together to share software, data, and expertise across sites.

The proximity between Columbia and Penn will greatly facilitate collaboration and coordination between the two sites at minimal cost. We will exchange monthly one-day visits to discuss recent results and plan the necessary follow-up steps. This can be done very cheaply using the Chinatown Bus service which connects Chinatown in New York City with its counterpart in Philadelphia, at a cost of $10 per person one-way. For about $500 per year we will be able to integrate students more thoroughly into the project with face-to-face meetings, which really do foster collaboration better than conference calls, especially when project members will not have worked together previously. These meetings will be particularly useful during the evaluation stages of the project and when we are preparing papers based upon joint results. During weeks when we do not have such physical meetings, we will keep in touch via hour-long teleconferences at a set day and time to keep up-to-date on progress at both institutions. The PIs and students will also meet at conferences each year. The budget includes appropriate amounts for bus transportation, conference attendance (Domestic Travel) and for phone calls (Communication).

In addition, we will maintain a password protected project website which will be constantly updated, tracking most recent results, to-do items and general project progress. Columbia has followed this approach in all of its research projects and found it invaluable for managing cross-site collaborations, to keep participants informed about stages of progress in annotation and analysis and to give everyone access to the data.

The following paragraphs outline how we will allocate our time for the research described in previous sections.

Year 1 The first year will be devoted to an intensive corpus analysis of the Games Corpus as described in Section D.5. Columbia will focus on the analysis of acoustic and prosodic features while Penn will work on lexical entrainment. The main goal will be to identify the features for which there is evidence that entrainment occurs, as well as which features are correlated and what the temporal scope of entrainment is for these features. Penn will also augment the coreference annotations on the Switchboard corpus to allow cross-corpus validation of the findings on the Games Corpus. Penn will also produce an improved prototype algorithm for reference generation. We will report our findings if possible at both speech (INTERSPEECH) and NLP conferences (International Conference on Natural Language Generation, ACL), as well as HLT.

Year 2 In the second year we will perform the perception experiments described in Section D.6. Subjects will be recruited and experiments performed at both institutions. We will continue our corpus-based analyses in parallel. In addition, we will test and refine our entrainment models on the Switchboard Corpus. We will report on our findings at the same conferences noted above.

Year 3 In the last year of the project we will analyze the results of our perception studies and focus on integrating our findings into a generation component for the ***Let's Go*** Spoken Dialogue System, as described in Section D.6. We will conduct the experiments also described in Section D.6 comparing the entrained versions of the generation component with the non-entrained and 'anti-entrained' versions for naturalness, efficacy, and efficiency. During this year we will also prepare our corpora for distribution (over the web if possible) to the research community. Again, we will report on our findings at the conferences mentioned for Year 1.

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Publications most closely related to proposal

2006. J. Hirschberg, A. Gravano, A. Nenkova, E. Sneed, and G. Ward. "Intonational overload: uses of the H* !H* L- L% contour in read and spontaneous speech," Labphon-9. To appear.

2006. D. Litman, J. Hirschberg, and M. Swerts. "Characterizing and Predicting Corrections in Spoken Dialogue Systems," *Computational Linguistics*, 32 (3):417-438.

2006. A. Gravano and J. Hirschberg, "Effect of genre, speaker, and word class on the realization of given and new information," INTERSPEECH 2006, Pittsburgh.

2006. J. Liscombe, J. Venditti, and J. Hirschberg, "Detecting Certainness in Spoken Tutorial Dialogues," INTERSPEECH 2005, Lisbon.

2002. J. Hirschberg, "Communication and Prosody: Functional Aspects of Prosody," *Speech Communication: Special Issue on Dialogue and Prosody*: 36, ed. J. Terken and M. Swerts.

Other Publications

2005. R. Carlson, J. Hirschberg, and M. Swerts, "Cues to Upcoming Swedish Prosodic Boundaries: Subjective judgment studies and acoustic correlates," *Speech Communication,* 46:326-333.
2005. A. Rosenberg and J. Hirschberg, "Acoustic/Prosodic and Lexical Correlates of Charismatic Speech," INTERSPEECH 2005, Lisbon.
2004. J. Hirschberg, D. Litman, and M. Swerts, "Prosodic and Other Cues to Speech Recognition Failures," *Speech Communication*, 43(1-2):155-75.
2004. M. E. Beckman, J. Hirschberg, and S. Shattuck-Hufnagel, "The Original ToBI System and the Evolution of the ToBI Framework," in S. A. Jun, ed., *Prosodic Typology: The Phonology of Intonation and Phrasing*, Oxford.
2000. J. Hirschberg, "A Corpus-Based Approach to the Study of Speaking Style," in *Festschrift in Honor of Gosta Bruce*, ed. M. Horne, Kluwer.

Synergistic Activities

- President, International Speech Communication Association (ISCA), 2005--, Vice-President, 2003-5, and Board Member, 1999--
- Editor-in-Chief (one of three), *Speech Communication*, 2003--
- Editor-in-Chief, *Computational Linguistics,* 1993-2003
- Member, Executive Board, Association for Computational Linguistics, 1993-2003
- Fellows Selection Committee, AAAI, 2006-8
- General Chair, HLT/NAACL 2004
- Co-developer, ToBI Conventions for Transcribing Standard American English
- Diversity Efforts: Member, Columbia SEAS Diversity Committee, Task Force on Diversity in the Sciences and Engineering, STRIDE (a committee of the CU ADVANCE Program dealing with dual career issues); Faculty Advisor, WICS and WICSE (Women in Computing, Science and Engineering)

Collaborators (past 48 months)

Mary Beckman (Ohio State), Stefan Benus (Brown), Jason Brenier (Colorado), Rolf Carlson (KTH), David Elson (Columbia), Sarah Friedman (Stonybrook), Michel Galley (Columbia), Sarah Gilman (Columbia), Cynthia Girand (Colorado), Martin Graciarena (SRI), Sachin Kajarekar (SRI), Andreas Kathol (SRI), Diane Litman (U Pittsburgh), Kathy McKeown (Columbia), Laura Michaelis (Colorado), Ani Nenkova (Stanford), Bryan Pellom (Rosetta Stone), Stefanie Shattuck-Hufnagel (MIT), Elizabeth Shriberg (SRI/ICSI), Elisa Sneed (Northwestern), Andreas Stolcke (SRI/ICSI), Marc Swerts (Tilburg), Jennifer Venditti (Columbia), Gregory Ward (Northwestern), Stephen Whittaker (Sheffield), and GRAs below

Graduate Advisor: Bonnie Webber (University of Pennsylvania)

Graduate Advisees and Postdoctoral Scholars

Current GRAs: Jackson Liscombe, Sameer Maskey, Frank Enos, Andrew Rosenberg, Agustin Gravano, Fadi Biadsy; Former PhD Advisees: Christine Nakatani, Shimei Pan; Former Postdocs: Jennifer Venditti, Stefan Benus

Ani Nenkova

Department of Computer and Information Science
University of Pennsylvania

Education

Columbia University	Computer Science	PhD 2006
Columbia University	Computer Science	MS 2004
Sofia University	Computer Science	BS 2000

Appointments

Jul 2007--- Assistant Professor, Department of Computer and Information Science, University of Pennsylvania
Feb 2006--- Postdoctoral Fellow, Department of Linguistics, Stanford University
Summer'04 Research intern, Microsoft research
Summer'02 Research intern, Avaya Labs
Summer'01 Research intern, NEC

Publications most closely related to proposal

2006. Jason Brenier, Ani Nenkova, Anubha Kothari, Laura Whitton, David Beaver, Dan Jurafsky. "The (Non)Utility of Linguistic Features for Predicting Prominence in Spontaneous Speech", IEEE/ACL Workshop on Spoken Language Technology, (SLT 2006), Aruba.

2006. Ani Nenkova, "Speech Summarization Evaluation", Interspeech 2006, Pittsburgh

2005. Ani Nenkova, Advaith Siddharthan and Kathleen McKeown, "Automatically learning cognitive status for multi-document summarization of newswire*", Joint Meeting of the Human Language Technology Conference and the Conference on Empirical Methods in Natural Language Processing,* HLT/EMNLP 2005, Vancouver, B.C., Canada.

2004. Julia Hirschberg, Agustin Gravano, Ani Nenkova, Elisa Sneed, Gregory Ward, "Intonational overload: uses of the H* !H* L- L% contour in read and spontaneous speech", *Ninth Conference on Laboratoty Phonology*, University of Illinois at Urbana-Champaign.

2003. Ani Nenkova and Kathleen McKeown, "References to Named Entities: A Corpus Study", *Human Language Technology Conference/ North American chapter of the Association of Computational Linguistics annual meeting* (NAACL-HLT 2003), Short Paper Proceedings, Edmonton, Canada.

Other Publications

2006. Ani Nenkova, Lucy Vanderwende and Kathleen McKeown, "A compositional context-sensitive multi-document summarizer", *29th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval* (SIGIR 2006), Seattle, USA.

2005. Kathleen McKeown, Rebecca Passonneau, David Elson, Ani Nenkova, Julia Hirschberg , "Do Summaries Help? A Task-Based Evaluation of Multi-Document Summarization", *28th Annual International ACM SIGIR Conference on Research and Development in Information Retrieval* (SIGIR 2005), Salvador, Brazil.

2005. Ani Nenkova, "Automatic Text Summarization of Newswire: Lessons Learned from the Document Understanding Conference", *20th National Conference on Artificial Intelligence* (AAAI'05), Pittsburgh, USA.

2004. Advaith Siddharthan, Ani Nenkova and Kathleen McKeown, "Syntactic Simplification for Improving Content Selection in Multi-Document Summarization", *20th International Conference on Computational Linguistics* (COLING 2004), Geneva.

2004. Ani Nenkova and Rebecca Passonneau, "Evaluating Content Selection in Summarization: the Pyramid Method", *Human Language Technology Conference/ North American chapter of the Association of Computational Linguistics annual meeting* (HLT/NAACL 2004), Boston, USA.

Synergistic Activities

- **President Women** in Computer Science, Columbia University (2002—2005)
- **Organizer** Seminar on professional preparedness, Columbia CS (2003—2005)
- **Senior PC member** *the Human Language Technology/North American chapter of the Association for Computational Linguistics Conference* (HLT-NAACL) 2007
- **Co-chair** of *the Human Language Technology/North American chapter of the Association for Computational Linguistics Conference* (HLT-NAACL) 2004 student workshop; student workshop at *European Summer School in Logic, Language and Information* (ESSLLI'01), Helsinki, Finland
- **Journal Reviewing:** *Computational Linguistics* (2006)**;** *Cognitive Linguistics* (2006)**;** *Information Processing and Management* (2006)
- **Conference and Workshop Reviewing:** *Recent advances in natural language processing* (RANLP) 2001; *European conference on artificial intelligence* (ECAI) 2002; *Human Language Technology/North American ACL Conference* (HLT-NAACL) 2003 student workshop; *Recent advances in natural language processing* (RANLP) 2003 ; *Joint Conference on Digital Libraries* (JCDL) 2004; *International joint conference on artificial intelligence* (IJCAI) 2005; *National conference on artificial intelligence* (AAAI) 2006 member posters track; *Empirical methods in natural language processing* (EMNLP) 2006
- **Program Committee Member** : ESSLLI 2001 student workshop; HLT-NAACL 2004 student workshop; ACL-NAACL 2005 student workshop; *International joint conference on natural language processing* (IJCNLP 2005); RANLP 2005; ACL 2006 student workshop; *International conference on natural language generation* (INLG) 2006 student session; ACL-COLING 2006 *workshop on intrinsic and extrinsic evaluation for machine translation and summarization;* HLT/NAACL-2006 *workshop on Analyzing Conversations in Text and Speech* (ACTS)

Collaborators (past 48 months)

David Beaver (University of Texas at Austin), Jason Brenier (University of Colorado at Boulder), David Elson (Columbia University), Agustin Gravano (Columbia University), Aaron Harnly (Columbia University), Julia Hirschberg (Columbia University), Dan Jurafsky (Stanford University), Anubha Kothari (Stanford University), Kathleen McKeown (Columbia University), Rebecca Passonneau (Columbia University), Owen Rambow (Columbia University), Advaith Siddharthan (Cambridge University), Elisa Sneed (Northwestern University), Gregory Ward (Northwestern University) , Laura Whitton (Stanford University), Lucy Vanderwende (Microsoft Research)

Graduate Advisor: Kathleen McKeown (Columbia University)

SUMMARY PROPOSAL BUDGET YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Columbia University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Julia B Hirschberg**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Julia B Hirschberg - PI**	**0.00**	**0.00**	**1.00**	$ **18,662**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**1.00**	**18,662**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**2**) GRADUATE STUDENTS				**60,096**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**78,758**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**6,226**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**84,984**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **Computer** $ **5,000**					
TOTAL EQUIPMENT				**5,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,500**	
2. FOREIGN				**10,500**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**300**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**40,864**	
TOTAL OTHER DIRECT COSTS				**41,164**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**146,148**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Computer Services (Rate: 61.0000, Base: 6000) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				**65,748**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**211,896**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **211,896**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Julia B Hirschberg**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 1

**** I- Indirect Costs**
Material & Supplies (Rate: 61.0000, Base 300)
Other Direct Costs (Rate: 61.0000, Base 1500)
Salaries (Rate: 61.0000, Base 84984)
Travel (Rate: 61.0000, Base 15000)

SUMMARY PROPOSAL BUDGET YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Columbia University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Julia B Hirschberg**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Julia B Hirschberg - PI**	**0.00**	**0.00**	**1.00**	$ **19,408**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**1.00**	**19,408**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**1**) GRADUATE STUDENTS				**31,248**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**50,656**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**5,838**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**56,494**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) **Computer** $ **5,000**					
TOTAL EQUIPMENT				**5,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**3,000**	
2. FOREIGN				**7,000**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**300**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**22,682**	
TOTAL OTHER DIRECT COSTS				**22,982**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**94,476**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Computer Services (Rate: 61.0000, Base: 4000) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				**44,099**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**138,575**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **138,575**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Julia B Hirschberg**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 2

**** I- Indirect Costs**
Materials & Supplies (Rate: 61.0000, Base 300)
Other Direct Costs (Rate: 61.0000, Base 1500)
Salaries (Rate: 61.0000, Base 56494)
Travel (Rate: 61.0000, Base 10000)

SUMMARY PROPOSAL BUDGET YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Columbia University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Julia B Hirschberg**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Julia B Hirschberg - PI**	**0.00**	**0.00**	**1.00**	$ **20,185**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**1.00**	**20,185**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**1**) GRADUATE STUDENTS				**32,496**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**52,681**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**6,072**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**58,753**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**3,000**	
2. FOREIGN				**7,000**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**300**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**23,197**	
TOTAL OTHER DIRECT COSTS				**23,497**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**92,250**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Computer Services (Rate: 61.0000, Base: 4000) (Cont. on Comments Page)**					
TOTAL INDIRECT COSTS (F&A)				**45,477**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**137,727**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **137,727**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Julia B Hirschberg**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET COMMENTS - Year 3

**** I- Indirect Costs**
Materials & Supplies (Rate: 61.0000, Base 300)
Other direct costs (Rate: 61.0000, Base 1500)
salaries (Rate: 61.0000, Base 58752)
travel (Rate: 61.0000, Base 10000)

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Columbia University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Julia B Hirschberg**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Julia B Hirschberg - PI**	**0.00**	**0.00**	**3.00**	$ **58,255**	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**3.00**	**58,255**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**4**) GRADUATE STUDENTS				**123,840**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**182,095**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**18,136**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**200,231**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.) $ **10,000**					
TOTAL EQUIPMENT				**10,000**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**10,500**	
2. FOREIGN				**24,500**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**900**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**0**	
5. SUBAWARDS				**0**	
6. OTHER				**86,743**	
TOTAL OTHER DIRECT COSTS				**87,643**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**332,874**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				**155,324**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**488,198**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **488,198**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Julia B Hirschberg**

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

BUDGET JUSTIFICATION

SALARIES & WAGES

Julia Hirschberg: PI — 1 month of Hirschberg's summer research, with an annual increase of 4%

Graduate Students: Two Graduate Research Assistants (GRAs) will be supported for 12 months; two in Year I and one of these also in Years II and III.

GRAs receive a yearly stipend as follows:

Year I : $30,048
Year II: $31,248
Year III: $32,496

FRINGE — The fringe rate is 26.8%.
No fringe is charged on GRA stipend during the academic year; the University makes up the difference. Fringe at the rate of 8.15% is charged for the summer months only.

EQUIPMENT — We have planned for the purchase of 4 PCs: two in Year I and two in Year II; there will be no purchase of equipment in Year III. These will be used for the GRAs and to support our experiments.

TRAVEL

Domestic travel is requested for the PI and three graduate students; Year I we requested funds for the PI and two graduate students and Years II & III, we requested funds for the PI and one graduate student. For Years II & III we anticipate a slight increase in all categories.

$1500: Domestic travel

Economy airfare:	$250.00
Bus Transportation	$360.00
Registration Fee:	$350.00
Hotel (conference rate): 3 days @ $130/night:	$390.00
Per Diem @ $50/day	$150.00

$3500: International Travel

Economy airfare:	$1400.00
Registration Fee:	$650.00
Hotel (conference rate): 5 days @ $220/night:	$1100.00
Per Diem@$70	$ 350.00

This travel plan will allow for a yearly travel as follows: 1 short trip, 3 round trips every other month via bus transportation, and 1 international trip to present our investigations to one conference.

SUPPLIES, COMMUNICATION, COMPUTER

We are requesting funds to cover supplies and communication costs associated with the project. We are also requesting funds to pay User Fees to the Computer Science Department Central Facilities. Each user of central facilities must pay $2000 yearly to defray the cost of technical support and central equipment. This cost is subsidized by the department and the university; the actual cost is far higher.

TUITION:

GRAs receive a yearly tuition as follows:
Year I: $16,682
Year II: $17,182
Year III: $17,697

Tuition must be charged as direct cost on all contracts.

INDIRECT COSTS

Indirect costs rate is 61% and is not charged on tuition nor equipment, which costs $2000 and above.

SUMMARY PROPOSAL BUDGET YEAR 1

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Pennsylvania

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ani Nenkova

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ani Nenkova - Assistant Professor**	**0.00**	**0.00**	**1.00**	$ **9,778**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**1.00**	**9,778**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**1**) GRADUATE STUDENTS				**25,000**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**34,778**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**2,924**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**37,702**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**2,100**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**10,000**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**2,200**	
5. SUBAWARDS				**0**	
6. OTHER				**22,228**	
TOTAL OTHER DIRECT COSTS				**34,428**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**79,230**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 57.5000, Base: 57001)**					
TOTAL INDIRECT COSTS (F&A)				**32,776**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**112,006**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **112,006**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ani Nenkova

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

1 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Pennsylvania

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ani Nenkova

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ani Nenkova - Assistant Professor**	**0.00**	**0.00**	**1.00**	$ **10,267**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**1.00**	**10,267**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**1**) GRADUATE STUDENTS				**25,500**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**35,767**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**3,070**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**38,837**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**2,100**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**3,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**2,275**	
5. SUBAWARDS				**0**	
6. OTHER				**23,452**	
TOTAL OTHER DIRECT COSTS				**29,227**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**75,164**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 57.5000, Base: 51711)**					
TOTAL INDIRECT COSTS (F&A)				**29,734**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**104,898**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **104,898**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ani Nenkova

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET YEAR 3

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Pennsylvania

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ani Nenkova

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ani Nenkova - Assistant Professor**	**0.00**	**0.00**	**1.00**	$ **10,780**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	**0.00**	**0.00**	**0.00**	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	**0.00**	**0.00**	**1.00**	**10,780**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL ASSOCIATES	**0.00**	**0.00**	**0.00**	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	**0.00**	**0.00**	**0.00**	**0**	
3. (**1**) GRADUATE STUDENTS				**26,000**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**36,780**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**3,223**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**40,003**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**5,000**	
2. FOREIGN				**2,100**	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ **0**					
2. TRAVEL **0**					
3. SUBSISTENCE **0**					
4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**3,500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**0**	
3. CONSULTANT SERVICES				**0**	
4. COMPUTER SERVICES				**2,350**	
5. SUBAWARDS				**0**	
6. OTHER				**24,695**	
TOTAL OTHER DIRECT COSTS				**30,545**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**77,648**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **MTDC (Rate: 57.5000, Base: 52953)**					
TOTAL INDIRECT COSTS (F&A)				**30,448**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**108,096**	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **108,096**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ani Nenkova

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION
University of Pennsylvania

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Ani Nenkova

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Ani Nenkova - Assistant Professor**	0.00	0.00	3.00	$ 30,825	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	3.00	30,825	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (3) GRADUATE STUDENTS				76,500	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				107,325	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				9,217	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				116,542	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				15,000	
2. FOREIGN				6,300	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				17,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				6,825	
5. SUBAWARDS				0	
6. OTHER				70,375	
TOTAL OTHER DIRECT COSTS				94,200	
H. TOTAL DIRECT COSTS (A THROUGH G)				232,042	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				92,958	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				325,000	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 325,000	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Ani Nenkova

ORG. REP. NAME*

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INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

PRINCIPAL INVESTIGATOR: ANI NENKOVA
SPONSOR: NSF
BAA: 06-572
BUDGET PERIOD: THIRTY-SIX MONTHS

TITLE: **RI: Collaborative Research: Speaking More Like You: Lexical, Acoustic/Prosodic, and Discourse Entrainment for Spoken Dialogue Systems"**

NAME		% EFFORT	YEAR 1	YEAR 2	YEAR 3	TOTAL COSTS
FACULTY *A Nenkova*	***P.I.***	***10%***	$9,778	$10,267	$10,780	**$30,824**
GRADUATE RESEARCH FELLOWS		***100%***	$25,000	$25,500	$26,000	**$76,500**
EMPLOYEE BENEFITS - DHHS-approved FULL TIME RATE of 29.9%			$2,924	$3,070	$3,223	**$9,217**
EMPLOYEE BENEFITS - DHHS-approved PART TIME RATE of 9.7%			$0	$0	$0	**$0**
			$37,701	$38,836	$40,003	**$116,541**
CURRENT EXPENSE						
TRAVEL - DOMESTIC			$5,000	$5,000	$5,000	**$15,000**
TRAVEL - FOREIGN			$2,100	$2,100	$2,100	**$6,300**
OTHER EXPENSE						
SUPPLIES FOR RESEARCH			$10,000	$3,500	$3,500	**$17,000**
POST DOC MED INS			$0	$0	$0	**$0**
REPRINTS & PG CHG/DUPLIC			$0	$0	$0	**$0**
COMPUTER USAGE			$2,200	$2,275	$2,350	**$6,825**
TOTAL DIRECT COSTS			$57,001	$51,711	$52,953	**$161,666**
OVERHEAD @ 57.5%			$32,776	$29,734	$30,448	**$92,958**
SUB-TOTAL			$89,777	$81,445	$83,401	**$254,624**
TUITION **$16,985**	**FEES**	**$3,004**	$19,989	$20,988	$21,984	**$62,961**
RF MEDICAL INSURANCE		**$2,240**	$2,240	$2,464	$2,710	**$7,414**
TOTAL			**$112,006**	**$104,898**	**$108,096**	**$325,000**

Pending and Current Support

Investigator: Julia Hirschberg

Support	Pending
Project/Proposal Title:	RI: Collaborative Research: Speaking More Like You: Lexical, Acoustic/Prosodic, and Discourse Entrainment in Spoken Dialogue Systems
Source of Support:	NSF
Total Award Amount:	$488,197: Total Award Period: 09/01/07-08/31/2010
Location:	Columbia University

Person-Months Per Year Committed to the Project.
Cal: 0.00 Acad: 0.00 Sumr: 1.00

Support:	Current
Project/Proposal Title:	Collaborative Research: Translating Prosody in a English/Chinese Language Tutoring System
Source of Support:	NSF
Total Award Amount:	$480,321 Total Award Period Covered: 08/16/05-08/11/08
Location of Project:	Columbia University

Person-Months Per Year Committed to the Project.
Cal:0.00 Acad: 0.00 Sumr: 1.00

Support:	Current
Project/Proposal Title:	GALE: Novel Information Gathering and Harvesting Techniques for Intelligence in Global Autonomous Language Environments
Source of Support:	DARPA/IPTO
Total Award Amount:	$1,911,200 Total Award Period Covered: 09/01/2005-08/31/2007
Location of Project:	SRI International

Person-Months Per Year Committed to the Project.
Cal: 0.00 Acad: 3.00 Sumr 0.00

Support:	Current
Project/Proposal Title:	ITR: Recognizing and Understanding Emotion in Speech
Source of Support:	NSF (DHS) IIS-0325399 (with SRI and University of Colorado)
Total Award Amount:	$3,700,00 (contingent on annual renewals; Columbia Total $1,277,249) Total Award Period Covered: 09/01/03 - 08/31/07

Location of Project: Columbia University
Person-Months Per Year Committed to the Project.
Cal:0.00 Acad: 0.00 Sumr: 1.00

Support: Current
Project/Proposal Title: Dialogue Prosody For Interactive Voice Response Systems
Source of Support: NSF IIS-03-07905
Total Award Amount: $530,553 Total Award Period Covered: 07/01/03-06/30/07
Location of Project Columbia University
Person-Month Per Year Committed to the Project:
Cal: 0.00 Acad: 0.00 Sumr: 0.00

Support: Current
Project/Proposal Title: 2006 Faculty Award
Source of support: IBM
Total Award: $60,000 Total Period Covered: 09/01/05-8/31/07
Location of Proj: Columbia
Person-Months Per Year committed to project:
Cal: 0.00 Acad: 0.00 Sumr: 0.00

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Ani Nenkova**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **RI: Collaborative Research: Speaking More Like you: Lexical, Acoustic/Prosodic, and Discourse Entrainment for Spoken Dialogue Systems**

Source of Support: **NSF**

Total Award Amount: $ **325,000** Total Award Period Covered: **09/01/07 - 08/31/10**

Location of Project: **University of Pennsylvania**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **1.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

---

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Facilities at Columbia University

Computer Facilities: Currently, the Columbia Computer Science Department facilities include a shared infrastructure of over 20 Sun and Pentium servers, both multiprocessors and single processors, connected via 100 Mb/s and Gigabit Ethernet links; two Sun Ultra 2 file servers; one Sun Ultra 10 RAID file server with 100GB storage, three dual-processor Sun Enterprise 250 servers; two Sun Ultra 1 server with RAID disk array and a StorageTek 9730 DLT tape robotic arm unit. There are two web servers; a Sun Enterprise 250 primary server and an Sun Ultra 5 backup server. The servers will be generally available for the project.

Our research facilities are staffed by four professional systems administrators who are responsible for operating systems and network support, miscellaneous hardware and software maintenance, and trouble-shooting. These staff members allow individual researchers to avoid spending time on hardware and software problems. To help defray the costs of these departmental facilities, in addition to electricity and climate control charges, each research group pays per capita facilities fees.

Natural Language and Spoken Language Processing Laboratories

Our research will be conducted in the Natural Language Processing Laboratory (NLP) and the Spoken Language Processing Lab (SLPG) at Columbia University. The SLPG has facilities for studio quality audio recording, for video recording, and for state-of-the-art computing and speech analysis. Speech data is collected using a Tascam digital audio recorder and Crown headworn microphones. Recording is done in an 8x8 foot double-walled sound proof booth. Video equipment includes a Hitachi DVD Camcorder. We have a Sun Fire V210 computing server, and share a Linux computing cluster and multi-terabyte file server with the NLP Group. In addition, the lab houses about a dozen Linux and Windows workstations, most equipped with high quality sound cards. The group maintains a large collection of speech corpora and other databases, collected at Columbia and elsewhere.

The NLP and SLPG groups have numerous computers purchased and supported by research funds: 1 Sun Ultra 80 server, 4 Sun Ultra 30 servers, several Sun Ultra 20 servers, 1 Sun Blade server, a Terabyte PC Linux-based fileserver, 4 high-end PC Linux servers, and a number of Unix-based (Sun Ultra 10 and PC Linux) and Microsoft Windows lab workstations. To this mix, we recently added 2 Sun Fire file servers, an Apple Xserve RAID, and 2 Sun Fire compute servers, and 2 Dell OptiPlex Pentium4 compute servers. All of these machines are connected to the departmental ethernet. In addition, all the group's Ph.D. students and research staff persons personal workstations at their desks.

Another important asset of the group is its sophisticated set of software tools. Many tools have been obtained from external sources: Church's Part-of-Speech tagger from AT&T; Collins' parser, a robust statistical parser from AT&T; the Alembic Workbench from MITRE; CLASSIC (an implementation of KL-ONE); LFG Grammar Writer's Workbench from Xerox; PC-KIMMO from the CLR; WordNet from Princeton University; FrameNet from ICSI; and IdentiFinder from BBN. The group's locally developed tools include: FUF, the Functional Unification Formalism; CFUF, a

graph-based implementation of the FUF language implemented in C and embedded within a Scheme interpreter; Surge, a syntactic realization grammar for text generation; Crep, a regular expression matcher forcorpus retrieval; Segmenter, a text segmentation utility; Verber, a utility design to conflate semantically related verbs together; Xtract, an automatic collocation compiler; LinkIT, a tool for identifying and relating noun phrases within a document; Centrifuser, a domain- and genre-specific multidocument summarization system; SimFinder, identifies spans of texts that convey similar meaning; MultiGen, a multi-document text summarizer; DEMS, the Dissimilarity Engine for Multidocument Summarization; DEFINDER, a text-mining tool for extracting definitions from medical text; and DefScriber, a definitional question-answering system. In addition, the Spoken Language Processing Group has developed and acquired a large number of speech processing tools for data analysis, including XWAVES, Wavesurfer, and Praat as well as tools developed in the lab. We have the use of speech recognition and generation technologies acquired as freeware or through the courtesy of researchers at CMU and IBM.

Columbia is a member of the LDC and thus also has access to all data offered by this consortium.

FACILITIES, EQUIPMENT & OTHER RESOURCES

FACILITIES: Identify the facilities to be used at each performance site listed and, as appropriate, indicate their capacities, pertinent capabilities, relative proximity, and extent of availability to the project. Use "Other" to describe the facilities at any other performance sites listed and at sites for field studies. USE additional pages as necessary.

Laboratory:

Clinical:

Animal:

Computer:

Office:

Other:

MAJOR EQUIPMENT: List the most important items available for this project and, as appropriate identifying the location and pertinent capabilities of each.

OTHER RESOURCES: Provide any information describing the other resources available for the project. Identify support services such as consultant, secretarial, machine shop, and electronics shop, and the extent to which they will be available for the project. Include an explanation of any consortium/contractual arrangements with other organizations.

All facilities and resources needed to complete this work are available at the University of Pennsylvania School of Engineering & Applied Science

Carnegie Mellon

Language Technologies Institute
4502 Newell Simon Hall
Carnegie Mellon University
5000 Forbes Avenue
Pittsburgh, Pennsylvania 15213-8213

(412) 268-6599
(412) 268-6298 (fax)

To whom it may concern:

As one of the PIs in the development of the spoken dialog system Let's Go (cmuletsgo.org), we are very happy for Profs Hirschberg and Nenkova to use our core system in their project. Let's Go has been deployed for the Pittsburgh public giving bus information outside hours of the local Port Authority. Let's Go is based on the Ravenclaw/Olympus (www.ravenclaw-olympus.org) dialog system freely distributed by CMU.

As we see Let's Go as a platform for testing spoken dialog systems we see the support of Hirschberg and Nenkova's project of entrainment as being a ideal example of projects we would like to see exploiting our current system. We are happy to provide access to the system and give advice and support to them in their project.

Yours faithfully,

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1. Julia Hirschberg; Columbia University; PI
2. Ani Nenkova; University of Pennsylvania; co-PI