APPLICATION FOR FEDERAL ASSISTANCE

SF 424 R&R

3. DATE RECEIVED BY STATE	State Application Identifier

1. TYPE OF SUBMISSION

❍Pre-application ●Application ❍Changed/Corrected Application

2. DATE SUBMITTED 10/17/2016

Applicant Identifier

4. a. Federal Identifier

b. Agency Routing Identifier

c. Previous Grants.gov Tracking ID

5. APPLICANT INFORMATION **Organizational DUNS:** 161202122

Legal Name: The Board of Regents of the University of Wisconsin System

Department: Division:

Street1: Suite 6401 Street2: 21 N Park St

City: Madison County/Parish: Dane State: WI: Wisconsin

Province: Country: USA: UNITED STATES ZIP / Postal Code: 53715-1218

Person to be contacted on matters involving this application

Prefix:	First Name:	Middle Name:	Last Name:	Suffix:
	Darlene	A	Holte	

Position/Title: University Grants & Contracts Specialist, Sr

Street1: 21 N. Park St. Street2: Suite 6401

City: Madison County/Parish: Dane State: WI: Wisconsin

Province: Country: USA: UNITED STATES ZIP / Postal Code: 53715-1218

Phone Number: 608-262-3822 Fax Number: 608-262-5111 Email: johnsonholte@rsp.wisc.edu

6. EMPLOYER IDENTIFICATION NUMBER *(EIN) or (TIN)*: 396006492

7. TYPE OF APPLICANT: H: Public/State Controlled Institution of Higher Education

Other (Specify):

Small Business Organization Type ❍Women Owned ❍Socially and Economically Disadvantaged

8. TYPE OF APPLICATION:

●New ❍Resubmission

❍Renewal ❍Continuation ❍Revision

If Revision, mark appropriate box(es).

❍A. Increase Award ❍B. Decrease Award ❍C. Increase Duration

❍D. Decrease Duration ❍E. Other *(specify)*:

Is this application being submitted to other agencies? ❍ Yes ● No What other Agencies?

9. NAME OF FEDERAL AGENCY:
National Institutes of Health

10. CATALOG OF FEDERAL DOMESTIC ASSISTANCE NUMBER:
TITLE:

11. DESCRIPTIVE TITLE OF APPLICANT'S PROJECT:
Seed words: the impact of word learning on category induction

12. PROPOSED PROJECT:

Start Date	Ending Date
07/01/2017	06/30/2019

13. CONGRESSIONAL DISTRICT OF THE APPLICANT:
WI-002

14. PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix:	First Name:	Middle Name:	Last Name:	Suffix:
	GARY		LUPYAN	

Position/Title: ASSOCIATE PROFESSOR
Organization Name: The Board of Regents of the University of Wisconsin System
Department: PSYCHOLOGY-GEN
Division:
Street1: 1202 W JOHNSON ST
Street2:
City: MADISON
County/Parish:
State: WI: Wisconsin
Province:
Country: USA: UNITED STATES
ZIP / Postal Code: 53706-1611
Phone Number: 917-843-4868
Fax Number:
Email: LUPYAN@WISC.EDU

15. ESTIMATED PROJECT FUNDING

a. Total Federal Funds Requested	$420,750.00
b. Total Non-Federal Funds	$0.00
c. Total Federal & Non-Federal Funds	$420,750.00
d. Estimated Program Income	$0.00

16. IS APPLICATION SUBJECT TO REVIEW BY STATE EXECUTIVE ORDER 12372 PROCESS?

a. YES ○ THIS PREAPPLICATION/APPLICATION WAS MADE AVAILABLE TO THE STATE EXECUTIVE ORDER 12372 PROCESS FOR REVIEW ON:

DATE:

b. NO ● PROGRAM IS NOT COVERED BY E.O. 12372; OR

○ PROGRAM HAS NOT BEEN SELECTED BY STATE FOR REVIEW

17. By signing this application, I certify (1) to the statements contained in the list of certifications* and (2) that the statements herein are true, complete and accurate to the best of my knowledge. I also provide the required assurances * and agree to comply with any resulting terms if I accept an award. I am aware that any false, fictitious, or fraudulent statements or claims may subject me to criminal, civil, or administrative penalties. (U.S. Code, Title 18, Section 1001)

●I agree

The list of certifications and assurances, or an Internet site where you may obtain this list, is contained in the announcement or agency specific instructions.

18. SFLLL or other Explanatory Documentation. File Name: Mime Type:

19. Authorized Representative

Prefix:	First Name:	Middle Name:	Last Name:	Suffix:
	BRENDA	A	EGAN	

Position/Title: Managing Officer
Organization Name: The Board of Regents of the University of Wisconsin System
Department: Research & Sponsored Programs
Division:
Street1: 21 N. Park Street, Suite 6401
Street2:
City: Madison
County/Parish: Dane
State: WI: Wisconsin
Province:
Country: USA: UNITED STATES
ZIP / Postal Code: 53715-1218
Phone Number: 608-262-3822
Fax Number:
Email: nih@rsp.wisc.edu

Signature of Authorized Representative	Date Signed
BRENDA A EGAN	10/17/2016

20. Pre-application File Name: Mime Type:

21. Cover Letter Attachment File Name: CoverLetter_DONE1027246438.pdf Mime Type: application/pdf

October 15th, 2016

To the Center for Scientific Review (CSR) and the Division of Receipt and Referral (DRR):

Enclosed for your consideration is a new grant application entitled "**Seed words: the impact of word learning on category induction"**

This application is in response to the Exploratory/Developmental Research Grant Award (R21), PA-16-161; the research strategy outlines a research program to be completed in two years.

We suggest the National Institute of Child Health and Human Development (NICHD) as the appropriate institute to review this grant.

Because the topic of the grant includes research on typically developing children's language development, the following subcommittee within NICHD is suggested:

(1) Biobehavioral and Behavioral Sciences Subcommittee.

We also recommend a study section that has expertise in the study of children's language:

(1) LCOM

If you need any additional information, please contact one of the PIs: Gary Lupyan (lupyan@wisc.edu) or Haley Vlach (hvlach@wisc.edu).

Thank you for your consideration.

Sincerely,

Gary Lupyan, Ph.D.
Associate Professor
University of Wisconsin, Madison

Haley A. Vlach, Ph.D.
Assistant Professor
University of Wisconsin, Madison

Project/Performance Site Location(s)

Project/Performance Site Primary Location

Organization Name: The Board of Regents of the University of Wisconsin System

* Street1: Suite 6401		Street2: 21 N Park St
* City: Madison	County: Dane	* State: WI: Wisconsin
Province:	* Country: USA: UNITED STATES	* Zip / Postal Code: 53715-1218
DUNS Number: 161202122	* Project/Performance Site Congressional District: WI-002	

File Name	Mime Type

Additional Location(s)

RESEARCH & RELATED Other Project Information

1. * Are Human Subjects Involved?	● Yes	○ No
1.a. If YES to Human Subjects		
Is the Project Exempt from Federal regulations?	○ Yes	● No
If yes, check appropriate exemption number		
Exemption Number:	_ 1 _ 2 _ 3 _ 4 _ 5 _ 6	
If no, is the IRB review Pending?	● Yes	○ No
IRB Approval Date:		
Human Subject Assurance Number	00005399	
2. * Are Vertebrate Animals Used?	○ Yes	● No
2.a. If YES to Vertebrate Animals		
Is the IACUC review Pending?	○ Yes	○ No
IACUC Approval Date:		
Animal Welfare Assurance Number		
3. * Is proprietary/privileged information included in the application?	○ Yes	● No
4.a. * Does the Project have an Actual or Perceived Impact – positive or negative – on the environment?	○ Yes	● No
4.b. If yes, please explain:		
4.c. If this project has an actual or potential impact on the environment, has an exemption been authorized or an environmental assessment (EA) or environmental impact statement (EIS) been performed?	○ Yes	○ No
4.d. If yes, please explain:		
5.a. * Is the research performance site designated, or eligible to be designated, as a historic place?	○ Yes	● No
5.b. If yes, please explain:		
6.a. * Does this project involve activities outside the U.S. or partnership with International Collaborators?	○ Yes	● No
6.b. If yes, identify countries:		
6.c. Optional Explanation:		

7. Project Summary/Abstract	ProjectSummary_DONE1027294422.pdf	Mime Type: application/pdf
8. Project Narrative	ProjectNarrative_DONE1027246431.pdf	Mime Type: application/pdf
9. Bibliography & References Cited	references1027294492.pdf	Mime Type: application/pdf
10. Facilities & Other Resources	Environment_DONE1027246428.pdf	Mime Type: application/pdf
11. Equipment	Equipment_DONE1027246433.pdf	Mime Type: application/pdf

PROJECT SUMMARY/ABSTRACT

Background: We now know that children's language learning is strongly influenced by their linguistic environment including the type and quality of the language they hear. We also know that larger vocabularies during early childhood are associated with positive academic, economic, and even health outcomes later in life. Lacking, however, is a mechanistic understanding of the nature of the causal links between children's word learning and long-term outcomes. The current research addresses this gap by examining whether learning certain "seed words"—words with high inductive potential—accelerates word learning to a greater degree than other words and causes higher performance in non-linguistic categorization tasks.

Specific Aim 1: To identify "seed" words that are associated with consistently faster vocabulary growth

Specific Aim 2: To determine whether teaching "seed" words yields positive language outcomes.

Specific Aim 3: To test when teaching seed words promotes category induction in nonverbal tasks.

Methodology: We will examine children's language and cognitive development in a microgenetic longitudinal study. One-hundred twenty 30- to 36-month-old children will be randomly assigned to one of three experimental conditions: (a) a high inductive word training condition, (b) a low inductive potential word training condition, and (c) a control condition in which children do not receive language training. We predict that children trained on previously identified "seed words" will have faster vocabulary development and higher performance on a nonverbal category induction task than children in the other two experimental conditions.

Significance: The proposed studies will contribute to a greater understanding of children's language development. By undertaking a theory-guided identification of early-learned "seed" words and measuring the effect that learning these words has on subsequent language development, the proposed work will inform the design of future language interventions. By investigating the relationship between word knowledge and category learning, the proposed work aims to understand why language abilities are so closely linked to other cognitive abilities.

PROJECT NARRATIVE

We examine whether children's early learning of "seed words"—words with high inductive potential—predicts faster vocabulary growth in subsequent months and whether knowing such words improves cognitive function. This work helps elucidate the mechanisms responsible for the large differences observed in children's linguistic proficiency and helps to understand why early language proficiency is so predictive of later performance on putatively nonverbal tasks.

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ENVIRONMENT (FACILITIES & OTHER RESOURCES)

The University of Wisconsin, Madison. The University of Wisconsin, Madison is recognized throughout the world as one of the great U.S. universities. Founded in 1848, UW–Madison is the flagship campus of the University of Wisconsin System and the original 1862 land grant university in Wisconsin. It continues to be Wisconsin's comprehensive teaching and research university with a statewide, national, and international mission. The university's academic reputation has been rated among the top 10 in the country in many areas of study since the beginning of the last century. According to current figures from the National Science Foundation, UW–Madison ranks 3rd in annual research expenditures in science and engineering and 5th in expenditures outside science.

In every sense, the University of Wisconsin–Madison is a public university. Active in the dissemination of knowledge, the university is guided by the "Wisconsin Idea," which holds that research and education should improve people's lives beyond the university classroom. The university's longstanding partnership with Wisconsin and its citizens is an integral component of its mission to create, integrate, transfer, and apply knowledge. This scientific environment at UW-Madison will contribute to the probability that the proposed project will be successful. Indeed, the current proposal exemplifies the mission of the university by integrating multiple fields of research with the long-term goal of improving the design of clinical and cognitive interventions, particularly early intervention programs.

Dr. Haley Vlach directs the **Learning, Cognition, & Development (*LCD*) Lab** which is the **primary research site** for the proposed research. The department and university has provided Dr. Vlach with all the tools necessary for success: start-up funds, departmental resources, and collegial support. All of these resources have allowed the Vlach to establish a productive laboratory, the LCD Lab. The LCD Lab is a four-room suite, including a reception room, a work area for researchers, and two testing areas. The LCD Lab will be the primary location when participants visit campus, and for data storage and data analysis.

Resources for recruiting child participants. The LCD lab has existing connections to local child care centers (e.g., daycares, preschools, after school programs) for recruitment and data collection; these are approved research sites by the UW-Madison IRB. The lab also has access to a child care center database consisting of over 200 local centers. The LCD Lab typically enrolls approximately 500 new children in ongoing research studies each year and has a strong track record of working with families to participate in research studies.

The proposed research requires enrolling approximately 120 new children (60 per year). The LCD Lab has more than adequate existing resources for recruiting the participants necessary for the grant application. Indeed, the proposed recruitment requires only 12% of the lab's existing recruitment resources.

Additional resources: Wisconsin Center for Educational Research (WCER). The LCD Lab is also supported by WCER. WCER projects are funded by a variety of government agencies, including the National Institutes of Health (NIH), as well as by a number of private foundations and other organizations. WCER's outside funding exceeds $40 million annually. WCER supports the LCD Lab in the following areas: business and other grant administration services; technical services; and communication and dissemination services. The Business Office provides projects with budgeting, forecasting, accounting and financial management, human resource management, and guidance on human subjects compliance. The Technical Services support staff provides multimedia services, custom software development, computer support, and a number of collaborative technologies, including large-scale, toll-free teleconferencing; point-to-point video conferencing; and web-based desktop sharing tools. The Communication and Dissemination Services staff provides pre-award editorial support, disseminates research through a working paper series, and employs a public information specialist to disseminate research findings through a variety of print and electronic media. Finally, WCER has existing connections to local schools, which could be used as additional participant recruitment sites if needed.

Dr. Gary Lupyan's research primarily involves behavioral studies with college-aged and adult participants as well as computational and corpus analytic work. The lab facilities are less central to the proposed work, but are listed briefly for completeness.

Lupyan's laboratory includes a behavioral testing suite with 4 individual testing rooms and a place for a research assistant to monitor progress via closed-circuit cameras and a master console. Additional space includes a separate testing room containing an Eyelink 1000 eye-tracker and a Soterix Medical 1x1 low-intensity transcranial direct current stimulator (tDCS). The behavioral testing rooms also allow for video and audio recording with audio and video calibration equipment. Lab personnel develop experiments using all

open-source tools (Python, Javascript), making them ideally suited for dissemination. The primary testing population of Lupyan's lab is college-aged students from the department participant pool (approx. 3150 participants per year are available, with each student participating in up to 7.5 hours). Lupyan's lab also collects data from more diverse samples via Amazon Mechanical Turk and other crowdsourcing venues.

EQUIPMENT

See Environment (Facilities & Other Resources) section.

RESEARCH & RELATED Senior/Key Person Profile (Expanded)

PROFILE - Project Director/Principal Investigator

Prefix: First Name*: GARY Middle Name Last Name*: LUPYAN Suffix:

Position/Title*: ASSOCIATE PROFESSOR
Organization Name*: The Board of Regents of the University of Wisconsin System
Department: PSYCHOLOGY-GEN
Division:
Street1*: 1202 W JOHNSON ST
Street2:
City*: MADISON
County:
State*: WI: Wisconsin
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 53706-1611

Phone Number*: 917-843-4868 Fax Number: E-Mail*: LUPYAN@WISC.EDU

Credential, e.g., agency login: glupyan80

Project Role*: PD/PI Other Project Role Category:

Degree Type: PhD Degree Year: 2007

	File Name
Attach Biographical Sketch*:	LupyanBios-ketch_NIH_2016_DONE1027246440.pdf
Attach Current & Pending Support:	

PROFILE - Senior/Key Person

Prefix: First Name*: Haley Middle Name Last Name*: Vlach Suffix:

Position/Title*: Assistant Professor
Organization Name*: The Board of Regents of the University of Wisconsin System
Department: Educational Psychology
Division: Education
Street1*: 1025 W Johnson St
Street2: 859 Educational Sciences
City*: Madison
County: Dane
State*: WI: Wisconsin
Province:
Country*: USA: UNITED STATES
Zip / Postal Code*: 53715-1218

Phone Number*: 608/262-6105 Fax Number: E-Mail*: hvlach@wisc.edu

Credential, e.g., agency login: hvlach30

Project Role*: PD/PI Other Project Role Category:

Degree Type: PhD Degree Year: 2012

	File Name
Attach Biographical Sketch*:	VlachBiosketch_DONE1027246435.pdf
Attach Current & Pending Support:	

PROFILE - Senior/Key Person

Prefix: First Name*: Michael Middle Name Last Name*: Frank Suffix:

Position/Title*: Associate Professor

Organization Name*:	Stanford University
Department:	
Division:	
Street1*:	450 Serra Mall
Street2:	
City*:	Stanford
County:	
State*:	CA: California
Province:	
Country*:	USA: UNITED STATES
Zip / Postal Code*:	94305-2015

Phone Number*: 650 724-4003 Fax Number: E-Mail*: mcfrank@stanford.edu

Credential, e.g., agency login:

Project Role*: Consultant Other Project Role Category:

Degree Type: PhD Degree Year: 2010

	File Name
Attach Biographical Sketch*:	Frank_Bio1027294465.pdf
Attach Current & Pending Support:	

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Gary Lupyan

eRA COMMONS USER NAME (credential, e.g., agency login): glupyan80

POSITION TITLE: Associate Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Cornell University	B.A. Summa cum Laude	05/2002	Cognitive Science
Carnegie Mellon University	Ph.D.	08/2007	Cognitive Psychology / Cognitive Neuroscience
Cornell University	Postdoc	04/2008	Cognitive Science
University of Pennsylvania	Postdoc	05/2010	Cognitive Neuroscience

A. Personal Statement

My primary research agenda is to understand how human cognition and perception are augmented by learning and using anguage, as further detailed in contributions to science sections. To answer this question I employ methods from cognitive science and cognitive neuroscience, including a very wide array of behavioral methods, eye-tracking, neural network simulations, transcranial direct current stimulation, online crowdsourced studies, and large-scale analyses of language grammars and text corpora. My interdisciplinary approach is complimented by training in and collaborations with developmental psychologists including Dr. Haley Vlach, and second PI on this proposal. We believe that our joint expertise is very well suited for the proposed project which combines corpus analytic methods with child-language learning and design and administration of a category induction task.

My lab currently has three graduate students and two postdoctoral trainees. I have previously trained three other postdoctoral fellows one of whom (Lynn Perry) just finished her first year as an Assistant Professor at University of Miami. Beyond training lab personnel, I have been actively involved in graduate training by offering a new course on programming and data-automation techniques specifically designed for psychology graduate students. I have served as the head of the Cognitive and Cognitive Neuroscience area group for two years which involved coordinating training opportunities for graduate students and postdocs and organizing professional development sessions.

These four publications are most closely related to the current proposal.

a. Lupyan, G., Rakison, D. H., & McClelland, J. L. (2007). Language is not just for talking: labels facilitate learning of novel categories. *Psychological Science*, *18*(12), 1077–1082. PMID: 18031415
b. Rakison, D. H., & Lupyan, G. (2008). Developing object concepts in infancy : an associative learning perspective. *Monographs of the Society for Research in Child Development*, *73*(1), 1–110. PMID: 18346226
c. Perry, L. K., & Lupyan, G. (2014). The role of language in multi-dimensional categorization: Evidence from transcranial direct current stimulation and exposure to verbal labels. *Brain and Language*, *135*, 66–72. http://doi.org/10.1016/j.bandl.2014.05.005 PMID: 24980415

d. Edmiston, P., & Lupyan, G. (2015). What makes words special? Words as unmotivated cues. *Cognition*, *143*, 93–100. http://doi.org/doi: 10.1016/j.cognition.2015.06.008 PMID: 26117488

B. Positions and Honors

Positions:

2003-2007 Graduate Student. Carnegie Mellon University and the Center for the Neural Basis of Cognition. Pittsburgh, PA. Advisor: James L. McClelland.
2007-2008 Postdoctoral Researcher, Cornell University, Cognitive Science Program
2008-2010 Postdoctoral Researchers, University of Pennsylvania, Institute for Research in Cognitive Science and Center for Cognitive Neuroscience
2010-2016 Assistant Professor, University of Wisconsin-Madison Dept. of Psychology.
2016- Associate Professor, University of Wisconsin-Madison Dept. of Psychology
2016-2017 Visiting Scientist, Max Planck Institute for Psycholinguistics (Sabbatical)

Selected Honors

2008 APA Division of Experimental Psychology New Investigator Award
2011 APS "Rising Star"
2012 Vilas Associate Award

Other Experience and Professional Memberships

Professional Memberships

Cognitive Science Society, Cognitive Development Society, Society for Research in Child Development, Vision Sciences Society, Psychonomics Society Fellow

Ad Hoc Reviewing

Annual Conference of the Cognitive Science Society, Conference on the Evolution of Language, Cognitive Psychology, Vision Science, Psychonomic Bulletin & Review, QJEP, PNAS, Connection Science, Cognitive Science, Developmental Science, Child Development, Psychological Review, JEP: G, JEP:LMC, Journal of Memory and Language, Cognition, Language and Cognitive Processes, AP&P, Perception, Emotion, Journal of Cognitive Neuroscience, PLoS ONE, Frontiers series, Current Biology, Philosophy of Science, Cambridge University Press, Proceedings of the Royal Society, Behavioral and Brain Sciences, Language Learning, Trends in Cognitive Sciences.

Other synergistic activities:

I have organized numerous symposia (e.g., Cognitive Science Conference, Psychonomics Society, European Society for Cognitive Science, European Society for Philosophy and Psychology
Guest editor of special issues of *Frontiers in Psychology*, *TopiCS in Cognitive Science* on Big Data in Psychology.
Associate Editor, *Journal of Language Evolution* (Oxford University Press)
Member of the Cognitive Science Program Committee

C. Contribution to Science

Language Augmented Cognition and Perception.

One of the core design features of language is the use of words to denote categories, e.g., using the word "dog" to refer to dogs in general. Words are commonly seen as a kind of "pointer" to concepts with the assumption that the word simply maps on to pre-existing concepts. I have argued for an alternative: verbal labels do not simply point or refer to nonlinguistic concepts, but rather actively modulate the construction of these conceptual representations during learning and continue to work as uniquely powerful cues for activate these representations once the concept can be said to be learned. In support of this argument, I have shown that controlling for familiarity, named categories are easier to learn than unnamed ones. Once learned, labels activate conceptual knowledge more effectively than nonverbal cues. For example, "dog" activates knowledge

about dogs more robustly than equally familiar, predictive, and unambiguous nonverbal cues like a barking sound. This *label advantage* extended to newly learned labels which were more effective than newly learned sounds in activating the associated concept, and can be shown to operate within 100 ms of visual onset—a finding that strongly supports the idea that words deploy powerful categorical priors within which subsequent information is processed.

a. Lupyan, G., Thompson-Schill, S.L. (2012). The evocative power of words: Activation of concepts by verbal and nonverbal means. *Journal of Experimental Psychology: General*. 141(1), 170-186. PMID 21928923 PMCID: PMC4124531
b. Lupyan, G., Mirman, D., Hamilton, R., and Thompson-Schill, S.L. (2012). Categorization is modulated by transcranial direct current stimulation over left prefrontal cortex. *Cognition, 124*(1), 36-49. NIHMS372202. PMCID: PMC4114054
c. Lupyan, G. (2012). What do words do? Towards a theory of language-augmented thought. In B. H. Ross (Ed.), *The Psychology of Learning and Motivation* (Vol. 57, pp. 255–297). Academic Press.
d. Lupyan, G. and Mirman, D. (2013). Linking language and categorization: Evidence from aphasia. *Cortex*, *49*(5), 1187–1194. doi:10.1016/j.cortex.2012.06.006 PMID: 22846462 PMID: 22846462

Language, prediction, and the programmable mind.

Converging evidence points to the idea that the central nervous system comprises a hierarchical predictive system with each layer attempting to predict the output of the layer below it. My students and collaborators have been working on a theory that links this idea of predictive coding with the work on language-augmented cognition by viewing words as instrumental to the ability to form high-level hypotheses, used by the organism to differentially weight sensory inputs, for constructing more abstract and compositional mental representations that are critical to the kinds of cognitive flexibility at which humans excel. One consequence of this work for translational impact is understanding the link between language and "general" intelligence. Although contemporary theories of intelligence draw sharp distinctions between "verbal" and "nonverbal" intelligence, it turns out that linguistic skill (vocabulary size, reading quantity) are some of the best predictors of "nonlinguistic" (fluid) intelligence. Understanding the mechanisms underlying these relationships—a growing part of my research program—promises to help ameliorate cognitive effects of impoverished linguistic environments.

a. Lupyan, G. & Ward, E.J. (2013). Language can boost otherwise unseen objects into visual awareness. *Proceedings of the National Academy of Sciences*. doi:10.1073/pnas.1303312110 PMCID: PMC3761589
b. Lupyan, G., & Clark, A. (2015). Words and the World: Predictive coding and the language-perception-cognition interface. *Current Directions in Psychological Science*, *24*(4), 279–284. http://doi.org/10.1177/0963721415570732
c. Lupyan, G., & Bergen, B. (2016). How Language Programs the Mind. *Topics in Cognitive Science*, *8*(2), 408–424. http://doi.org/10.1111/tops.12155 PMID: 26184465
d. Lupyan, G. (2015). Cognitive Penetrability of Perception in the Age of Prediction: Predictive Systems are Penetrable Systems. *Review of Philosophy and Psychology*, *6*(4), 547–569. http://doi.org/10.1007/s13164-015-0253-4

The Linguistic Niche Hypothesis.

A further research focus in my lab concerns the origin of linguistic diversity. Although much is known about the ways that human languages differ, there is at present no comprehensive account of *why* humans speak multiple languages in the first place and why linguistic differences are what they are. In collaboration with investigators in linguistics, biology, and applied mathematics, I am leading an effort to apply ideas from biological evolution and principles of niche construction to understanding linguistic diversity. This research has been having a transformative effect on the field by showing that grammars of language appear to adapt to the socio-demographic environments such that, e.g., languages with many non-native speakers tend to undergo morphological simplification. This work involves large-scale statistical analyses of grammars, corpus analyses (e.g., examining the ways in which American English differs from British English), as well as experiments in which we see how different populations learn new verbal constructions. This work relates to the theme of linking language acquisition in children and adults through a rigorous examination of what aspects of language make language acquisition easier for children and what aspects make it difficult for adult learners. One counter-intuitive prediction of this line of research is that morphological simplification occurring in languages

with histories of adult learning (e.g., English), may simplify its learning by adults as an L2 while presenting additional challenges to learning it by children as an L1.

a. Lupyan, G., & Dale, R. A. (2010). Language Structure Is Partly Determined by Social Structure. *PLoS ONE*, *5*(1), e8559. http://doi.org/10.1371/journal.pone.0008559 PMCID: PMC2798932
b. Dale, R. A., & Lupyan, G. (2012). Understanding the origins of morphological diversity: The linguistic niche hypothesis. *Advances in Complex Systems*, *15*(3), 1150017–1–1150017–16. http://doi.org/10.1142/S0219525911500172
c. Lupyan, G., & Dale, R. A. (2015). The role of adaptation in understanding linguistic diversity. In R. de Busser & R. J. LaPolla (Eds.), *Language Structure and Environment: Social, cultural, and natural factors* (pp. 287–316). John Benjamins Publishing Co.
d. Lupyan, G., & Dale, R. (2016). Why are there different languages? The role of adaptation in linguistic diversity. *Trends in Cognitive Sciences*. 20(9), 649-660. PMID: 27499347

My publications can be found on MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/gary.lupyan.1/bibliography/44627246/public/?sort=date&direction=ascending

D. Research Support

Ongoing Research Support:

Wisconsin Alumni Research Fund (UW2020) 6/2017-6/2019
"From Simple Words to Complex Ideas: Understanding the Role of Language in Learning"
Role: PI (Haley Vlach is a Co-PI on this grant)
This grant funds a collaborative project between three departments (Psychology, Educational Psychology, and Human Development and Family Studies) to investigate the relationship between vocabulary size and cognition in preschool-aged children.

NSF 1331293 (PAC)
"Mechanisms of verbal effects on human categorization" *9/15/13-8/31/2017*
Role: PI
This grant funds the PI's main research program investigating on-line effects of language on conceptual representations particularly in the domain of categorization using behavioral studies and noninvasive neuro stimulation.

NSF 1344279 (INSPIRE Track 1) *9/15/13-8/31/2017*
Role: PI
"Selection as an organizing process: from molecules to languages"
Co PIs: Rick Dale, Suzanne Sindi, David Ardell (UC Merced); Russell Gray (U. Auckland)
This grant funds a highly interdisciplinary research program investigating non-canonical replicators and undertaking experimental studies of effects of network structure on transmission of novel linguistic forms.

Templeton Foundation – Metaknowledge Project Grant *11/2014-4/2017*
Uncovering priors in academic fields
Role: Co-PI
This work attempts to understand what predicts whether academics prefer one theory over another

Templeton Foundation – Metaknowledge Project Grant *11/2014-4/2017*
Using iterated explanations to understand what makes theories satisfying
Role: Co-PI
We are studying what structural features make verbal explanations satisfying.

Completed research support

Language as an adaptive system - Wisconsin Alumni Research Fund (Internal Grant) *7/1/13 – 6/30/14*

Role: PI
This grant provides graduate student support and summer salary support to the PI to pursue work related to the adaptation of linguistic structures to cognitive biases of language learners.

Vilas Associate Award (Internal Grant) *7/1/2013 - 6/30-2015*
Role: PI
“Role of (Un)motivated mappings in language”;
This grant provides summer salary and flexible funds for the PI to pursue his experimental program on the cognitive functions of language in categorization.

Wisconsin Alumni Research Fund (Internal Grant) *7/1/14 – 6/30/15*
Cognitive consequences of electronic writing
Role: PI
This grant provides graduate student support for a project on how the ability to move written text made possible by word processors changes written language.

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: Haley A. Vlach

eRA COMMONS USER NAME (credential, e.g., agency login): hvlach30

POSITION TITLE: Assistant Professor

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Carnegie Mellon University	B.S.	5/2006	Psychology
University of California, Los Angeles	M.A.	12/2007	Psychology
University of California, Los Angeles	Ph.D.	6/2012	Psychology

A. Personal Statement

A central goal of the proposed experiments is to examine the role of word learning and vocabulary in children's cognitive development. During graduate school at UCLA, I received formal training in studying children's language and cognition. I have published numerous journal articles on word learning and have received several awards for this work. For instance, I was recently awarded the William Chase Award, a prestigious early career award in cognitive science. The current application builds logically on my prior work and represents the next step toward understanding how language promotes children's cognitive development.

I have the training, expertise, and institutional resources to successfully carry out the proposed experiments. As an Assistant Professor at the University of Wisconsin, Madison, I have established my own laboratory, the Learning, Cognition, and Development (LCD) Lab. In turn, I have established an independent line of research focusing on examining how word learning occurs across timescales (seconds, days, weeks, months, etc.). In addition, I have successfully administered multiple projects and grants, collaborated with other researchers, and produced several peer-reviewed publications from each project. These studies include NIH-funded projects on children's word learning and cognitive development. In sum, I have a demonstrated record of successful and productive research projects and my expertise and experience have prepared me to contribute to the proposed project.

Listed below are four journal articles that are most closely related to the current proposal:

Miller, H. E., Vlach, H. A., & Simmering, V. R. (in press). Producing spatial words is not enough: Understanding the relation between language and spatial cognition. *Child Development*.

Vlach, H. A., & DeBrock, C. A. (in press). Remember dax? Relations between children's cross-situational word learning, memory, and language abilities. *Journal of Memory and Language*.

Vlach, H. A. (2016). How we categorize objects is related to how we remember them: The shape bias as a memory bias. *Journal of Experimental Child Psychology, 152*, 12–30. doi: 10.1016/j.jecp.2016.06.013

Vlach, H. A. (2014). The spacing effect in children's generalization of knowledge: Allowing children time to forget promotes their ability to learn. *Child Development Perspectives, 8*, 163-168. doi: 10.1111/cdep.12079

B. Positions and Honors

Positions and Professional Experience

2012 – present: Assistant Professor, University of Wisconsin, Madison

Associate Editor and/or Editorial Board: *Frontiers in Developmental Psychology (2011 – present); Journal of Experimental Child Psychology (2016 – present)*

Ad hoc Reviewer (journals): *Applied Cognitive Psychology; Applied Psycholinguistics; British Journal of Developmental Psychology; British Journal of Educational Psychology; Child Development; Cognition; Cognitive Development; Cognitive Science; Developmental Psychology; Frontiers in Cognitive Science; Frontiers in Developmental Psychology; Frontiers in Language Sciences; Infant Behavior and Development; Infant and Child Development; Journal of Cognition and Development; Journal of Experimental Child Psychology; Journal of Experimental Psychology: Learning, Memory, and Cognition; Language Learning and Development; Journal of Memory and Language*

Ad hoc Reviewer (conferences): *Cognitive Development Society, Cognitive Science Society, International Conference on Development and Learning and on Epigenetic Robots, Society for Research on Child Development*

Ad hoc Reviewer (grants): *National Science Foundation*

Selected Honors and Awards

2015	William Chase Memorial Award, early career award in cognitive science
2013, 2014, & 2015	UW-Madison Hilldale Faculty Fellowship Award
2011	Society for Research in Child Development (SRCD) Student Travel Award
2010	Robert Glushko and Pamela Samuelson Award, Cognitive Science Society
2010	Distinction in Teaching Award, UCLA
2008-2009	Graduate Mentorship Research Fellowship, UCLA
2008 & 2009	Graduate Mentorship Summer Research Fellowship, UCLA
2008	NSF Graduate Research Fellowship, Honorable Mention
2007-2008	CONNECT Graduate Student Research Fellowship, UCLA
2006-2007	University Chancellor's Award and Fellowship, UCLA
2006	Gretchen Goldsmith Lankford Fellowship, Carnegie Mellon University
2006	Phi Beta Kappa, Carnegie Mellon University

C. Contribution to Science

1. Since the 1950s, memory researchers hypothesized that spaced learning should deter the generalization of knowledge because the forgetting that occurs between learning events limits learners' ability to retrieve prior learning. My work has demonstrated that spaced learning promotes children's word learning and implicates forgetting as the mechanism that supports, rather than deters, children's language development. This work counters the intuitive assumption that forgetting uniformly constrains children's learning, suggesting instead that forgetting is a domain-general process that promotes cognitive development. From this body of work, I developed a theoretical account to explain how forgetting promotes children's word learning and generalization: the *forgetting-as-abstraction account*. I was the leading researcher on each project that led to this theory and was the Co-PI on the NIH grant (R03 HD064909-01A1) that supported the research.

Listed below are four journal articles that are most closely related to this work:

Vlach, H. A. (2014). The spacing effect in children's generalization of knowledge: Allowing children time to forget promotes their ability to learn. *Child Development Perspectives, 8*, 163-168. doi: 10.1111/cdep.12079

Vlach, H. A., & Kalish, C. W. (2014). Temporal dynamics of categorization: Forgetting as the basis of abstraction and generalization. *Frontiers in Psychology, 5:1021*. doi: 10.3389/fpsyg.2014.01021

Vlach, H. A., Ankowski, A. A., & Sandhofer, C. M. (2012). At the same time or apart in time? The role of presentation timing and retrieval dynamics in generalization. *Journal of Experimental Psychology: Learning, Memory, & Cognition, 38*, 246-254. doi: 10.1037/a0025260

Vlach, H. A., Sandhofer, C. M., & Kornell, N. (2008). The spacing effect in young children's memory and category induction. *Cognition, 109*, 163-167. doi: 10.1016/j.cognition.2008.07.013

2. A long held assumption in research on children's word learning and language development is that, once children have mapped a word to a referent, they retain and can retrieve this mapping over extended periods of time. My work has challenged this assumption and demonstrated that children rapidly forget word-referent mappings. Moreover, my work has demonstrated that children's retention and retrieval of word pairings follows a similar pattern as forgetting curves from memory tasks, suggesting a central role of memory processes in children's word learning. I have been the leading researcher on several projects in this line of research. Moreover, I am the PI on a NIH grant (R03 HD081153-01A1) that is currently funding this work.

Listed below are four journal articles that are most closely related to this work:

Vlach, H. A., & Sandhofer, C. M. (2014). Retrieval dynamics and retention in cross-situational statistical learning. *Cognitive Science*, *38*, 757-774. doi: 10.1111/cogs.12092

Vlach, H. A., & Johnson, S. P. (2013). Memory constraints on infants' cross-situational statistical learning. *Cognition*, 127, 375-382. doi: 10.1016/j.cognition.2013.02.015

Vlach, H. A., & Sandhofer, C. M. (2012). Fast mapping across time: Memory mechanisms support children's ability to retain words. *Frontiers in Psychology, 3:46*. doi: 10.3389/fpsyg.2012.00046

Vlach, H. A., & Sandhofer, C. M. (2011). Developmental differences in children's context-dependent word learning. *Journal of Experimental Child Psychology, 108*, 394-401. doi: 10.1016/j.jecp.2010.09.011

3. A central theme of my research has been the examination of mechanisms underlying children's learning to (a) understand cognition and how cognition develops and (b) build an empirical base for the design of successful interventions. I have a body of work dedicated to bridging traditional psychological science with applied settings by elucidating how domain general cognitive processes (attention, memory, etc.) can be manipulated during interventions to support learning. In particular, I conducted several studies examining the spacing effect in learning interventions for children, a long-term goal of the proposed research in this grant.

Listed below are three journal articles that are most closely related to this work:

Gluckman, M., Vlach, H. A., & Sandhofer, C. M. (2014). Spacing simultaneously promotes multiple forms of learning in children's science curriculum. *Applied Cognitive Psychology, 28*, 266-273. doi: 10.1002/acp.2997

Vlach, H. A., & Sandhofer, C. M. (2012). Distributing learning over time: The spacing effect in children's acquisition and generalization of science concepts. *Child Development, 83*, 1137 - 1144. doi: 10.1111/j.1467-8624.2012.01781.x

Vlach, H. A. & Carver, S. M. (2008). The effects of observation coaching on children's graphic representations. *Early Childhood Research & Practice, 10*, 1-15.

Complete List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/haley.vlach.1/bibliography/47285445/public/?sort=date&direction=ascending

D. Research Support

Ongoing Research Support

Wisconsin Alumni Research Fund, UW2020, Lupyan (PI) June 2017 – June 2019
Title: From simple words to complex ideas: Understanding the role of language in learning
Project Focus: This grant funds studies investigating the relationship between vocabulary size and cognition in preschool-aged children.
Role: Co-PI

NSF DRL 1561531, Vlach (PI) Sept 2016 – Aug 2019
Title: To compare or space? The role of timing in children's science learning.
Project Focus: This research examines how the timing of learning effects children's acquisition of science vocabulary and concepts
Role: PI

NIH/NICHD R03 HD081153-01A1, Vlach (PI) Mar 2015 – Feb 2017
Title: Developing the ability to retain and retrieve word mappings across time.
Project Focus: This research examines how memory and language abilities contribute to children's retrieval of word mappings across timescales (seconds, minutes, days, weeks, etc.)
Role: PI

Completed Research Support (in chronological order)

Wisconsin Alumni Research Foundation, Vlach (PI) July 2015 – June 2016
Title: Individual and developmental differences in spaced learning
Project focus: The goal of this research is to outline the degree to which long-term memory abilities can predict the retention interval of massed vs. spaced information.
Role: PI

Wisconsin Alumni Research Foundation, Vlach (PI) July 2014 – June 2015
Title: Memory processes in children's cross-situational word learning.
Project Focus: The goal of this research was to outline how children develop the ability to retain and retrieve word-object pairings in cross-situational word learning tasks.
Role: PI

Wisconsin Alumni Research Foundation, Vlach (PI) July 2013 – June 2014
Title: Memory processes in young children's categorization and generalization.
Project Focus: This research examined how the timing of learning events promotes young children's ability to abstract relevant and irrelevant features of novel object categories.
Role: PI

MARCS Institute Research Grant, Escudero, Mulak, & Vlach (PIs) Aug 2012 – June 2013
Title: Cross-situational word learning: Effects of phonological similarity and set size.
Project Focus: This research examined infants' and adults' ability to use multiple cognitive processes (e.g., memory for auditory and visual input) in order to acquire new words in ambiguous learning situations.
Role: PI

NIH/NICHD R03 HD064909-01A1, Sandhofer (PI) Dec 2010 – Nov 2012
Title: Desirable difficulties in children's word learning.
Project Focus: This research examined how creating cognitive challenges during learning can promote young children's retention of new words.
Role: Co-PI

Excellence in Research Award, University of California, Los Angeles, Vlach (PI) Sept 2008 – Jun 2012
Title: Memory processes in children's inductive learning.
Project Focus: This research examined how forgetting and contextual variation support and deter young children's category learning, inductive learning, and generalization.
Role: PI

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. DO NOT EXCEED FIVE PAGES.

NAME: Frank, Michael C.

eRA COMMONS USER NAME (credential, e.g., agency login): frank.michael

POSITION TITLE: Associate Professor of Psychology and, by courtesy, Linguistics

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Stanford University	B.S.	08/2005	Symbolic Systems
Stanford University	B.A.	08/2005	Comparative Literature
Massachusetts Institute of Technology	Ph.D.	07/2010	Brain and Cognitive Sciences

A. Personal Statement

I am a developmental and cognitive psychologist with expertise in language acquisition, social cognition, and psycholinguistics more broadly. My work uses experimental and computational tools to provide a detailed characterization of both the social input to language learning and the learning mechanisms that operate over this input. I am especially interested in using novel experimental methods such as free-viewing eye-tracking and head-mounted camera data to provide information about the social context of children's word learning. The extra detail afforded by these methods has the promise of providing important data relevant to distinguishing between theoretical proposals. In addition, greater fidelity of measurement may have important clinical applications to social and language disorders such as autism. One important focus of my work in this area has been the development of analytic methods for eye-tracking analysis, including the use of statistical methods for correcting calibrations and computer vision for identifying social targets in naturalistic data. A second focus has been the creation of data-intensive resources such as Wordbank (http://wordbank.stanford.edu) and MetaLab (http://metalab.stanford.edu) to promote data sharing and aggregation in developmental psychology.

B. Positions and Honors

Positions and Employment

2014-Present Associate Professor of Psychology and, by courtesy, Linguistics, Stanford University, Stanford, CA

2010-Present Assistant Professor of Psychology and, by courtesy, Linguistics, Stanford University, Stanford, CA

Other Experience and Professional Memberships

2016-Present	Founding Member and Interim Executive Committee, Society for the Improvement of Psychological Science (SIPS)
2016-Present	Advisory Board, Databrary
2014-Present	Advisory Board, MacArthur-Bates Communicative Development Inventory
2014-Present	Governing Board Member, Cognitive Science Society
2010-Present	Program Committee, Cognitive Science Society
2006-Present	Member, Society for Research in Child Development
2005-Present	Member, Cognitive Science Society
2007-2009	Executive board member, Linguistic Society of America

Honors

2014	Kavli Frontiers of Science Fellow
2011	Robert J. Glushko Dissertation Prize, Cognitive Science Society
2011	Association for Psychological Science Rising Star
2005-2010	National Science Foundation Graduate Fellowship
2005-2010	Jacob Javits Fellowship for Graduate Study
2007-2009	Linguistic Society of America Bloch Fellowship
2009	Walle Nauta Award for Continued Dedication to Teaching, MIT BCS
2008	David Marr Prize for Best Student Paper, Cognitive Science Society
2008	Angus MacDonald Award for Excellence in Undergraduate Teaching, MIT BCS

C. Contribution to Science

1. What are the mechanisms of early language learning? I have also developed computational models for early word learning and other aspects of early language development (word segmentation, rule learning). These models have been applied to naturalistic observations as well as a range of experimental phenomena. They provide insights into how disparate empirical findings can be united into a single coherent framework instantiating statistical inferences over social representations.
   a. Roy, B. C., Frank, M. C., DeCamp, P., Miller, M., Roy, D. (2015). Predicting the birth of a spoken word. *Proceedings of the National Academy of Sciences, 112*, 12663–12668. PMID: 26392523
   b. Frank, M. C., Goldwater, S., Griffiths, T. & Tenenbaum, J. (2010). Modeling human performance in statistical word segmentation. *Cognition, 117,* 107–125. PubMed PMID: 20832060.
   c. Frank, M. C. & Tenenbaum, J. B. (2011). Three ideal observer models for rule learning in simple languages. *Cognition, 120,* 360-371. PubMed PMID: 21130985.
   d. Frank, M. C., Goodman, N. D., & Tenenbaum, J. (2009). Using speakers' referential intentions to model early cross-situational word learning. *Psychological Science, 20,* 578–585. PMID: 19389131.

2. How do we go beyond what is said to infer what a speaker actually intends to communicate? The study of linguistic pragmatics is an important component of understanding how social cognition supports language use. It also has broad implications for language acquisition more generally. My work has helped to develop a popular and influential computational framework for pragmatic language understanding, the Rational Speech Act model. In addition, I have applied this model and its variants to children's word learning and language comprehension.
   a. Nordmeyer, A. E., & Frank, M.C. (2014). The role of context in young children's comprehension of negation. *Journal of Memory and Language, 77*, 25-39.
   b. Frank, M. C., & Goodman, N. D. (2014). Inferring word meanings by assuming that speakers are informative. *Cognitive Psychology, 75*, 80-96. PMID: 25238461.
   c. Shafto, P., Goodman, N., & Frank, M. C. (2012). Learning from others: The consequences of psychological reasoning for human learning. *Perspectives in Psychological Science, 7, 341-351.*
   d. Frank, M.C. & Goodman, N. D. (2012). Predicting pragmatic reasoning in language games. *Science, 336*, 998. PMID: 22628647.

3. How do we use big data to characterize children's early language learning and how do we promote reproducible methods in child language research? In a new line of research, I have been exploring the intersection between issues of reproducibility and theory building in developmental psychology. I

contributed to the Open Science Collaboration's seminal reproducibility project, and am leading the ManyBabies collaborative replication project for infancy research. I have also worked to create online data-sharing resources for exploration, theory-development, and data aggregation (including Wordbank and MetaLab). These resources allow researchers to test theories against larger datasets and to create synthetic, quantitative theories that constrain experimental work. Together, this work aims to consolidate progress in studying early language learning and identify robust and replicable phenomena.

a. Lewis, M. L., Braginsky, M., Tsuji, S., Bergmann, C., Piccinini, P., Cristia, A., Frank, M. C. (under review). A quantitative synthesis of early language acquisition using meta-analysis.
b. Frank, M. C., Bergelson, E., Bergmann, C., Cristia, A., Floccia, C., Gervain, J., Hamlin, J. K., Hannon, E. E., Kline, M., Levelt, C., Lew-Williams, C., Nazzi, T., Panneton, R., Rabagliati, H., Soderstrom, M., Sullivan, J., Waxman, S., Yurovsky, D. (under review). A collaborative approach to infant research: Promoting reproducibility, best practices, and theory-building.
c. Frank, M. C., Braginsky, M., Yurovsky, D., Marchman, V. A. (2016). Wordbank: An open repository for developmental vocabulary data. *Journal of Child Language.* PMID: 27189114
d. Open Science Collaboration (2015). Estimating the reproducibility of psychological science. *Science, 349*. PMID: 26315443

4. How do we learn about the social world? While very young infants have a preference to look at faces, this preference is weak and inconsistent in the face of competing attentional demands. I have used eye-tracking methods to measure infants' ability to track faces and to attend to the social world more broadly. This work suggests that although face preferences are present early, they rely on visual search abilities and other mechanisms of visual attention that develop over the first several years of life. Abilities that are present in well-controlled studies may thus take several years to become robust, even in typical development.
    a. Frank, M. C., Amso, D., & Johnson, S. P. (2014). Visual search and attention to faces in early infancy. *Journal of Experimental Child Psychology, 118*, 13-26.
    b. Frank, M. C., Vul, E., & Saxe, R. (2012). Measuring the development of social attention using free-viewing. *Infancy, 17*, 355-375.
    c. Fletcher-Watson, S., Leekam, S. R., Benson, V., Frank, M. C., & Findlay, J. M., (2009). Eye-movement data reveals attention to social information in autism spectrum disorder. *Neuropsychologia, 47,* 248–257. PMID: 18706434.
    d. Frank, M. C., Vul, E., & Johnson, S. P. (2009). Development of infants' attention to faces during the first year. *Cognition, 110,* 160–170. PMCID: 2663531.

5. What is the relationship between the language we speak and the way we think about the world? My hypothesis is that language provides a tool for information storage and for computations. In support of this hypothesis, I have conducted research on cross-linguistic differences in cognition in the domains of number and color specifically. Our findings suggest that, while cross-linguistic differences in vocabulary can lead to differences in performance for complex tasks, verbal interference removes these differences. Thus, effects of language on cognition tend to be momentary and directly supported by linguistic representations.
    a. Frank, M. C., Fedorenko, E., Saxe, R., Lai, P., & Gibson, E. (2012). Verbal interference suppresses exact numerical representation. *Cognitive Psychology, 64*, 74-92. PMID: 22112644.
    b. Frank, M. C. & Barner, D. (2012). Representing exact number visually using mental abacus. *Journal of Experimental Psychology: General,* 141, 134-149. PMID: 21767040.
    c. Frank, M. C., Everett, D. L., Fedorenko, E., & Gibson, E., (2008). Number as a cognitive technology: Evidence from Pirahã language and cognition. *Cognition, 108,* 819–824. PMID: 18547557.
    d. Winawer J, Witthoft N, Frank MC, Wu L, Wade AR, Boroditsky L. Russian blues reveal effects of language on color discrimination. *Proceedings of the National Academy of Sciences*, 104(19), 7780-5. PMCID: PMC1876524.

Complete List of Published Work in MyBibliography:
http://www.ncbi.nlm.nih.gov/sites/myncbi/michael.frank.2/bibliography/44977067/public

D. Research Support

ACTIVE

BCS-1528526 (Frank) Frank (PI) 7/01/15 – 8/30/18
National Science Foundation
Wordbank: An Open Repository For Developmental Vocabulary Data
Support for a website aggregating data on the MacArthur-Bates Communicative Development Inventory, a widely-used vocabulary measure.

Role: PI

BCS-1456077 (Frank, Levy) Frank (Co-PI) 9/01/15 – 8/30/18
National Science Foundation
Collaborative Research: CompCog: Broad-coverage probabilistic models of communication in context
Support for research on probabilistic models of language comprehension in context and experiments on human language comprehension.

Role: Co-PI

HRD-1550667 Frank (Co-PI) 9/15/15 – 8/31/16
National Science Foundation
Collaborative Research: RAPID: Evaluating the Cognitive and Educational Benefits of Mental Abacus Training
Support for evaluation of mental arithmetic training for math education

Role: Co-PI

COMPLETED

R21 DC013689 Hardan (PI) 01/01/14 – 12/31/15
National Institutes of Health
Pivotal Response Treatment Package for Young Children with Autism
The goal of this investigation is to conduct a randomized controlled trial to examine the efficacy of a pivotal response treatment package (PRT-P), which combines parent training with in-home therapy, in improving language skills in young nonverbal children with autism.

Role: Co-PI

N00014-13-1-0287 Potts (PI) 01/01/13 – 12/31/15
Dept. of the Navy
Grounded Language Understanding as Social Cognition
The goal of this project is to create and test models of pragmatic language processing in simple referential language contexts.

Role: Co-PI

John Merck Scholars Frank (PI) 5/01/11 – 4/31/15
John Merck Foundation
Social attention and word learning in typical development and autism spectrum disorders
Support for research using eye-tracking methods for measuring correlations between linguistic and social-cognitive abilities across development.

Role: PI

RESEARCH & RELATED BUDGET - SECTION A & B, BUDGET PERIOD 1

*** ORGANIZATIONAL DUNS:** 161202122

*** Budget Type:** ● Project ○ Subaward/Consortium

Enter name of Organization: The Board of Regents of the University of Wisconsin System

*** Start Date:** 07-01-2017 *** End Date:** 06-30-2018 **Budget Period: 1**

A. Senior/Key Person

Prefix	* First Name	Middle Name	* Last Name	Suffix	* Project Role	Base Salary ($)	Cal. Months	Acad. Months	Sum. Months	* Requested Salary ($)	* Fringe Benefits ($)	* Funds Requested ($)
1.	IGOR	GARY	LUPYAN		PD/PI	0.00				0.00	0.00	0.00
2.	Haley		Vlach							0.00	0.00	0.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: Mime Type: **Total Senior/Key Person** **0.00**

B. Other Personnel

* Number of Personnel	* Project Role	Cal. Months	Acad. Months	Sum. Months	* Requested Salary ($)	* Fringe Benefits	* Funds Requested ($)
Total Number Other Personnel						**Total Other Personnel**	
						Total Salary, Wages and Fringe Benefits (A+B)	**0.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, BUDGET PERIOD 1

*** ORGANIZATIONAL DUNS:** 161202122

*** Budget Type:** ● Project ○ Subaward/Consortium

Enter name of Organization: The Board of Regents of the University of Wisconsin System

*** Start Date:** 07-01-2017 *** End Date:** 06-30-2018 **Budget Period: 1**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	* Funds Requested ($)
Total funds requested for all equipment listed in the attached file	
Total Equipment	

Additional Equipment: File Name: Mime Type:

D. Travel	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	
2. Foreign Travel Costs	
Total Travel Cost	

E. Participant/Trainee Support Costs	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees	**Total Participant/Trainee Support Costs**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, BUDGET PERIOD 1

*** ORGANIZATIONAL DUNS:** 161202122

*** Budget Type:** ● Project ○ Subaward/Consortium

Enter name of Organization: The Board of Regents of the University of Wisconsin System

*** Start Date:** 07-01-2017 *** End Date:** 06-30-2018 **Budget Period: 1**

F. Other Direct Costs	**Funds Requested ($)**
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8. Tuition Remission	0.00
Total Other Direct Costs	**0.00**

G. Direct Costs	**Funds Requested ($)**
Total Direct Costs (A thru F)	**0.00**

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	*** Funds Requested ($)**
1. MTDC	53	150,000.00	79,500.00
		Total Indirect Costs	**79,500.00**

Cognizant Federal Agency DHHS, Arif Karim, Dallas, 214-767-3261

(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)**
Total Direct and Indirect Institutional Costs (G + H)	**79,500.00**

J. Fee	**Funds Requested ($)**

K. * Budget Justification File Name: Mime Type:

(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION A & B, BUDGET PERIOD 2

*** ORGANIZATIONAL DUNS:** 161202122

*** Budget Type:** ● Project ❍ Subaward/Consortium

Enter name of Organization: The Board of Regents of the University of Wisconsin System

*** Start Date:** 07-01-2018 *** End Date:** 06-30-2019 **Budget Period: 2**

A. Senior/Key Person

Prefix	* First Name	Middle Name	* Last Name	Suffix	* Project Role	Base Salary ($)	Cal. Months	Acad. Months	Sum. Months	* Requested Salary ($)	* Fringe Benefits ($)	* Funds Requested ($)
1.	IGOR	GARY	LUPYAN		PD/PI	0.00				0.00	0.00	0.00
2.	Haley		Vlach							0.00	0.00	0.00

Total Funds Requested for all Senior Key Persons in the attached file

Additional Senior Key Persons: File Name: Mime Type: **Total Senior/Key Person** **0.00**

B. Other Personnel

* Number of Personnel	* Project Role	Cal. Months	Acad. Months	Sum. Months	* Requested Salary ($)	* Fringe Benefits	* Funds Requested ($)
Total Number Other Personnel						**Total Other Personnel**	
						Total Salary, Wages and Fringe Benefits (A+B)	**0.00**

RESEARCH & RELATED Budget {A-B} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTION C, D, & E, BUDGET PERIOD 2

*** ORGANIZATIONAL DUNS:** 161202122

*** Budget Type:** ● Project ○ Subaward/Consortium

Enter name of Organization: The Board of Regents of the University of Wisconsin System

*** Start Date:** 07-01-2018 *** End Date:** 06-30-2019 **Budget Period: 2**

C. Equipment Description

List items and dollar amount for each item exceeding $5,000

Equipment Item	* Funds Requested ($)
Total funds requested for all equipment listed in the attached file	
Total Equipment	

Additional Equipment: File Name: Mime Type:

D. Travel	Funds Requested ($)
1. Domestic Travel Costs (Incl. Canada, Mexico, and U.S. Possessions)	
2. Foreign Travel Costs	
Total Travel Cost	

E. Participant/Trainee Support Costs	Funds Requested ($)
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other:	
Number of Participants/Trainees	**Total Participant/Trainee Support Costs**

RESEARCH & RELATED Budget {C-E} (Funds Requested)

RESEARCH & RELATED BUDGET - SECTIONS F-K, BUDGET PERIOD 2

*** ORGANIZATIONAL DUNS:** 161202122

*** Budget Type:** ● Project ○ Subaward/Consortium

Enter name of Organization: The Board of Regents of the University of Wisconsin System

*** Start Date:** 07-01-2018 *** End Date:** 06-30-2019 **Budget Period: 2**

F. Other Direct Costs	**Funds Requested ($)**
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8. Tuition Remission	0.00
Total Other Direct Costs	**0.00**

G. Direct Costs	**Funds Requested ($)**
Total Direct Costs (A thru F)	**0.00**

H. Indirect Costs

Indirect Cost Type	**Indirect Cost Rate (%)**	**Indirect Cost Base ($)**	*** Funds Requested ($)**
1. MTDC	53	125,000.00	66,250.00
		Total Indirect Costs	**66,250.00**

Cognizant Federal Agency DHHS, Arif Karim, Dallas, 214-767-3261

(Agency Name, POC Name, and POC Phone Number)

I. Total Direct and Indirect Costs	**Funds Requested ($)**
Total Direct and Indirect Institutional Costs (G + H)	**66,250.00**

J. Fee	**Funds Requested ($)**

K. * Budget Justification File Name: Mime Type:

(Only attach one file.)

RESEARCH & RELATED Budget {F-K} (Funds Requested)

RESEARCH & RELATED BUDGET - Cumulative Budget

	Totals ($)
Section A, Senior/Key Person	**0.00**
Section B, Other Personnel	
Total Number Other Personnel	
Total Salary, Wages and Fringe Benefits (A+B)	**0.00**
Section C, Equipment	
Section D, Travel	
1. Domestic	
2. Foreign	
Section E, Participant/Trainee Support Costs	
1. Tuition/Fees/Health Insurance	
2. Stipends	
3. Travel	
4. Subsistence	
5. Other	
6. Number of Participants/Trainees	
Section F, Other Direct Costs	
1. Materials and Supplies	
2. Publication Costs	
3. Consultant Services	
4. ADP/Computer Services	
5. Subawards/Consortium/Contractual Costs	
6. Equipment or Facility Rental/User Fees	
7. Alterations and Renovations	
8. Other 1	
9. Other 2	
10. Other 3	
Section G, Direct Costs (A thru F)	**0.00**
Section H, Indirect Costs	**145,750.00**
Section I, Total Direct and Indirect Costs (G + H)	**145,750.00**
Section J, Fee	

R&R SUBAWARD BUDGET ATTACHMENT(S) FORM

Subaward IDC Ceiling: 25,000

Period	Subaward Direct Costs	Subaward Indirect Costs	Subaward Costs	Allocated To IDC Base
All Subawards				
1				
2				
All				

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1. Human Subjects Section

Clinical Trial? ☐ Yes ☒ No

*Agency-Defined Phase III Clinical Trial? ☐ Yes ☐ No

2. Vertebrate Animals Section

Are vertebrate animals euthanized? ☐ Yes ☐ No

If "Yes" to euthanasia

Is method consistent with American Veterinary Medical Association (AVMA) guidelines? ☐ Yes ☐ No

If "No" to AVMA guidelines, describe method and provide scientific justification

3. *Program Income Section

*Is program income anticipated during the periods for which the grant support is requested?

☐ Yes ☒ No

If you checked "yes" above (indicating that program income is anticipated), then use the format below to reflect the amount and source(s). Otherwise, leave this section blank.

*Budget Period	*Anticipated Amount ($)	*Source(s)

PHS 398 Cover Page Supplement

4. Human Embryonic Stem Cells Section

*Does the proposed project involve human embryonic stem cells? ☐ Yes ☒ No

If the proposed project involves human embryonic stem cells, list below the registration number of the specific cell line(s) from the following list: http://stemcells.nih.gov/research/registry/. Or, if a specific stem cell line cannot be referenced at this time, please check the box indicating that one from the registry will be used:

Cell Line(s): ☐ Specific stem cell line cannot be referenced at this time. One from the registry will be used.

5. Inventions and Patents Section (RENEWAL)

*Inventions and Patents: ☐ Yes ☐ No

If the answer is "Yes" then please answer the following:

*Previously reported: ☐ Yes ☐ No

6. Change of Investigator / Change of Institution Section

☐ Change of Project Director / Principal Investigator

Name of former Project Director/Principal Investigator

Prefix:

*First Name:

Middle Name:

*Last Name:

Suffix:

☐ Change of Grantee Institution

*Name of former institution:

PHS 398 Modular Budget, Periods 1 and 2

OMB Number: 0925-0001

Budget Period: 1

Start Date: 07/01/2017 End Date: 06/30/2018

A. Direct Costs

	Funds Requested ($)
* Direct Cost less Consortium Indirect (F&A)	150,000.00
Consortium Indirect (F&A)	0.00
* Total Direct Costs	150,000.00

B. Indirect (F&A) Costs

	Indirect (F&A) Type	Indirect (F&A) Rate (%)	Indirect (F&A) Base ($)	* Funds Requested ($)
1.	MTDC	53.00	150,000.00	79,500.00
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number) DHHS, Arif Karim, Dallas, 214-767-3261

Indirect (F&A) Rate Agreement Date 04/27/2015

Total Indirect (F&A) Costs 79,500.00

C. Total Direct and Indirect (F&A) Costs (A + B)

Funds Requested ($) 229,500.00

Budget Period: 2

Start Date: 07/01/2018 End Date: 06/30/2019

A. Direct Costs

	Funds Requested ($)
* Direct Cost less Consortium Indirect (F&A)	125,000.00
Consortium Indirect (F&A)	0.00
* Total Direct Costs	125,000.00

B. Indirect (F&A) Costs

	Consortium Indirect	Indirect (F&A) Rate (%)	Indirect (F&A) Base ($)	* Funds Requested ($)
1.	MTDC	53.00	125,000.00	66,250.00
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number) DHHS, Arif Karim, Dallas, 214-767-3261

Indirect (F&A) Rate Agreement Date 04/27/2015

Total Indirect (F&A) Costs 66,250.00

C. Total Direct and Indirect (F&A) Costs (A + B)

Funds Requested ($) 191,250.00

PHS 398 Modular Budget, Periods 3 and 4

OMB Number: 0925-0001

Budget Period: 3

Start Date: End Date:

A. Direct Costs

Funds Requested ($)

* Direct Cost less Consortium Indirect (F&A)

Consortium Indirect (F&A)

* Total Direct Costs

B. Indirect (F&A) Costs

	Indirect (F&A) Type	Indirect (F&A) Rate (%)	Indirect (F&A) Base ($)	* Funds Requested ($)
1.				
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number)

Indirect (F&A) Rate Agreement Date

Total Indirect (F&A) Costs

C. Total Direct and Indirect (F&A) Costs (A + B)

Funds Requested ($)

Budget Period: 4

Start Date: End Date:

A. Direct Costs

Funds Requested ($)

* Direct Cost less Consortium Indirect (F&A)

Consortium Indirect (F&A)

* Total Direct Costs

B. Indirect (F&A) Costs

	Indirect (F&A) Type	Indirect (F&A) Rate (%)	Indirect (F&A) Base ($)	* Funds Requested ($)
1.				
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number)

Indirect (F&A) Rate Agreement Date

Total Indirect (F&A) Costs

C. Total Direct and Indirect (F&A) Costs (A + B)

Funds Requested ($)

PHS 398 Modular Budget, Period 5 and Cumulative

OMB Number: 0925-0001

Budget Period: 5

Start Date: End Date:

A. Direct Costs

Funds Requested ($)

* Direct Cost less Consortium Indirect (F&A)

Consortium Indirect (F&A)

* Total Direct Costs

B. Indirect (F&A) Costs

	Indirect (F&A) Type	Indirect (F&A) Rate (%)	Indirect (F&A) Base ($)	* Funds Requested ($)
1.				
2.				
3.				
4.				

Cognizant Agency (Agency Name, POC Name and Phone Number)

Indirect (F&A) Rate Agreement Date

Total Indirect (F&A) Costs

C. Total Direct and Indirect (F&A) Costs (A + B)

Funds Requested ($)

Cumulative Budget Information

1. Total Costs, Entire Project Period

* Section A, Total Direct Cost less Consortium Indirect (F&A) for Entire Project Period	$	275,000.00
Section A, Total Consortium Indirect (F&A) for Entire Project Period	$	0.00
* Section A, Total Direct Costs for Entire Project Period	$	275,000.00
* Section B, Total Indirect (F&A) Costs for Entire Project Period	$	145,750.00
* Section C, Total Direct and Indirect (F&A) Costs (A+B) for Entire Project Period	$	420,750.00

2. Budget Justifications

Personnel Justification	Personnel_Justification_DONE1027294457.pdf
Consortium Justification	
Additional Narrative Justification	Additional_Narrative1027294459.pdf

Tracking Number:

Attachments

PersonnelJustification_attDataGroup0

File Name	Mime Type
Personnel_Justification_DONE1027294457.pdf	application/pdf

ConsortiumJustification_attDataGroup0

File Name	Mime Type

AdditionalNarrativeJustification_attDataGroup0

File Name	Mime Type
Additional_Narrative1027294459.pdf	application/pdf

PERSONNEL JUSTIFICATION

Key Personnel

Gary Lupyan (Principal Investigator), .9 month/year: will oversee the development and implementation of the word diary app, computations of the inductive potential of early-learned words (Specific Aim 1) and development of the category learning study (Specific Aim 3).

Haley Vlach (Principal Investigator), .9 month/year: will oversee the data collection with child participants in her lab, the Learning, Cognition, & Development Lab (Specific Aims 2-3).

Other Personnel

Post-doctoral researcher (To be identified), 12 months/year: The postdoc will play a key role in executing all aspects of the study, working closely with PIs Lupyan and Vlach.

Undergraduate Research Assistants (To be identified), *600 hours/year*: The research assistants will be responsible for conducting the pre-test, learning sessions at home, and post-tests. Research assistants will be paid on an hourly basis.

Consultant (Michael Frank; Stanford University): $2750/year: The development of this proposal benefited greatly from Wordbank, a large repository of children's vocabulary data. We will work with Dr. Frank to expand Wordbank to accommodate the richer datasets we will be collecting as part of this project thereby making them accessible to the public.

Personnel costs are consistent with policies of the University of Wisconsin-Madison. Increases in personnel costs are based on a 3% escalation. Fringe benefits are based on a projected Year 1 rate of 40.7% for faculty, 25.7% for the postdoctoral research associate and 4.3% for undergraduate assistants. Fringe rates are increased by 1% each year for all personnel. F&A is calculated at a rate of 53%.

ADDITIONAL NARRATIVE JUSTIFICATION

For Year 1 of the grant, 6 budget modules for a total of $150,000 has been requested. In Year 2, 5 modules totaling $125,000 has been requested. The additional module is requested in Year 1 to cover additional supplies needed early in the grant.

PHS 398 Research Plan

OMB Number: 0925-0001
Expiration Date: 10/31/2018

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SPECIFIC AIMS

Not all children learn to play the piano or throw fastballs, but all typically developing children learn to speak at least one language. For decades, the apparent ease with which children learn language (the so-called "language instinct" Pinker, 1994) has obscured the vast differences that exist in children's linguistic proficiency. For example, at 18 months, a child at the 80th percentile produces ~200 words from the MCDI checklist while one at the 20th percentile produces just 25. Children who hear more words in more varied contexts have substantially larger vocabularies and stronger language processing skills and these differences magnify with age (e.g., Fernald et al., 2013; Hart & Risley, 1995; Hoff, 2006; Huttenlocher et al., 2010). Language skills are strongly predictive of later academic (Fitzpatrick & Pagani, 2012; Walker et al., 1994), and economic (Chetty et al., 2010) outcomes. For example, a larger vocabulary at 24 months of age predicted academic performance three years later (Morgan et al., 2015) and, in our own analyses, reasoning ability in fifth grade is better predicted by a child's vocabulary at 36-months than by the child's reasoning ability at 36-months.

These provocative associations have inspired the launch of language interventions to close the so-called "word-gap", but **we do not know whether differences in language *cause* differences in cognitive/academic outcomes, and if so, why?** In fact, on a widespread view, links between language and cognitive skills reflect a common influence of general intelligence (e.g., Carroll, 1993; Sternberg & Kaufman, 2011) and so linguistic interventions would not be expected to narrow the negative consequences associated with lower language skills.

Building on the PIs' research programs on the cognitive functions of language (e.g., Lupyan, 2012, 2016) and language development and categorization (Vlach, 2014), we hypothesize that beyond the obvious communicative benefits of stronger language skills, word knowledge facilitates basic cognitive processes including categorization, inference, and reasoning by allowing words to function as categorical inductive priors. Our goal for this proposal is to identify "seed" words, knowing which is associated with faster language development, and to test causal links between learning these words and later linguistic and cognitive outcomes. Our long-term goal is to use this knowledge to lay the foundation for designing interventions to promote children's language and cognitive development.

Specific Aim 1: To identify "seed" words that are associated with consistently faster vocabulary growth. A child's vocabulary at a certain age are, unsurprisingly, predicted by the child's vocabulary at an earlier age. But such coarse measures obscure the possibility that knowing *certain* words (e.g., "color") can facilitate learning new words more than knowing other words (e.g., "yellow"). **We will identify a cluster of "seed" words** that lie at semantic hubs of children's lexical networks (Beckage et al., 2015; Hills et al., 2009). Knowing these words at time 1 is expected to predict better language skills at time 2. We will validate these results by analyzing longitudinal data from Wordbank and CHILDES.

Specific Aim 2: To determine whether teaching "seed" words yields positive language outcomes. After identifying seed words, we will empirically test the causal role these words play in in positive language outcomes using a training study of 30-36 month old children and comparing how teaching children these or a control set of words affects subsequent language development compared to a control no-training group. We hypothesize that **learning seed words will lead to faster word learning because the seed words sensitize children to important conceptual distinctions** controlling for demographic factors such as SES.

Specific Aim 3: To test when teaching seed words promotes category induction in nonverbal tasks. One reason why knowing certain words may facilitate learning other words is that rather than mapping onto pre-existing concepts, *learning a word helps reify conceptual distinctions*, a hypothesis supported by a growing body of literature which at present has not informed studies of language interventions. We will test this hypothesis through a nonverbal category induction task of the sort commonly used to measure young children's concept formation abilities. We hypothesize that if learning certain conceptual distinctions is promoted by learning certain words, then **learning words high in inductive potential may facilitate nonverbal category induction.**

The proposed work will contribute to a greater understanding of children's language and cognitive development. Taken together, the studies will (a) determine whether knowing some words is specifically associated with better language development, (b) use a training study to determine whether these associations are causal, (c) investigate the cognitive consequences of knowing these words for the ability to induce categorical relations—a fundamental cognitive skill. Understanding the ways in which differences in language proficiency are causally related to cognitive factors is critical for guiding interventions by developing a robust framework for understanding how early word knowledge promotes cognitive development.

SIGNIFICANCE

Children learn language in vastly different linguistic environments. A now well-known statistic is that by age 3, children of lower socioeconomic status (SES) hear ~30 million fewer words compared to children of higher SES (often termed the "word-gap", Hart & Risley, 1995). Differences in the amount of linguistic input are strongly predictive of children's language development as measured by vocabulary size, clausal diversity, and the efficiency with which they comprehend spoken language (e.g., Fernald, Marchman, & Weisleder, 2013; Fernald, Perfors, & Marchman, 2006; Hoff, 2006; Hurtado, Marchman, & Fernald, 2008), and early differences have been found to magnify with age (e.g., Fernald et al., 2013; Hart & Risley, 1995; Huttenlocher et al., 2010).

The benefits of stronger language on communication are self-evident, but a further reason why the vast differences in childhood language proficiency are of potential concern is that there appear to be **strong relationships between language skills and other cognitive outcomes**. For example, a larger vocabulary at 24 months predicts reading and mathematics achievement three years later, while keeping constant a wide variety of demographic and cognitive factors (Morgan, Farkas, Hillemeier, Hammer, & Maczuga, 2015). In our own analyses of national longitudinal datasets (Lupyan & Vlach, in prep) we found equally striking patterns. Reasoning ability in fifth grade is predicted by—not surprisingly—reasoning ability at 36 months, but it is *far better* predicted by the child's vocabulary at 36 months (EHRSE dataset, 2010). Language continues to be a surprisingly good predictor in adulthood. A 1SD increase on a short vocabulary test that is part of the General Social Survey is associated with a $6000 increase in annual income and self-reported health (controlling for education, race, gender, and age).

A growing recognition of the association between language and later outcomes has led to the launch of a number of linguistic intervention programs aimed at improving early language largely by focusing on increasing parental input (e.g., *Providence Talks*). These programs assume that the link between early language and later outcomes such as academic performance is causal (otherwise linguistic interventions would not be expected to lead to cognitive benefits), but the proposed mechanisms of such causal relationship are not well specified and the literature is overly reliant on correlational data (Hindman, Wasik, & Snell, 2016). The few randomized control studies that exist (Neuman & Dwyer, 2011; Neuman, Newman, & Dwyer, 2011) show that linguistic interventions can be effective in improving language skills with generalization to new domains. However, these studies relied exclusively on linguistic tests, leaving open the question of whether differences in language proficiency strongly predict performance on tasks that do not require complex language processing and so the causal connection between language proficiency and nonverbal cognitive skills remains unclear.

This proposal has three closely related aims. **First**, we will identify early-learned "seed" words using semantic network analyses. Knowing these words is hypothesized to be predictive of high vocabulary growth owing to the words' high inductive potential. **Second**, we test the *causal* relationship between knowledge of these words and vocabulary growth by using a word training study. **Third**, we test whether knowledge of seed words has consequences beyond word learning by testing children in a category induction test that parallels standardized tests used to assess children's nonverbal intelligence. Taken together, these three aims will help us better understand the factors responsible for differences in children's language development and provide a better foundation for understanding why children's language skills appear to be so strongly associated with cognitive, academic, and health outcomes.

Specific Aim 1: To identify "seed" words that are associated with consistently faster vocabulary growth. Despite the public focus on vocabulary *size* as the target of linguistic interventions, the relationship between early vocabulary and later language proficiency is far from perfect. For example, more than half of children at age 2 who show language delays catch up a year later (Dale, Price, Bishop, & Plomin, 2003), while many with average knowledge at age two fall behind a year later (Feldman et al., 2005). A number of studies offer hints that children's language learning trajectories and the relationship between the words they know can be more informative of later outcomes than sheer word quantity (Bates et al., 1994, 1994; Beckage & Colunga, 2013; Beckage, Mozer, & Colunga, 2015; Beckage, Smith, & Hills, 2011; Borovsky, Ellis, Evans, & Elman, 2015; Colunga & Smith, 2005; Hills et al., 2009a; Perry & Samuelson, 2011; Rowe et al., 2012). Indeed, children's likelihood of learning a word is predicted not simply by the word's occurrence in their environment, but its relationship to words the child knows (Borovsky et al., 2015) and its associations to other words in the child's environment (Hills, Maouene, Riordan, & Smith, 2010). Clearly, there is more to understanding differences in language development than counting how many words a child knows.

Although we have a growing understanding about the way children of a given age vary in their language skills (e.g., Bates et al., 1994; Beckage et al., 2011; Rowe et al., 2012), far less is known about how these differences are related to later language development and by what mechanisms. Using large corpora of child language such as CHILDES and Wordbank—a recently available repository of standardized vocabulary checklists

from thousands of children—and the ability to conduct graph theoretic analyses (Beckage et al., 2015; De Dayne et al., 2013; Hills et al., 2009b; Steyvers & Tenenbaum, 2005) now make it possible to identify "seed" words—words that may be especially useful for learning subsequent words. These words are predicted to be especially useful owing to their high inductive potential and centrality in semantic networks. For example, knowing words like "color" and "shape" may be predictive of learning specific color and shape words. Insofar as a verb like "break" is more central within a semantic network than a verb like "spill", it is knowing the former that should be more positively associated with vocabulary growth. **In this aim we will identify and validate a set of such seed words**. Because our first aim is somewhat exploratory and the feasibility of Aims 2 and 3 hinge on the outcomes of Aim 1, we present preliminary analyses in the Approach section which show that knowing certain words uniquely predicts later word knowledge beyond known factors.

Specific Aim 2: To determine whether teaching "seed" words yields positive language outcomes.
Finding that children who are early learners of a word like "color" go on to know more color words does not necessarily mean that knowing "color" *caused* children to better learn color words. In Aim 2, we test the causal connection through a microgenetic longitudinal training study. In this study, 30- to 36-month-old children will be taught seed words, control words, or no words. We will then observe children's language development through daily sampling over a 6 month period by using a smartphone/web-based parental word diary, supplemented by standardized vocabulary measures. Our hypothesis is that learning seed words will promote vocabulary development above and beyond known factors, such as vocabulary size at time 1 and SES, by sensitizing children to the relevant conceptual distinctions. That is, we expect children in the seed word learning condition to learn more words compared to children in the two control conditions.

Specific Aim 3: To test when teaching seed words promotes category induction in nonverbal tasks.
Words help us communicate. That much is uncontroversial. But do words also help us "think"? A common assumption in the psychometric literature is that associations between language and academic/cognitive outcomes are not causal. Instead, researchers have proposed that the high correlation between language and cognitive performance stems from a common factor (i.e., general intelligence, Carroll, 1993; Sternberg & Kaufman, 2011; cf. Oller, 1991). This idea mirrors a widespread assumption that words simply map onto preexisting meanings and therefore reflect rather our conceptual structure, but play a minor if any role in structuring our concepts and cognitive abilities more generally (e.g., Gleitman & Papafragou, 2005).

Challenging this view is a growing body of work demonstrating causal links between learning/using words and learning/inducing conceptual categories. Exposure to category names augments children's category learning and inference (e.g., Casasola, 2005; Havy & Waxman, 2016; Nazzi & Gopnik, 2001; Plunkett et al., 2008; Robinson et al., 2012; Waxman, 2004) and words continue to affect categorization in adulthood. For example, Lupyan et al. have shown that that knowing even an entirely redundant name for a novel category helps adults *learn* the categories (Lupyan, Rakison, & McClelland, 2007; Lupyan & Casasanto, 2015), and words play a unique role in activating conceptual knowledge (Edmiston & Lupyan, 2015; Lupyan & Thompson-Schill, 2012). Causal links between language and putatively nonverbal cognition are further strengthened by findings showing that interfering with language in healthy adults (Lupyan, 2009) impacts people's ability to categorize, as does noninvasive cortical stimulation of brain regions involved in naming (Lupyan et al., 2012; Perry & Lupyan, 2014, 2016), patterns that mirror categorization impairments observed in aphasia (Lupyan & Mirman, 2013). Together, the literature suggests that words may not be mere conveniences, but may play an important role in structuring our conceptual space in the moment and across developmental time (Lupyan, 2016; Lupyan & Bergen, 2016 for reviews).

Here, we posit that words may augment category induction by acting as powerful inductive priors (Lupyan, 2016; Lupyan & Clark, 2015; see also Gelman & Davidson, 2013). If knowing certain words is causally related to being able to *induce* certain categorical distinctions, then teaching children these words may sensitize children to the relevant categories even in nonverbal tasks. For example, knowing "color" may not only help children learn the words for specific colors, but may also help children to induce color as a relevant grouping dimension on a nonverbal task (which is, incidentally, a skill tested by virtually every nonverbal IQ test). We will test this hypothesis, which we elaborate in more detail below, by using modified versions of standard nonverbal cognitive assessments used with children of our targeted age (DeThorne & Schaefer, 2004).

INNOVATION
The proposed work is **high risk** in that Aims 2 and 3 depend on the outcome of Aim 1. For this reason, we have conducted preliminary analyses establishing the feasibility of Aim 1—see Approach. A further risk is the difficulty of determining that improvements in category induction are really due to word knowledge versus other concomitant factors. The **high reward** of the proposed research is several-fold. First, we are guaranteed to

make new discoveries even if the outcomes do not support our hypotheses. Just as it has been essential to know that children's early use of closed-class words (their 'referential style') was unrelated to vocabulary growth (the seminal multi-year investigation of Bates et al., 1994), so it is essential to explicitly study the relationship between a child's knowledge of words of varying induction potential and consequences—if any—for linguistic and cognitive development.

New measure: Identifying seed words—words with high inductive potential. We derive a new measure of a word's inductive potential by using a network centrality analysis and empirical measurement of the predictive power of knowing a word at time 1 on knowing semantically related words at time 2. Preliminary evidence suggests that even a simplified version of this measure children's language trajectories.

Innovative methodology: Microgenetic longitudinal word training study that combines standardized assessments with an online word-diary. We go beyond standardized language assessments by using an innovative online word-diary as a window on children's word production on a day-to-day basis. The word-diary will allow parents to enter via smartphone or webpage the new words they think their child comprehended or said that day. We will validate parental report using more objective assessments during lab visits. We aim to make the word-diary accessible to other labs and the public, and will be integrating the collected data into the Wordbank repository in a collaboration with Michael Frank (serving as a consultant).

Integrating disparate bodies of knowledge. To test the hypothesis that word knowledge can drive cognitive development, our theoretical framework integrates research from developmental science, cognitive psychology, educational psychology, cognitive neuroscience, and computational linguistics. By bridging these domains, the proposed studies will extend research on children's vocabulary development in a new direction to generate an explanation for why children's language skills have such stark consequences for later outcomes.

Implications for the design of clinical interventions. A tacit assumption of language interventions aiming to close the "word-gap" is that the link between early language and later cognitive/academic outcomes is causal, but there is a lack of studies testing such causal links between better language learning and positive cognitive outcomes. Our work will test whether greater language proficiency (focusing on knowledge of "seed words") plays a causal role in promoting children's cognitive abilities. If successful, our work may suggest specific words that should be taught as part of language interventions.

APPROACH

Preliminary analyses: Identifying seed words. Our proposal hinges on identifying "seed words". We predict that knowing a word at Time 1 will lead to a larger vocabulary at a later time point, over and beyond obviously predictive factors like the child's vocabulary at time 1. To begin identifying "seed" words, we conducted a series of analyses using data from Wordbank (Frank, Braginsky, Yurovsky, & Marchman, 2016) which combines the MCDI vocabulary checklists from thousands of children, and CHILDES, a corpus of child-produced speech in natural interactions (MacWhinney, 2000).

(1) Predicting vocabulary from dictionary centrality. One possible contributor to a word's status as a seed word is its centrality in a semantic network (which we here approximate with a dictionary). We computed a centrality measure of the words on the MCDI checklist using the procedure developed by Vincent-Lamarre et al. (2016). To do this one begins with a full dictionary (e.g., *Merriam-Webster*), and iteratively removes all words that are never used in defining any other word. The words that are left are the *Kernel* (K) (typically about 12% of the words) and can be used to generate the (dictionary) meanings of all the words in the dictionary. One can then calculate a measure representing the minimum distance (*minDist*) from the kernel. It is 0 if word *w* is in the kernel and otherwise is the maximum *minDist* of all the words that define *w*, +1.

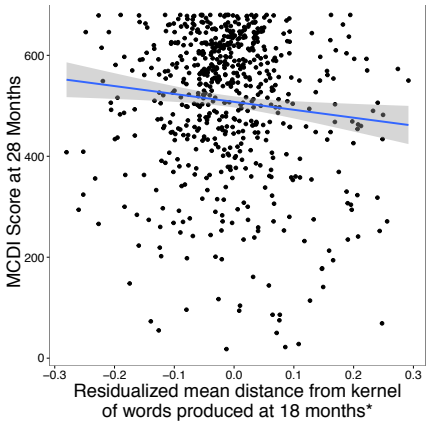

Figure 1: Each dot represents a child (N=646). Children with MCDI-reported vocabularies containing more central words (smaller distance from kernel) at 16 months have larger vocabularies at 28 months, controlling for vocabulary size at 18 months and word frequency of known words.

We obtained from Wordbank MCDI checklist data from 646 children tested first at 16 and then at 28 months. We then predicted their vocabulary at 28 months from their vocabulary at 18 months and the mean *minDist* of the words they were checked off as producing at 18 months. Vocabulary at time 1 of course predicted vocabulary at time 2 (b=.005, t=8.8, p<.0001. As shown in Fig. 1, *minDist* was additionally predictive (*b*=-

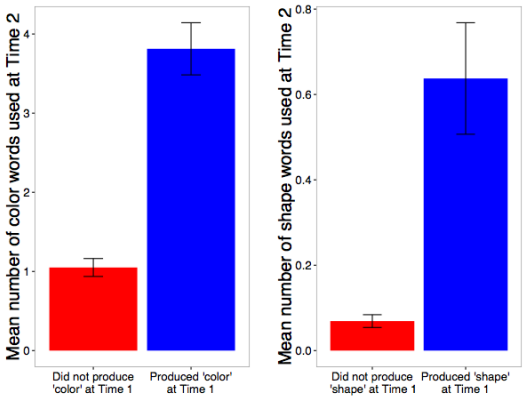

Figure 2: CHILDES analysis of 181 children who produced or did not produce the word "color" (left) or "shape" (right) at Time 1 (M_{age}=38 mo) the mean number of color and shape words the same children produced at time 2 (M_{age}=55 mo.). Error bars show ±1SE of the mean. See text for full analyses that control for confounds. Note: y-scale is different in the two graphs.

153, *t*=-3.8, *p*=.0001). A 1SD change in *minDist* at 16 months predicted a .18 SD increase in vocabulary a year later. Residualized *minDist* was also significant predictor of the *change* in vocabulary between time 1 and 2, *p=.0001* while vocabulary at time 1 was not, *p=.13.*

(2) Predicting knowledge of adjectives from knowledge of the dimensional label. We also conducted analyses using CHILDES, which has the advantage of containing all the words used by the observed children during natural interactions rather than a common list of words as does the MCDI. We were interested in whether knowing the dimensional labels "color" and "shape" at time 1 predicted knowledge of basic color words (e.g., "red", "green"…) and basic shape words (e.g., "square", "circle", etc.), respectively, at time 2. As shown in Fig. 2, this was very much the case. Spontaneous production of "color" at time 1 significantly predicted later production of basic color names controlling for age, vocabulary, and number of color words known at time 1 (*b*=.35, *t*=4.86, *p*<.0001). A similar result was found for 'shape' predicting subsequently produced names of basic shapes (*b*=.45, *t*=6.23, *p*<.0001). Producing "color" did not predict later production of shape-words and producing "shape" did not predict later production of color words, *p*'s>.2.

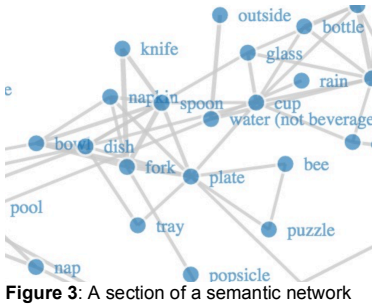

Figure 3: A section of a semantic network of MCDI words showing that "plate" may have higher inductive potential than "knife".

Identifying "seed" words to use in training. The above analyses provide tantalizing evidence that knowing *certain* words at time 1 predicts subsequent language development. These two analyses have shortcomings that we will remedy as part of Aim 1. First, the *minDist* measure is not readily useful for selecting words for training because it is strongly dependent on dictionaries that are full of words unknown to children. A network constructed from dictionary definitions approximates only roughly a network constructed from a child's typical lexicon. We will therefore calculate a new measure of centrality by augmenting the approach above with data from CHILDES (which goes beyond the words on the MCDI and contains a much more realistic child lexicon than any dictionary) and by utilizing graph-theoretic analyses developed by Hills et al. (2009b) and Beckage at al. (2013; 2015) as a way to calculate words that act as lexical hubs (e.g., Fig. 3). Assisted by Michael Frank as consultant, we will identify 20-30 nouns and adjectives that are expected to make especially good seed words and 20-30 additional nouns and adjectives that are predicted to be poorer seed words based on their network centrality. The selections will be validated using the kind of longitudinal regression analyses of Wordbank and MCDI data described above. The two word lists will be equated on lexical factors, such as frequency in speech and contextual diversity. The methods we use to identify seed words in English can be readily adapted to other languages and will inform the design of future cross-linguistic investigations.

Participants. We will recruit 120 30-to 36-month-old typically developing monolingual English-speaking children from local daycare centers with which Dr. Vlach has a working relationship. We chose this age range because children of this age have sizable yet highly variable vocabularies and because it is the youngest age at which category induction tasks can be reasonably conducted (DeThorne & Schaefer, 2004). We have conducted Monte Carlo power analyses (Muthén & Muthén, 2002) to verify that this sample size (N = 40/condition) yields high (>90%) power.

Experimental conditions. Children will be assigned to one of three groups: (1) high inductive-potential word training, (2) low inductive-potential word training control, or (3) a no-language instruction control. The only difference between these groups is in word training (Sessions 3 – 5; see Fig. 4). Group assignments will be quasi-random to ensure that the three groups have children of the same age, familial SES, and language abilities and IQ as assessed during Session 1. The study will occur in four phases: **pre-test**, **learning** (according to experimental condition), **growth**, and **post-test** (see Fig. 4).

***Pre-test phase (Sessions 1-2): Language assessments*:** Parents and children will be presented with a series of tasks that measure children's language skills, intelligence using standardized assessments, and a category induction pretest (see below). The assessments will be administered at PI Vlach's lab and/or children's home and across two visits in Week 1 (order counterbalanced). Parents will also complete a demographic sur-

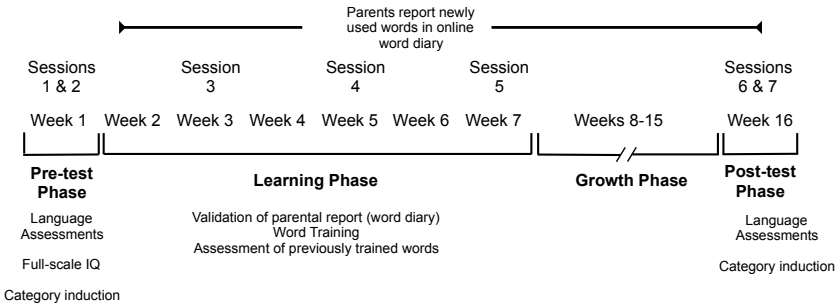

Figure 4: Schematic of the study design

vey requesting the family demographics and basic health information previously found to related to language development (Morgan et al., 2015).

Language assessments: Parents will be asked to complete a CDI-III short vocabulary checklist (normed for 30-36 month-olds) and a supplemental vocabulary checklist consisting with the seed and control words identified in Aim 1 (ensuring that we do not train children on words they already know). Children's receptive and expressive vocabulary will be assessed using the Peabody Picture Vocabulary Test, PPVT-IV (Dunn & Dunn, 2007) and the Expressive Vocabulary Test, EVT-2 (Williams, 2007).

Standardized Intelligence assessment: Children will be presented with the Wechsler Preschool and Primary Scale of Intelligence™ (WPPSI-IV) to obtain a full-scale IQ score.

Category induction test: The category induction test will be modeled after assessments validated for use in children of our age group (DeThorne & Schaefer, 2004). The child will be presented with several pictures and will be asked to (1) select the picture that doesn't belong (*odd-one out trial*) or (2) select from a set of pictures one that best goes with the others (*grouping trial*). For example, assuming "shape" is a trained seed word and "circle" is a matched non-seed word, the task will include several trials where the to-be-induced distinction is square vs. rectangles. The induction task (8 grouping and 8 odd-one out trials) will be identical for all groups to allow for direct comparisons. It is noteworthy that *all* existing nonverbal intelligence tests used with young children are category induction tasks of this sort involving odd-one out or grouping on the basis of (induced) category membership, pointing to the robustness of this method and the centrality of category induction to contemporary conceptions of intelligence.

Learning phase (Sessions 3-5): Vocabulary verification and word training. We will train children in three sessions (Weeks 3, 5, and 7). Each session will consist of two phases: vocabulary verification and word training. In the verification phase we will test a random subset of words that parents reported that their children produced in the past two weeks to validate the parental report. Comprehension will be assessed via a PPVT-style test trial where they will be asked to identify a referent from four pictures and via an EVT-style test where they will be asked to produce a word that names a picture or group of pictures as necessary.

Word training will parallel established paradigms (Sandhofer & Smith, 1999; Smith et al., 2002). Children will be shown pictures multiple instances of a category and a single instance of a contrastive non-category member. The experimenter will show and label the pictures to children. For example to train 'color', the experimenter will say, "Look at these colorful toys… these are all colored. Let's put all the colored toys in the bucket! This toy goes in the bucket, this other toy goes in the bucket, etc." and, "What about this one? This one [an achromatic toy] does not go in the bucket. It is not colored." We will select the control training words to allow us to use the same materials, e.g., the same toys can be used to train children with a specific color word "yellow" rather than "color." In the no-language instruction condition, children will also be shown the same pictures, but the experimenter will not label the pictures (e.g., "Let's put this one in the bucket."). This equates to some extent children's familiarity with the materials allowing us to more selectively ascertain the specific influence of word training and insuring that the hypothesized poorer performance for the no-training group is not due to simple differences in familiarity.

Children in the two instruction conditions will be trained on 10 of the words identified in Aim 1 that are not known to the child during Session 1. Each word will be trained at each session. At the end of the last training session, children's comprehension of each trained word will be tested using a PPVT-style test where they will be asked to identify a referent from four pictures providing an estimate of the efficacy of the training regime.

Growth phase. This phase of the experiment will be about two months in duration (Weeks 7-16) and children will not receive vocabulary training during this time. The growth phase will afford an opportunity to examine changes in vocabulary growth for the three groups.

Post-test phase (Sessions 6-7): Language assessment and category induction. The post-test will occur about 2 months following the last training session (Session 5) during Week 16 (i.e., at 34-40 months) using the same procedure as in Sessions 1-2. We will conclude with the same category induction test used in Session 1.

Parental word-diary. As part of the grant we will develop a smartphone/web-based word diary application that parents will be asked to use to report any new words they hear their child using and words they believe their child newly understands. Using such an interactive diary allows us to send parents alerts and reminders and prompt them to report on specific production of words, as needed. Parents will also be asked to check-in nightly with a short survey about parents' perception of children's daily language history (e.g., how talkative was your child today?) and parent-child interaction (e.g., did you try to teach your child a new word today?).

Some of the strategies for incentivizing parents' daily use of the app are outlined in the Human Subjects section. As an extra bonus, at the completion of the study we will be able to present parents with a beautiful illustration of their children's vocabulary development. In addition to testing our hypothesis that training seed words leads to faster vocabulary growth, we will use the collected word data to conduct exploratory analyses about how, e.g., parents' perceptions of their children's learning interacts with vocabulary trajectories.

Predicted results. We predict that children in the high inductive word learning condition will: (a) Learn more new words—specifically words semantically 'subordinate' to the trained words (b) Insofar as many of these words are likely included in standard PVT and EVT assessments, the seed-word training group is expected to improve more on these measures (c) We anticipate that the seed training group will show an advantage on the category induction because knowledge of these words will facilitate forming hypotheses about what the target items have in common (e.g., common shape, common color). (d) Word training (seed>non-seed>no-training) will contribute to word learning and category induction while controlling for SES and other demographic factors known to influence word learning.

Analytic approach. Our data are ideally suited for analysis with linear/logistic mixed effects models with which the PIs have expertise. All analyses will be examined for outliers and validated with robust regression. Although we are measuring several child, parent, and family factors that might simultaneously affect the degree to which children benefit from vocabulary training, those factors might still fail to control for a potential confounding bias. Thus, we will conduct a sensitivity analysis to examine how robust our effect estimates are to unobserved confounding (Vanderweele & Arah, 2011). Beyond these confirmatory analyses, we will conduct exploratory analyses to provide insights into the parental role of word learning on microgenetic (in-the-moment and daily) and longitudinal (weeks and months) timescales and to help formulate future hypotheses about the design of especially effective linguistic interventions.

Alternative Considerations. We may find that word training does not influence untrained vocabulary. This would mean that the strong longitudinal relationships we discovered (e.g., "color" predicting knowledge of color words) are not causal (or else not measurable with this design). This too is important to know as the ability to identify seed words developed in Aim 1 may remain an important diagnostic of later language delays even if the connection is correlational. Discovering that verbal training does not influence category induction is likewise critical to know as it would help rule out the possibility that the strong associations between language proficiency and e.g., later academic performance result from causal influences of language on categorization. Methodologically, we may discover that some of the identified seed words are too difficult for children to learn. We will work to choose easier-to-learn words and/or train on fewer words allowing for longer training sessions. Finally, we acknowledge the challenge of identifying matched seed and non-seed words that allow us to use the very same training materials for the training groups. We will work to overcome this potential challenge through further pilot testing.

Timeline. The proposed research will be completed over 2 years as outlined in the table to the right.

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Identification of seed words								
Development of word-diary app								
Category induction task development								
Staff Training								
Data collection								
Data analysis								
Manuscript preparation and publication								

SUMMARY. There are strong links between early language proficiency and later cognitive and academic performance and there is reason to believe that some of these associations may be causal (indeed, this is assumed by intervention programs launched to ameliorate the 'word gap'). Our proposal investigates the causal nature of this link while also illuminating some of the causes of the large differences in childhood language proficiency. We identify "seed words"—words located at semantic hubs and thereby predicted to act as especially good inductive priors. We then teach these words to 30-36 month-old children and compare their subsequent vocabulary knowledge to two control groups using a microgenetic approach. Finally, we test the relationship between learning these seed words and successfully inducing categories in a nonverbal category induction task. The proposed work addresses longstanding theoretical questions about the links between language and the rest of cognition and informs the design of effective childhood language interventions.

PROTECTION OF HUMAN SUBJECTS

Risks to Human Subjects

***a. Human Subjects Involvement, Characteristics, and Design*.** A total of 120 typically developing children (30- to 36-month-olds) and their parents will participate in the proposed study. Children at this age experience rapid periods of language and cognitive development and thus are the targeted age group for this proposal. Children's parents will be asked to fill out surveys requesting (a) basic demographic data and contact information and (b) daily reports of the words their children know and produce.

All subjects in this proposal are considered vulnerable subjects. Thus, extra care will be taken to ensure that participants understand their data will be kept confidential and that their decision to participate will in no way affect either their academic or professional standing, or their ability to receive health care at the University of Wisconsin, Madison. An equal number of female and male child participants will be recruited and racial/ethnic categories are expected to match the levels in the Madison/Dane County community and surrounding population as outlined in the Targeted/Planned Enrollment Tables for each study.

Recruitment procedures. Children will be recruited from child care centers (e.g., daycares, preschools, after school programs, etc.) in the Madison/Dane County community. The child care centers will be chosen to represent a diverse group of children, from a range of socioeconomic backgrounds, ethnic/racial groups, etc. Parents will be contacted using a variety of methods. For instance, after center directors have committed to participating in the study, researchers will staff an informational table during times parents drop-off or pick-up their children. This table will include samples of experimental materials, and researchers will be available to answer parents' questions about participation. Consent forms and surveys will be handed out and may be returned immediately or in postage-paid envelopes.

Children will also be recruited from Dr. Vlach's Learning, Cognition, & Development (LCD) Lab family database. The LCD Lab family database consists of hundreds of families in the Madison/Dane County area that have expressed interest in having their children participate in ongoing research.

The data collection sites will be Dr. Vlach's LCD Lab space and/or children's homes (with parental permission).

Strategies for increasing retention/reducing attrition. Attrition could occur in the longitudinal study. Several strategies will be used to reduce the possibility of attrition. First, children and families will receive increasingly more valuable gifts for participating in the study as incentives to continue participation in subsequent sessions (e.g., a children's book, then a $20 gift card to an educational games store, etc.). Parents will receive incentives for completing the word diaries every day. Second, during the time between sessions, families will be mailed small gifts as tokens of appreciation for their continued involvement. For example, on children's birthdays, families will be mailed a small set of children's books as a thank you for their continued participation in the study. Third, during the consent process, parents will be asked for their contact information for follow-up sessions and interest in having the study conducted at their home. If children's parents are unable to bring them to the LCD Lab for a visit, researchers will offer to schedule a visit at the child's home. Fourth, in the scenario that families have changed their contact information and have not informed researchers of these changes, public records (e.g., reverse people searches, public directories, etc.) will be used to determine a participant's new contact information. Finally, a week before each scheduled experimental session, researchers will provide parents with a reminder (e.g., a phone call, email, text message, etc.) with the date/time of upcoming sessions.

***b. Sources of Materials*.** Data will be collected specifically for the series of experiments proposed in the Research Strategy. During the learning and testing sessions, children's exposure to and choice of novel objects/toys/pictures will be recorded by the experimenter. Children's language and cognitive abilities will be measured using a series of behavioral tasks requiring the recognition and ordering of novel objects/toys, which will also be recorded by the experimenter. Parents will be asked to fill out a survey collecting basic sociodemographic data (e.g., parent education level, family income, etc.) and daily reports of their children's language skills. Data collection from children will in the LCD Lab and/or the child's home and data collection from parents will occur in a secure, online application.

All participant data will be stored anonymously in a locked room in the PIs' lab(s); only trained research personnel have access to the locked room. Upon parents and children consenting to participate, participants will be assigned a pseudorandom alphanumeric subject ID that bears no relation to name, gender, age, or

other identifying characteristics. Consent forms, which contain both subject ID and name, will be kept in a locked filing cabinet. The coding between participant name and ID, in addition to participant contact information, will be maintained digitally on a master list in the archived records of the laboratory, which are password-protected. Access to the identifying information both on the consent forms and digitally will be limited to project management personnel. Questionnaires, identified only by subject ID, will be stored in a locked filing cabinet in the in the PIs' lab space.

***c. Potential Risks*.** The tasks we propose to use have not been known to cause significant discomfort or harm beyond simple boredom. Thus, there is minimal risk.

Adequacy of Protection Against Risks

***a. Recruitment and Informed Consent*.** Participants will be recruited through the University of Wisconsin, Madison daycare/preschool database and LCD Lab family database. All procedures for recruiting from the database have been approved by University of Wisconsin, Madison's Institutional Review Board (IRB) and are monitored by several faculty members at the University of Wisconsin, Madison, including Dr. Haley Vlach.

Parents will be contacted and asked if they would like to have their children participate in the study. Parents will be asked to provide written informed consent to have their children participate in the study. Children will also be asked to provide assent by verbally asking them if they would like to participate in the study. Parents and children will be informed beforehand that they need not answer any questions should they not wish to. The consent form will explain all the procedures that will occur in detail and parents will be provided an extra copy for their records. Parents will be provided the opportunity to clarify any questions with the PI/Co-PI and/or study personnel. It will be reiterated, to both the parent and child, that they may discontinue participation at any time without penalty.

***b. Protection Against Risk*.** Parent and children's personal information and data will be kept confidential as noted in Section 1b: Sources of Materials. Parents and children will be reminded that their participation is voluntary and that they may choose to discontinue at any time. These procedures have been applied in previous studies in Dr. Vlach's labs without issue.

Potential Benefits of the Proposed Research to the Subjects and Others

Children will receive a small gift, such as a book, as a thank you for participating in each session of the study. In multi-session studies, children will receive gifts, parents will be compensated $100 for their participation, and participants' parking costs on UW-Madison's campus will be reimbursed. As part of participating in the study, children may gain additional practice at attending to, learning, and recalling new information. A major benefit of the proposed word-diary study is the knowledge parents will gain of their child's vocabulary growth during the study period. As part of the development of the word-diary app, we will develop an attractive graphical depiction of the child's word network and learning trajectory that parents will be able to print out or share online with others. In all, the risks of the research are extremely low and the benefit—understanding how knowing certain types of words impacts linguistic and cognitive growth—is quite large. These benefits outweigh the risks involved.

Importance of the Knowledge to be Gained

The knowledge that may be gained as a result of this proposed research is quite high. As mentioned above, in the 'Potential Benefits of the Proposed Research to the Subject and Others' section, knowledge about children's language and cognitive development will be gained from this research. The knowledge can be used to design interventions for children. The risks in this study are quite minimal, thus the importance of the knowledge to be gained greatly outweighs the risks involved.

INCLUSION OF WOMEN AND MINORITIES

For all proposed studies, equal numbers of male and female children and parents will be included. Subjects from all racial and ethnic groups will be invited to participate.

Data from 2010 (the most recent year available, posted on the U.S. Census Bureau's website) provide information regarding the racial and ethnic makeup of the local population. For the proposed studies, the participants will be recruited from the local population in the city of Madison/Dane County. The breakdown for Dane County is as follows: 81.3% White (not of Hispanic origin), 5.4%, Black (not of Hispanic origin), 5.1%, Asian, 6.1% Hispanic, <.05% Native Hawaiian, 0.5% American Indian and Alaska Native, and 1.6% Mixed. The Madison/Dane County area contains a relatively small population of most racial and ethnic groups. Thus, special measures will be taken to ensure a diverse sample of participants in this research (target goal: at least 30% of participants from underrepresented groups). For example, a successful procedure that has been used in past research is to work with local child care centers that attract a diverse group of children.

See attached tables for number of participants to be targeted in each ethnic and racial category in the proposed research. Halfway through each study, we will summarize the actual enrollment in terms of racial and ethnic groups. If we find that we are not following our targeted enrollment, we will adjust our recruitment procedure and target the ethnic/racial groups that have too few participants.

INCLUSION OF CHILDREN

The experiments proposed in the Research Strategy will include typically developing children, aged 30- to 36-months-old at the start of study, and their parent(s). Children at these ages are included because (a) they are at a stage of development in which they are experiencing rapid changes in language and cognitive development, and (b) are at a critical age for early interventions. Power analyses were conducted for sample sizes in order to assure that an appropriate number of children have been included in the proposal (see Methods section for each of the studies).

The PI (Dr. Gary Lupyan) and Co-PI (Dr. Haley Vlach) have worked with child participants for their entire career. Both researchers are well versed in the special requirements of research with young children, such as community outreach for recruitment, coordinating multiple sessions and visits, the need for friendly staff, comfortable environs in the lab setting, toys and babysitting for younger/older siblings, diaper changing facilities, and so forth. Dr. Vlach's Learning, Cognition, & Development (LCD) Lab at the University of Wisconsin, Madison, has existing connections with several local child care centers. Moreover, the LCD Lab family database consists of hundreds of families interested in participating in research studies.

LEADERSHIP PLAN

Dr. Gary Lupyan and Dr. Haley Vlach will both serve as PIs on this project.

Why Multiple PIs? The PIs joint expertise bridges the fields of cognitive neuroscience, developmental psychology, and computational linguistics. Indeed, Drs. Lupyan and Vlach bring complementary training and methodological strengths to bear on shared questions in the study of language and cognition. This multi-disciplinary approach is necessary for implementing the innovative methodology and conducting the high risk/high reward studies included in the proposed work.

Previous Collaborations. Dr. Lupyan and Dr. Vlach have known each other for many years and have been collaborating on several projects. For instance, the PIs are currently collaborating on a series of studies examining how parent-child interactions contribute to children's language skills and categorization. Indeed, the PIs have acquired funding from the Wisconsin Alumni Research Foundation (WARF) and are actively designing new studies, co-mentoring students and post-docs, and preparing research for publication. In brief, the PIs have a strong working relationship that will ensure the success of the current research.

Current Research. The PIs have jointly developed the current proposal, including generating hypotheses, developing the protocols, and writing. The PIs will continue to communicate weekly, either by phone, e-mail, or in person to discuss experimental design, data analysis and administrative responsibilities. The PIs will share their respective research results with other researchers, key personnel, and consultants. They will work together to discuss any changes in the direction of the research projects and the reprogramming of funds, if necessary. The PIs will be jointly responsible for submission of progress reports to NIH.

Given their complementary backgrounds, the two PIs will take the lead on different aspects of the project, but will be jointly responsible for the scientific and technical direction of the project. Dr. Vlach will oversee the data collection with child participants in her lab, the Learning, Cognition, & Development (LCD) Lab. Data collection will involve a team of undergraduate, graduate, and post-doctoral researchers, and Dr. Vlach will ensure that the team has the training necessary to perform data collection. Dr. Lupyan will oversee the development and implementation of the word diary app, computations of the inductive potential of early-learned words, and development of the category learning study. Indeed, Dr. Lupyan has experience in developing web-based applications for collecting data from participants and analyzing corpus data.

Drs. Lupyan and Vlach will co-mentor the graduate student and post-doctoral researcher to be hired on this project. To facilitate the student's and post-doctoral fellow's professional development, they will attend both Dr. Lupyan's and Dr. Vlach's individual lab meetings, as well as all joint project meetings. Drs. Lupyan and Vlach will meet with individually with each student/postdoc on a regular basis to discuss their professional development and the project advancement.

Intellectual Property. The PIs will follow all guidelines included in the UW–Madison Intellectual Policies and Procedures for University Research. If the PIs have questions about these policies, they will contact the Office of the Vice Chancellor for Research and Graduate Education consulting center. A publication policy will be established by the PIs based on the relative scientific contributions of the PIs and key personnel.

Conflict Resolution. If a potential conflict arises, the PIs will meet and attempt to resolve the dispute. If they fail to resolve the dispute, the disagreement shall be referred to an arbitration committee consisting of one impartial senior executive from each PI's department and a third impartial senior executive mutually agreed upon by both PIs. No members of the arbitration committee will be directly involved in the research grant or disagreement.

Change in PI Location. If a PI moves to a new institution, attempts will be made to transfer the relevant portion of the grant to the new institution. In the event that a PI cannot carry out his/her duties, a new PI will be recruited as a replacement at one of the participating institutions.

STANFORD UNIVERSITY

STANFORD, CALIFORNIA 94305

Michael C. Frank
Stanford University
Department of Psychology
450 Serra Mall
Stanford, CA 94305
650-724-4003

October 11, 2016

Dear Dr. Lupyan,

I am writing in enthusiastic support of your proposal with Dr. Vlach, "Seed words: the impact of word learning on category induction."

The proposed research is exciting and synthetic work that probes a deep question: how does learning specific parts of a language support the broader trajectory of cognitive development. Critically, the proposed work is an ambitious attempt to assess causal relationships between "seed words" – words that seem to be related to particular kinds of abstract concepts or relationships – and specific outcomes like novel word learning or category induction. Either a success *or* a failure here could be informative, as the alternative proposal – that vocabulary largely reflects, rather than shaping, cognitive development – has also been influential.

Should this proposal be funded, I will be pleased to collaborate with you on using data from Wordbank (as well as research that we have done with semantic networks) to develop predictors of early vocabulary, and will also look forward to consulting on other aspects of the research. I am especially interested in helping to think about structuring and evaluating interventions to test the "seed word" hypothesis.

Sincerely,

Michael C. Frank
Associate Professor of Psychology
and, by courtesy, Linguistics

Letters of Support from Child Care Centers

These child care centers (day cares, preschools, etc.) have agreed to support the research in this proposal, serve as a recruitment site, and adhere to the UW-Madison IRB guidelines for ethical research practices. The total number of children that attend these centers is approximately 150 children, which is more children than the planned enrollment for this grant proposal. All child care center names have been blinded to protect their anonymity of participation.

Center #1

THE UNIVERSITY of WISCONSIN MADISON

Dear UW-Madison IRB,

I, NICOLE SCHNEIDER, agree to allow the Learning, Cognition, & Development Lab at the University of Wisconsin, Madison, to conduct their study at my center. I understand that the research will involve a 30 minute activity with each child, with the possibility of a 15 minute follow-up activity at a later date.

I also agree to adhere to the ethical guidelines put forth by the UW-Madison IRB and will act in the best interests of the children at my center.

Signature: _____ Date: 6·13·15

Center #2

THE UNIVERSITY of WISCONSIN MADISON

Dear UW-Madison IRB,

I, Chanel Clark, agree to allow the Learning, Cognition, & Development Lab at the University of Wisconsin, Madison, to conduct their study at my center. I understand that the research will involve a 30 minute activity with each child, with the possibility of a 15 minute follow-up activity at a later date.

I also agree to adhere to the ethical guidelines put forth by the UW-Madison IRB and will act in the best interests of the children at my center.

Signature: Chanel Clark Date: 7/14/15

Center #3

Dear UW-Madison IRB,

I, Sheryl Strommen, agree to allow the Learning, Cognition, & Development Lab at the University of Wisconsin, Madison, to conduct their study at my center. I understand that the research will involve a 30 minute activity with each child, with the possibility of a 15 minute follow-up activity at a later date.

I also agree to adhere to the ethical guidelines put forth by the UW-Madison IRB and will act in the best interests of the children at my center.

Signature: Sheryl Strommen Date: 7-27-15

Center #4

Dear UW-Madison IRB,

I, Tracy Hietpas, agree to allow the Learning, Cognition, & Development Lab at the University of Wisconsin, Madison, to conduct their study at my center. I understand that the research will involve a 30 minute activity with each child, with the possibility of a 15 minute follow-up activity at a later date.

I also agree to adhere to the ethical guidelines put forth by the UW-Madison IRB and will act in the best interests of the children at my center.

Signature: Tracy Hietpas Date: 6-25-15

Center #5

THE UNIVERSITY of WISCONSIN MADISON

Dear UW-Madison IRB,

I, Rita Thompson, agree to allow the Learning, Cognition, & Development Lab at the University of Wisconsin, Madison, to conduct their study at my center. I understand that the research will involve a 30 minute activity with each child, with the possibility of a 15 minute follow-up activity at a later date.

I also agree to adhere to the ethical guidelines put forth by the UW-Madison IRB and will act in the best interests of the children at my center.

Signature: _____ Date: 8.6.15

Center #6

THE UNIVERSITY of WISCONSIN MADISON

Dear UW-Madison IRB,

I, Rhiannon Belanger, agree to allow the Learning, Cognition, & Development Lab at the University of Wisconsin, Madison, to conduct their study at my center. I understand that the research will involve a 30 minute activity with each child, with the possibility of a 15 minute follow-up activity at a later date.

I also agree to adhere to the ethical guidelines put forth by the UW-Madison IRB and will act in the best interests of the children at my center.

Signature: _____ Date: 7/28/15

RESOURCE SHARING PLAN

The proposed research will generate word production and comprehension data that we believe will be highly useful for researchers of language development. We will integrate the de-identified data into Wordbank (http://wordbank.stanford.edu/). Python/R-based analysis scripts for the CHILDES corpora will be made available through GitHub.

Papers resulting from this grant will be made available on the investigators' lab websites and the raw data and analytic scripts available via OSF/GitHub

PHS Assignment Request Form

Funding Opportunity Number: PA-16-161

Funding Opportunity Title: NIH Exploratory/Developmental Research Grant Program (Parent R21)

Awarding Component Assignment Request *(optional)*

If you have a preference for an Awarding Component (e.g., NIH Institute/Center) assignment, please use the link below to identify the most appropriate assignment then enter the short abbreviation (e.g., NCI or National Cancer Institute) in "Assign to/Do Not Assign To Awarding Component" sections below. Your first choice should be in column 1. All requests will be considered; however, locus of review is predetermined for some applications and assignment requests cannot always be honored.

Information about Awarding Components can be found here:
https://grants.nih.gov/grants/phs_assignment_information.htm#AwardingComponents

	1	2	3
Assign to Awarding Component:	NICHD		
Do Not Assign to Awarding Component:			

Study Section Assignment Request *(optional)*

If you have a preference for a study section assignment, please use the link below to identify the most appropriate study section then enter the short abbreviation for that study section in the "Assign to/Do not Assign to Study Section" sections below. Your first choice should be in column 1. All request will be considered; however, locus of review is predetermined for some applications and assignment request cannot always be honored.

For example, you would enter "CAMP" if you wish to request assignment to the Cancer Molecular Pathobiology study section or enter "ZRG1 HDM-R" if you wish to request assignment to the Healthcare Delivery and Methodologies SBIR/STTR panel for informatics. Be careful to accurately capture all formatting (e.g., spaces, hyphens) when you type in the request.

Information about Study Sections can be found here:
https://grants.nih.gov/grants/phs_assignment_information.htm#StudySection

	1	2	3
Assign to Study Section: *(only 20 characters allowed)*	LCOM		
Do Not Assign to Study Section: *(only 20 characters allowed)*			

PHS Assignment Request Form

List individuals who should not review your application and why *(optional) Only 1000 characters allowed*

Identify Scientific areas of expertise needed to review your applications *(optional)*

Note: Please do not provide names of individuals

	1	2	3	4	5
Expertise: *Only 40 characters allowed*	child language	category induction	word learning	semantic networks	

PHS Inclusion Enrollment Report

Study Title: Seed words: the impact of word learning on category induction

*** Delayed Onset Study?**	❍ **Yes**	● **No**
If study is not delayed onset, the following selections are required:		
Enrollment Type	● **Planned**	❍ **Cumulative (Actual)**
Using an Existing Dataset or Resource	❍ **Yes**	● **No**
Enrollment Location	● **Domestic**	❍ **Foreign**
Clinical Trial	❍ **Yes**	● **No**
NIH-Defined Phase III Clinical Trial	❍ **Yes**	● **No**

Comments: In addition to enrolling the participants below we will be making use of previously collected MCDI word checklists (Published on Wordbank) and child-directed speech that is part of the CHILDES corpus

Racial Categories	**Ethnic Categories**									
	Not Hispanic or Latino			Hispanic or Latino			Unknown/Not Reported Ethnicity			**Total**
	Female	**Male**	**Unknown/ Not Reported**	**Female**	**Male**	**Unknown/ Not Reported**	**Female**	**Male**	**Unknown/ Not Reported**	
American Indian/ Alaska Native	1	1		0	0					2
Asian	6	6		0	0					12
Native Hawaiian or Other Pacific Islander	1	1		0	0					2
Black or African American	6	6		1	1					14
White	28	28		10	10					76
More than One Race	5	5		2	2					14
Unknown or Not Reported										
Total	47	47		13	13					120

Proposal Summary

Proposal Number: **Proposal Status:**
Sponsor Deadline: 06/16/2016 **Submission Method:**
Submission Type: Application

INVESTIGATOR DATA

PROJECT DIRECTOR / PRINCIPAL INVESTIGATOR CONTACT INFORMATION

Prefix:	First Name:	Middle Name:	Last Name:	Suffix:
	GARY		LUPYAN	

Position/Title:	ASSOCIATE PROFESSOR	**Organization:**	The Board of Regents of the University of Wisconsin System
Department:	PSYCHOLOGY-GEN	**Division:**	
Street1:	1202 W JOHNSON ST	**Street2:**	
City:	MADISON	**County:**	
State:	WI	**Zip Code:**	53706-1611
Country:	USA	**Employee ID:**	
Phone:	917-843-4868	**Fax:**	
Email:	LUPYAN@WISC.EDU		

First Budget Period Effort: **Calendar:** **Academic:** **Summer:**

Status of PI: Tenure/Tenure Track
Status Waiver Required? No
Signed Intellectual Property Waiver Attached?
Signed Conflict of Interest Disclosure Attached?
Agency Certification Documentation Attached?
Cost Sharing Authorization Form Attached?

SPONSOR DATA

Agency: National Institutes of Health
Proposal Type
Sponsor Mechanism: NIH Exploratory/Developmental Research Grant Program (Parent R21)
Sponsor Type:
Sponsor Code:
Sponsor Name:
SubDivision 1:
SubDivision 2:

PROJECT DATA

Title of Project: Seed words: the impact of word learning on category induction
Is This a Subcontract? No
If Yes, who is prime?
Type of Proposal: Grant
Type of Agency: Federal
Kind of Application: New
Previous Grant # or Federal Identifier:
Change in grantee institution?
Type of Project: Basic

PROJECT ADMINISTRATION

Who is responsible for this research?

Departmental Identification Number:	**Primary:**	**Secondary:**
Departmental Name:	**Primary:**	**Secondary:**
Primary Dept. Contact Info:		
Account Classification:	**Primary:**	**Secondary:**

Other Institutional Code:
NAICS Code:

COMPLIANCE DATA

Are animal subjects used?	No
Is IACUC review pending?	
IACUC Protocol #	
IACUC Approval Date:	
Are human subjects used?	Yes
Is IRB review pending?	Yes
IRB Protocol #	
IRB Approval Date:	

Does this project involve use of any of the following? Radioactive Material(s), Radiation Producing Devices(s), Recombinant DNA, Biohazardous Chemical(s), Class IIIb or IV Lasers, Other certifications of health, safety and/or environmental compliance.

BUDGET DATA

Performance Dates	**Begin Date**	**End Date**
First Budget Period:	07/01/2017	06/30/2018
Cumulative Budget Period:	07/01/2017	06/30/2019

Cost Sharing Information	**Mandatory**	**Voluntary**
Committed:		
Amount:		
Source:		

Budget Period	**Direct Cost**	**Indirect Cost**	**Total Cost**
Period 1:	150,000	79,500	229,500
Period 2:	125,000	66,250	191,250
Total:	275,000	145,750	420,750

AWARD DATA

Award #: **Contract #:** **Date:**

Budget Period	**Direct Cost**	**Indirect Cost**	**Total Cost**
Period 1:			
Period 2:			
Total:			

EXPORT CONTROL

1. Will the project involve participation, collaboration or access to information by foreign nationals, defined as: individuals with foreign citizenship, foreign governments, foreign associations and corporations, or foreign political parties? Note: Foreign nationals granted US citizenship, or permanent residence "green card" or granted status as a "protected individual", e.g., political refugees and political asylum holders are "EXEMPT" from deemed export rule.
2. Will the project involve the shipment of equipment, technology, software, materials data or other information?
3. Will the project involve a foreign subcontract or other foreign contractual agreement?

COMMENTS AND EXPLANATIONS

PLEASE INDICATE ANY SPECIAL INSTRUCTIONS BELOW: