

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

SUGGESTED REVIEWERS:

Not Listed

REVIEWERS NOT TO INCLUDE:

Not Listed

Pursuant to PAPPG Chapter II.C.1.e., each PI, co-PI, and other senior project personnel identified on a proposal must provide collaborator and other affiliations information to help NSF identify appropriate reviewers.(v.4/21/2017)

Please complete this template (e.g., Excel, Google Sheets, LibreOffice), save as .xlsx or .xls, and upload directly as a Fastlane Collaborators and Other Affiliations single copy doc.
Do not upload .pdf.

There are five tables:

- A: Your Name & Affiliation(s);
- B: PhD Advisors/Advisees (all);
- C: Collaborators;
- D: Co-Editors;
- E: Relationships

List names as Last Name, First Name, Middle Initial. Additionally, provide email, organization, and department (optional) to disambiguate common names.

Fixed column widths keep this sheet one page wide; if you cut and paste text, set font size at 10pt or smaller, and abbreviate, where necessary, to make the data fit.

To insert *n* blank rows, select *n* row numbers to move down, right click, and choose Insert from the menu.

You may fill-down (ctrl-D) to mark a sequence of collaborators, or copy affiliations. Excel has arrows that enable sorting. "Last active" dates are optional, but will help NSF staff easily determine which information remains relevant for reviewer selection.

Table A: List your Last Name, First Name, Middle Initial, and organizational affiliation (including considered affiliation) in the last 12 months.

A	Your Name:	Your Organizational Affiliation(s), last 12 r	Last Active Date
	Ashley J. Thomas	Harvard	
		University of California, Irvine	7/1/2018
		University of California, Berkeley	5/15/2008

Table B: List names as Last Name, First Name, Middle Initial, and provide organizational affiliations, if known, for the following.

- G: Your PhD Advisor(s)
- T: All your PhD Thesis Advisees
- P: Your Graduate Advisors

to disambiguate common names

B	Advisor/Advisee Name:	Organizational Affiliation	Optional (email, Department)
G:	Barbara W. Sarnecka	University of California, Irvine	Cognitive Science
T:			
P:			

Table C: List names as Last Name, First Name, Middle Initial, and provide organizational affiliations, if known, for the following.

- A: Co-authors on any book, article, report, abstract or paper (with collaboration in last 48 months; publication date may be later).
- C: Collaborators on projects, such as funded grants, graduate research or others (in last 48 months).

to disambiguate common names

C	Name:	Organizational Affiliation	Optional (email, Department)	Last Active
---	-------	----------------------------	------------------------------	-------------

A:	Paul Piff	University of California, Irvine	piff@uci.edu, psychology and social b	currently
A:	Pete Ditto	University of California, Irvine	phditto@uci.edu, psychology and social behavior	
C:	P. Kyle Stanford	University of California, Irvine	stanford@uci.edu, LPS	12/16/17

Table D: List editorial board, editor-in-chief and co-editors with whom you interact. An editor-in-chief should list the entire editorial board.

B: Editorial board: Name(s) of editor-in-chief and journal (in past 24 months).

E: Other Co-Editors of journals or collections with whom you directly interacted (in past 24 months).

to disambiguate common names

D	Name:	Organizational Affiliation	Journal/Collection	Last Active
B:				
E:				

Table E: List persons for whom a personal, family, or business relationship would otherwise preclude their service as a reviewer.

R: Additional names for whom some relationship would otherwise preclude their service as a reviewer.

to disambiguate common names

D	Name:	Organizational Affiliation	Optional (email, Department)	Last Active
R:				

Pursuant to PAPPG Chapter II.C.1.e., each PI, co-PI, and other senior project personnel identified on a proposal must provide collaborator and other affiliations information to help NSF identify appropriate reviewers.(v.4/21/2017)

Please complete this template (e.g., Excel, Google Sheets, LibreOffice), save as .xlsx or .xls, and upload directly as a Fastlane Collaborators and Other Affiliations single copy doc.

Do not upload .pdf.

There are five tables:

A: Your Name & Affiliation(s);

B: PhD Advisors/Advisees (all);

C: Collaborators;

D: Co-Editors;

E: Relationships

List names as Last Name, First Name, Middle Initial. Additionally, provide email, organization, and department (optional) to disambiguate common names.

Fixed column widths keep this sheet one page wide; if you cut and paste text, set font size at 10pt or smaller, and abbreviate, where necessary, to make the data fit.

To insert *n* blank rows, select *n* row numbers to move down, right click, and choose Insert from the menu.

You may fill-down (ctrl-D) to mark a sequence of collaborators, or copy affiliations. Excel has arrows that enable sorting.

"Last active" dates are optional, but will help NSF staff easily determine which information remains relevant for reviewer selection.

Table A: List your Last Name, First Name, Middle Initial, and organizational affiliation (including considered affiliation) in the last 12 months.

A	Your Name:	Your Organizational Affiliation(s), last 12 r	Last Active Date
	Rebecca Saxe	MIT	
		Harvard	6/28/2006
		Oxford University	6/1/2000

Table B: List names as Last Name, First Name, Middle Initial, and provide organizational affiliations, if known, for the following.

G: Your PhD Advisor(s)

T: All your PhD Thesis Advisees

P: Your Graduate Advisors

to disambiguate common names

B	Advisor/Advisee Name:	Organizational Affiliation	Optional (email, Department)
G:	Kanwisher, Nancy	MIT	
G:	Carey, Susan	Harvard University	
T:	Young, Liane	Boston College	
T:	Koster-Hale, Jorie	MIT	
T:	Skerry, Amy	Kahn Acadamy	
T:	Richardson, Hilary	MIT	
T:	Dae Houlihan , Sean	MIT	
T:	Kosakowski , Heather	MIT	
T:	Deen, Ben	MIT	

Table C: List names as Last Name, First Name, Middle Initial, and provide organizational affiliations, if known, for the following.

A: Co-authors on any book, article, report, abstract or paper (with collaboration in last 48 months; publication date may be later).

C: Collaborators on projects, such as funded grants, graduate research or others (in last 48 months).

to disambiguate common names

C	Name:	Organizational Affiliation	Optional (email, Department)	Last Active
C:	Powell, Lindsey	Massachusetts Institute of Technology		
A:	Powell, Lindsey	Massachusetts Institute of Technology		
A:	Houlihan, S.D.	Massachusetts Institute of Technology		
A:	Kleiman-Weiner, Max	Massachusetts Institute of Technology		
A:	Tenenbaum, Joshua	Massachusetts Institute of Technology		
A:	Adolphs, Ralph	CalTech		
A:	Marina Bedny	John Hopkins University		
A:	Alfonso Caramazza	Harvard		
A:	Dilks, Danny	Emory		
A:	Frank, Michael	Stanford		
A:	Gabrieli, John	Massachusetts Institute of Technology		
A:	Evelina Fedorenko	MHG		
A:	Edward Gibson	Massachusetts Institute of Technology		
A:	Hyowon Gweon	Stanford		
A:	Kanwish, Nancy	Massachusetts Institute of Technology		
A:	Knobe, Joshua	Yale University		
A:	Pascual-Leone, Alvaro	Harvard Medical School		
A:	Redcay, Elizabeth	University of Maryland;		
C:	Sabbagh, Mark	Queen's University		
C:	Spunt, Robert	CalTech		
C:	van Bavel, Jay	NYU		
C:	Young, Liane	Boston College		
C:	Yarkoni, Tal	University of Texas at Austin		
C:	Vul, Ed	UCSD		
C:	Koldewyn, Kami	Bangor University		

Table D: List editorial board, editor-in-chief and co-editors with whom you interact. An editor-in-chief should list the entire editorial board.

B: Editorial board: Name(s) of editor-in-chief and journal (in past 24 months).

E: Other Co-Editors of journals or collections with whom you directly interacted (in past 24 months).

to disambiguate common names

D	Name:	Organizational Affiliation	Journal/Collection	Last Active
B:				1/1/17
E:				

Table E: List persons for whom a personal, family, or business relationship would otherwise preclude their service as a reviewer.

R: Additional names for whom some relationship would otherwise preclude their service as a reviewer.

to disambiguate common names

D	Name:	Organizational Affiliation	Optional (email, Department)	Last Active
R:				

Pursuant to PAPPG Chapter II.C.1.e., each PI, co-PI, and other senior project personnel identified on a proposal must provide collaborator and other affiliations information to help NSF identify appropriate reviewers.(v.4/21/2017)

Please complete this template (e.g., Excel, Google Sheets, LibreOffice), save as .xlsx or .xls, and upload directly as a Fastlane Collaborators and Other Affiliations single copy doc.
Do not upload .pdf.

There are five tables:

A: Your Name & Affiliation(s);

B: PhD Advisors/Advisees (all);

C: Collaborators;

D: Co-Editors;

E: Relationships

List names as Last Name, First Name, Middle Initial. Additionally, provide email, organization, and department (optional) to disambiguate common names.

Fixed column widths keep this sheet one page wide; if you cut and paste text, set font size at 10pt or smaller, and abbreviate, where necessary, to make the data fit.

To insert *n* blank rows, select *n* row numbers to move down, right click, and choose Insert from the menu.

You may fill-down (ctrl-D) to mark a sequence of collaborators, or copy affiliations. Excel has arrows that enable sorting.

"Last active" dates are optional, but will help NSF staff easily determine which information remains relevant for reviewer selection.

Table A: List your Last Name, First Name, Middle Initial, and organizational affiliation (including considered affiliation) in the last 12 months.

A	Your Name:	Your Organizational Affiliation(s), last 12 months	Last Active Date
	Elizabeth Spelke	Harvard	
		MIT	6/1/2001
		Cornell	6/1/1996
		University of Pennsylvania	6/1/1986

Table B: List names as Last Name, First Name, Middle Initial, and provide organizational affiliations, if known, for the following.

G: Your PhD Advisor(s)

T: All your PhD Thesis Advisees

P: Your Graduate Advisors

to disambiguate common names

B	Advisor/Advisee Name:	Organizational Affiliation	Optional (email, Department)
G:	Eleanor Gibson	Cornell	
G:	Ulric Neisser	Cornell	
T:	Jones, Susan	University of Illinois	
T:	Winkler-Rhoades, Nathan	MIT	
T:	Landau, Barbara	Johns Hopkins	
T:	Baillargeon, Renee	University of Illinois	
T:	Phillips, Ann	U of Michigan	
T:	Kim, In-Kyeong	La Sierra U	
T:	Hermer, Linda	University of Florida	
T:	Vishton, Peter	College of William and Mary	
T:	Van de Walle, Gretchen	Rutgers	
T:	Wang, Ranxiao	University of Illinois	
T:	Barth, Hilary	Wesleyan	
T:	Wood, Justin	USC	
T:	Shuman, Miles		
T:	Lipton, Jennifer	Harvard	

T:	Shusterman, Anna	Wesleyan	
T:	Huang, Yi Ting	University of Maryland	
T:	Shutts, Kristin	University of Wisconsin	
T:	Olson, Kristina	University of Washington	
T:	Kinzler, Katherine	University of Chicago	
T:	Lamont, Kristin	McKinsey & Co	
T:	Beier, Jonathan	University of Maryland	
T:	Hyde, Daniel	University of Illinois	
T:	Bernier, Emily	Google Inc	
T:	Soley, Gaye	U. Barcelona	
T:	Ziv, Talee	Hebrew University	
T:	Heiphetz, Larisa	Boston College	
T:	Schachner, Adena	Boston University	
T:	Afshordi, Narges	Current (Harvard)	
T:	Spokes, Annie	Current (Harvard)	
T:	Cogsdill, Emily	Current (Harvard)	
T:	Hobbs, Kathryn	Current (Harvard)	
T:	Skerry, Amy	Kahn Academy	
T:	Dillon, Moira	Current (Harvard)	

Table C: List names as Last Name, First Name, Middle Initial, and provide organizational affiliations, if known, for the following.

A: Co-authors on any book, article, report, abstract or paper (with collaboration in last 48 months; publication date may be later).

**C: Collaborators on projects, such as funded grants, graduate research or others (in last 48 months).
to disambiguate common names**

C	Name:	Organizational Affiliation	Optional (email, Department)	Last Active
A:	Powell, Lindsey	MIT		
A:	Dillon, Moira	Harvard (now NYU)		
A:	Kannan, Geetha	Abdul Latif Jameel Poverty Action Lab South Asia		
A:	Dean, Joshua	MIT		
A:	Ullman, Tomer	MIT		
A:	Battaglia, Peter	Deep Mind Technologies		
A:	Spokes, Annie	Harvard		
A:	Persichetti, Andrew	Emory University		
A:	Dilks, Daniel	Emory University		
A:	Duflo, Esther	MIT, Jameel Poverty Action Lab		
A:	Hobbs, Kathryn	Harvard		
A:	Mehr, Sam	Harvard		
A:	Huang, Yi Ting	University of Maryland College Park		
A:	Shutts, K	Harvard		
A:	Moulson, M.C.	Ryerson University		
A:	Huang, Yi	Beijing Normal University		
A:	Lee Ann Song	Harvard		
A:	Gibson, Eleanor	MIT		
A:	Khanum, Saeeda	NUST, Islamabad, Pakistan		
A:	Hanif, Rubina	Quaid-i-Azam University		
A:	Berteletti, Ilaria	University of Illinois		
A:	Hyde, Daniel C.	University of Illinois		
A:	Jara-Ettinger, Julian	Yale		
A:	Pires, Ana C.	University of the Republic, Montevideo, Uruguay		
A:	Roger Levy	MIT		
A:	Piantoadosi, Steve	University of Rochester		
A:	Dehaene-Lambertz, Ghislaine	Université Paris-Sud		
A:	Liu, Shari	Harvard		

A:	Soley, Gaye	Bogazici University		
A:	McCrink, Koleen	Barnard College		
A:	Tennenbaum, Joshua	MIT		
C:	Carey, Susan	Harvard		
C:	Dehaene, Stanis	Universite Paris-SUD		
C:	Harris, Paul	Harvard		

Table D: List editorial board, editor-in-chief and co-editors with whom you interact. An editor-in-chief should list the entire editorial board.

B: Editorial board: Name(s) of editor-in-chief and journal (in past 24 months).

E: Other Co-Editors of journals or collections with whom you directly interacted (in past 24 months).

to disambiguate common names

D	Name:	Organizational Affiliation	Journal/Collection	Last Active
B:				
E:				

reviewer.

R: Additional names for whom some relationship would otherwise preclude their service as a reviewer.

to disambiguate common names

D	Name:	Organizational Affiliation	Optional (email, Department)	Last Active
R:				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative (or Equivalent) or Individual Applicant

By electronically signing and submitting this proposal, the Authorized Organizational Representative (AOR) or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding conflict of interest (when applicable), drug-free workplace, debarment and suspension, lobbying activities (see below), nondiscrimination, flood hazard insurance (when applicable), responsible conduct of research, organizational support, Federal tax obligations, unpaid Federal tax liability, and criminal convictions as set forth in the NSF Proposal & Award Policies & Procedures Guide (PAPPG). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U.S. Code, Title 18, Section 1001).

Certification Regarding Conflict of Interest

The AOR is required to complete certifications stating that the organization has implemented and is enforcing a written policy on conflicts of interest (COI), consistent with the provisions of PAPPG Chapter IX.A.; that, to the best of his/her knowledge, all financial disclosures required by the conflict of interest policy were made; and that conflicts of interest, if any, were, or prior to the organization's expenditure of any funds under the award, will be, satisfactorily managed, reduced or eliminated in accordance with the organization's conflict of interest policy. Conflicts that cannot be satisfactorily managed, reduced or eliminated and research that proceeds without the imposition of conditions or restrictions when a conflict of interest exists, must be disclosed to NSF via use of the Notifications and Requests Module in FastLane.

Drug Free Work Place Certification

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent), is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Proposal & Award Policies & Procedures Guide.

Debarment and Suspension Certification

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

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency?

Yes

No

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Proposal & Award Policies & Procedures Guide.

Certification Regarding Lobbying

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

Certification for Contracts, Grants, Loans and Cooperative Agreements

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

- (1) No Federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any Federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

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

Certification Regarding Nondiscrimination

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Proposal & Award Policies & Procedures Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

- (1) community in which that area is located participates in the national flood insurance program; and
- (2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

- (1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
- (2) for other NSF grants when more than \$25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

Certification Regarding Responsible Conduct of Research (RCR)

(This certification is not applicable to proposals for conferences, symposia, and workshops.)

By electronically signing the Certification Pages, the Authorized Organizational Representative is certifying that, in accordance with the NSF Proposal & Award Policies & Procedures Guide, Chapter IX.B., the institution has a plan in place to provide appropriate training and oversight in the responsible and ethical conduct of research to undergraduates, graduate students and postdoctoral researchers who will be supported by NSF to conduct research. The AOR shall require that the language of this certification be included in any award documents for all subawards at all tiers.

CERTIFICATION PAGE - CONTINUED**Certification Regarding Organizational Support**

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that there is organizational support for the proposal as required by Section 526 of the America COMPETES Reauthorization Act of 2010. This support extends to the portion of the proposal developed to satisfy the Broader Impacts Review Criterion as well as the Intellectual Merit Review Criterion, and any additional review criteria specified in the solicitation. Organizational support will be made available, as described in the proposal, in order to address the broader impacts and intellectual merit activities to be undertaken.

Certification Regarding Federal Tax Obligations

When the proposal exceeds \$5,000,000, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal tax obligations. By electronically signing the Certification pages, the Authorized Organizational Representative is certifying that, to the best of their knowledge and belief, the proposing organization:

- (1) has filed all Federal tax returns required during the three years preceding this certification;
- (2) has not been convicted of a criminal offense under the Internal Revenue Code of 1986; and
- (3) has not, more than 90 days prior to this certification, been notified of any unpaid Federal tax assessment for which the liability remains unsatisfied, unless the assessment is the subject of an installment agreement or offer in compromise that has been approved by the Internal Revenue Service and is not in default, or the assessment is the subject of a non-frivolous administrative or judicial proceeding.

Certification Regarding Unpaid Federal Tax Liability

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Federal Tax Liability:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has no unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

Certification Regarding Criminal Convictions

When the proposing organization is a corporation, the Authorized Organizational Representative (or equivalent) is required to complete the following certification regarding Criminal Convictions:

By electronically signing the Certification Pages, the Authorized Organizational Representative (or equivalent) is certifying that the corporation has not been convicted of a felony criminal violation under any Federal law within the 24 months preceding the date on which the certification is signed.

Certification Dual Use Research of Concern

By electronically signing the certification pages, the Authorized Organizational Representative is certifying that the organization will be or is in compliance with all aspects of the United States Government Policy for Institutional Oversight of Life Sciences Dual Use Research of Concern.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE		DATE
NAME Ashley Thomas		Electronic Signature		Nov 1 2017 7:15PM
TELEPHONE NUMBER 805-701-5276	EMAIL ADDRESS ashleyjt@uci.edu		FAX NUMBER	

PROJECT SUMMARY

Overview:

A human's first social relationship is with their caregiver. These relationships are often considered to be affiliative relationships, which are relationships characterized by people motivated to approach and care for one another (Fiske, 1992). Indeed, even preverbal infants recognize affiliative relationships, expecting that an individual who imitates will approach who they imitated (Powell, Spelke, 2017) and expecting that individuals who coordinate their actions will move in the same patterns (Powell & Spelke, 2013). Infants also seem to prefer those who perform affiliative actions, for example, preferring helpers over hinderers (Hamlin, Wynn, Bloom, 2007), those who imitate others (Powell, Spelke, 2017), and those who comfort others (Spokes & Spelke, 2017). The proposed project will build on these findings, investigating two possible mechanisms that could lead children to form affiliative relationships with people beyond their caregivers. The findings will inform larger theories about 'core social knowledge' and the how social motivations develop over the first two years of life.

The first goal is to investigate whether infants, ages 4 months, 12 months and 24 months, use their caregivers as 'references' in their social evaluations. Do infants use information about who their caregivers affiliate with in their own social evaluations? The second goal is to investigate whether infants have a general motivation to see others affiliating. Eventually we will test whether it matters what relationship their caregivers have with those individuals. Do they prefer to see others reunite in general or only those who previously affiliated with their caregiver? To measure preference, these studies use the well-validated measures of preferential looking and reaching. The studies also use a more novel measure, fNIRS (functional near-infrared spectroscopy) to compare activation in the MPFC (medial prefrontal cortex) associated with social reward in adults to activation in the LPFC which is associated with information reward in adults.

Intellectual Merit:

The results of these studies will be of broad interest: First, all humans begin life by observing their caregivers in their environment. Understanding how infants use their caregivers as a 'reference' in evaluating novel people is of fundamental interest in areas such as social and moral development. These studies could provide one way that children develop in-group biases, especially biases found only in later childhood, such as racial preferences. Second, these studies use both well-validated measures and a more novel but successfully piloted one (fNIRS). This will allow us to differentiate between whether infants prefer stimuli because they get information reward or social reward from interacting with it. Third, early deficits in social motivation has been linked to autism spectrum disorders. These results could be applied to investigate whether the typical pattern of development that we find, is also found in atypical populations. For example, do children with autism spectrum disorder get reduced reward from looking at people affiliating than typically developing children do?

Broader Impacts:

This fellowship will be integral in my goal of becoming a Professor at a Research I University. The proposed work is ambitious, but it will allow the PI to significantly expand her skillset and broaden her research program. Dr. Spelke and Dr. Saxe will provide hands-on training in behavioral and fNIRS methodologies used for studying young infants. They will also provide hands on training for, professional development, dissemination of research, and theory-building in the field of cognitive development. Moreover, as a post-doctoral trainee, the PI will continue to build her strong record of (1) Mentoring 1st generation, and underrepresented minority (URM) students?The Saxelab currently has funding to support underrepresented minority research assistant positions, and the Spelke lab prioritizes mentoring URM as research assistants. (2) Scientific communication to the broader public: The PIs plan to broadly disseminate the results of this work to the public (3) Education and Outreach to Relevant Communities: Parents will be inherently interested in how their actions toward others inform their children's feelings about others. The PI will participate in educational events through the Saxelab such as the MIT work-life center, Cambridge science festival, and early head start programs where the findings will be described to parents.

TABLE OF CONTENTS

For font size and page formatting specifications, see PAPPG section II.B.2.

	Total No. of Pages	Page No.* (Optional)*
Cover Sheet for Proposal to the National Science Foundation		
Project Summary (not to exceed 1 page)	1	_____
Table of Contents	1	_____
Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) (Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	13	_____
References Cited	4	_____
Biographical Sketches (Not to exceed 2 pages each)	6	_____
Budget (Plus up to 3 pages of budget justification)	5	_____
Current and Pending Support	3	_____
Facilities, Equipment and Other Resources	3	_____
Special Information/Supplementary Documents (Data Management Plan, Mentoring Plan and Other Supplementary Documents)	6	_____
Appendix (List below.) (Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	_____	_____
Appendix Items:		

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

Finding one's social circle: How caregivers influence the social evaluations of infants.

A. Introduction: Affiliative relationships

As a social species, humans must create and maintain social relationships in order to thrive. One fundamental type of social relationship is an affiliative relationship, which is characterized by motivations to approach others and to care for them (Durkheim, 1912; Fiske, 1991; Tooby & Cosmides, 2005). These relationships occur in several settings, for example, in families, religious groups, or circles of friends. Some prominent scholars consider humans' earliest relationships—the ones we have with our mother and other caregivers—to be prototypical examples of affiliative relationships (Fiske & Haslam, 2005; see Hrdy, 2001 for review).

Across cultures, affiliation is often signaled through actions that unify people and delineate the in-group from the out-group. For example, affiliated people often synchronize their actions or imitate one another, such as in military formations or when dancing. They might also change their appearance so they look the same, for example by wearing uniforms or modifying their bodies through tattooing. Or they might physically connect, as when comforting, hugging, kissing or when nursing one's child.

People are motivated to be included in affiliative relationships (Baumeister & Leary, 1995; Over, 2016). Adults feel positive emotions both when they strengthen or create their own affiliative relationships and when they witness others doing so (Fiske, Schubert, & Seibt, 2016, 2017). For example, people feel good when hugging an old friend, or holding their baby for the first time, and they also feel good watching a stranger reunited with their family, or watching a YouTube video of a child comforting a pet.

In the proposed studies, we investigate two possible mechanisms that could lead infants to form and maintain affiliative relationships. First, infants may use their caregiver as a 'reference,' when evaluating new individuals—looking for information about whom to approach and whom to avoid. That is, infants may use their caregivers' affiliative behavior to decide who is in their in-group and who is not. Second, infants may have a general preference to see others affiliating. Here we ask if infants—as adults (Fiske et al., 2017)—like to watch others affiliating with one another. Or if it matters whether the individuals are members of their in-group. To test this, we ask if infants have a general preference to see affiliated individuals reunite. Next we ask if this preference differs depending on their caregiver's relationship with those individuals. If it infants have a preference to see others reunite who are affiliated with their caregiver, but have a preference to see individuals *separated* who their caregivers avoid, it could reflect an early developing mechanism that would reinforce social group structure.

B. Background: Previous work showing infants understand affiliative relationships

From infancy, humans recognize signals of affiliation. Infants seem to infer affiliation when they see others imitating, synchronizing, speaking a common language, or comforting one another. For example, 4 and 5-month-old infants expect that an individual who imitates another individual will approach that individual later (Powell & Spelke, 2016). Seven-month-old infants expect that individuals who synchronize their actions, by facing one another and moving in a circle, will move in the same patterns later (Powell & Spelke, 2013). Nine-month-olds expect that people who speak the same language will act friendly toward one another (Liberman, Woodward, & Kinzler, 2017) and 12-month-olds expect individuals who speak the same language, or who act friendly toward one another, to prefer the same foods (Liberman, Woodward, Sullivan, & Kinzler, 2016). Finally, 15-old infants expect that two smaller individuals who are comforted by a common larger one, will affiliate with one another by touching and synchronizing their actions (Spokes & Spelke, 2017).

Affiliation also seems to affect infants' social motivations: When infants observe affiliation, they tend to act in prosocial ways, and positively evaluate those who perform affiliative actions. For example, when 18-month-old infants are presented with two individuals touching, they are more likely to spontaneously help an experimenter, than when they are presented with two individuals facing away from one another (Over & Carpenter, 2009). Eighteen-month-olds are also more likely to help an experimenter if the experimenter imitates them beforehand (Carpenter, Uebel, & Tomasello, 2013). Affiliative actions also seem to influence preverbal infant's evaluations—6-month-olds prefer helpers over hinderers (Hamlin, Wynn, & Bloom, 2007) and 4-month-olds prefer individuals who imitate others over those who

do not (Powell & Spelke, 2016) and prefer those who comfort others over those who do not (Spokes, Venkatesan & Spelke, 2017). Thus, it seems that infants as young as 4 months old, can recognize signals of affiliative relationships and prefer those who engage in actions that signal affiliation. This work suggests that infants prefer those who engage in affiliative behavior even when the infants are not the target of those behaviors. They highlight the possibility that infants may attend to their caregivers' affiliative interactions with others, in order to learn about and extend their own social group.

Interestingly however, infants' inferences and evaluations of imitation are asymmetric. Although 4-month-olds prefer individuals who imitate and comfort others over those who do not, they show no preference for those who are imitated over those who are not imitated. Likewise, although 4 and 5-month-olds expect that an imitator will approach the individual they imitated, they do not expect the target to approach its imitator (Powell & Spelke, 2018).

One possible explanation for this finding is that young infants selectively pay attention to and prefer 'social actors' (the individuals who perform social actions), and ignore 'social targets' (the individuals whom social actions are directed toward). In the case above, the 'social actors' would be the ones imitating others, the 'social targets' would be the ones who were imitated (see Powell & Spelke, 2018; and Spelke, 2016 for discussion). However, an alternative explanation for the asymmetry is that infants pay attention to good candidates for affiliative partners, and that being imitated is not necessarily informative to this end. After all, one could be imitated or helped without ever reciprocating any action, or even noticing. However, if a person is imitated or comforted by someone that the infant has a relationship with, then it might indicate that the person is part of their in-group, and thus would be a good candidate for an affiliative partner. In the proposed studies, we investigate the idea that infants might be more attentive to social targets in situations where the infant already has a relationship with the social actor—and of course, the primary relationship in any infant's life is that with their caregiver.

The idea that infants pay attention to good candidates for affiliative partners is in line with work which shows that, 5-month-olds prefer those who speak their native language (Kinzler, Dupoux, & Spelke, 2012; Kinzler, Shutts, DeJesus, & Spelke, 2009), 6-month olds prefer those who help instead of hinder (Hamlin et al., 2007), 12-month-olds prefer those who prefer the same foods as them (Mahajan & Wynn, 2012), 15-month olds prefer fair individuals (Burns & Sommerville, 2014), and 24-month olds prefer those who win zero-sum conflicts (Thomas, Abramyan, Lukowski, Thomsen, & Sarnecka, 2016). Moreover, the idea that infants might prefer those who their caregivers affiliate with accords with the idea that people align their values with the values of the people they care about (Kleiman-Weiner, Saxe, & Tenenbaum, 2017). Since infants' primary relationships are with their caregivers, if infants are indeed motivated by 'external alignment', then they might align their own social evaluations with the social evaluations of their caregivers.

Indeed, infants as young as 9-months use 'social referencing'—they look to the emotional reaction of others to evaluate situations (Campos, Sorce, Emde, & Svejda, 2013). One study closely related to our proposal found that 10-month-old infants did *not* act more friendly toward a stranger in situations where their caregiver acted friendly versus neutral to the stranger (Feinman & Lewis, 1983). However there are several reasons why the infants may have not differentiated between strangers in this study—in the experiment, infants sat by their mother and as a stranger approached, the mother either spoke to the stranger in a friendly or neutral tone. Infants may have frightened by the unfamiliar strangers, such that any difference between the two conditions was undetectable. To avoid this issue we use puppets in our experiments instead of live actors (see below). This set-up also might have made it difficult for the preverbal infants to interpret linguistic cues or infants may have been confused about where the positive versus neutral communication was being directed. See Approach for ways we address this issue.

At least one study provides support for the hypothesis that infants may indeed look to their caregivers as references. In an observational study with infant chimpanzees, Evans and Tomasello (Evans & Tomasello, 1986) observed that infant chimpanzees in captivity initiate play more often with their mothers' 'friends' than with other adults. However, as the authors point out, it is unclear whether the infants' behaviors were due to their mothers relationship with the adults, or to past interactions that the infant chimpanzee may have had with their mothers' friends.

In the proposed studies we will investigate whether human infants use their caregivers as references in their social evaluations. In the first series of studies, infants will observe either their caregivers, or another infant's caregiver interacting with puppets on video, and then we will ask whether infants prefer one puppet to another. We measure evaluation by measuring whether infants reach selectively for one puppet over another, or prefer to look at one puppet over another. We will also investigate why infants have this preference using fNIRs (see fNIRS below). Our studies place infants in the role of 3rd party observers for several reasons. First, infants are better observers than actors. For example, 6-month-old infants, who observe a person intentionally reaching for an object infer that the person prefers that object—if they are habituated to a human hand repeatedly reaching for one of two objects, and the objects are switched, they show renewed attention if the hand reaches in the same location but for a different object (Woodward, 1998). However, 14-month-olds fail to incorporate this information into their helping behavior—if they see the same scene, and then see that the actor is trying but failing to reach for objects, they readily help the actor reach an object, but randomly select which object to hand to her (Hobbs & Spelke, 2015; see also Repacholi & Gopnik, 1997). The second reason for using a 3rd party approach is that it is difficult to control people's direct interactions with infants, which could result in difficult to interpret findings. This is also why we plan to have infants evaluate puppets instead of live actors in the study. Third, this work builds on previous work using a 3rd party approach—sometimes using looking time to measure expectation or preference (e.g. Kuhlmeier, Wynn, & Bloom, 2003; Powell & Spelke, 2013; Pun, Birch, & Baron, 2016; Sloane, Baillargeon, & Premack, 2012; Spokes & Spelke, 2017; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011) and sometimes using reaching to measure preference (e.g. Burns & Sommerville, 2014; Hamlin, Wynn, & Bloom, 2007; Powell & Spelke, in prep; Thomas & Sarnecka in prep). This work suggests that before infants are capable of many coordinated and effective social actions, they are adept at observing and interpreting the social actions and relationships of others.

The proposed work asks if infants, ages 4 months, 12 months and 24 months, use their caregivers as references when deciding whether to approach or avoid others. Infants will see videos of either their caregivers or strangers interacting with puppets. Then we investigate whether infants have a general preference for situations where people are able to engage in affiliative behaviors, over situations where they are not, specifically whether they prefer to see separated others reunite. We test the three age ranges to investigate possible developmental changes in infant's social knowledge and inferences (see E for hypotheses).

C. Broader Impacts of the Proposed Activities

This work will provide a description of the typical developmental trajectory for fundamental social motivations. This will inform other fields (e.g., education, special education, clinical psychology and psychiatry) that seek to understand and treat (1) problems related to dysfunctional affiliative relationships (e.g., child abuse and neglect, social exclusion, prejudice) and (2) developmental disabilities that interfere with forming these social relationships (e.g., autism spectrum disorders). For example, much of the previous work on bullying and social exclusion, focuses on individual attributes of the victim or perpetrator (Killen & Rutland, 2011). These studies could provide a starting point about how children's existing social relationships play a role in whether other children get excluded. Indeed, recent interventions with older children, that have considered the motivation to belong have seen success (e.g. Walton, 2014), but less is known about younger children's motivations. This is especially important in interventions to prevent social isolation, which disproportionately affects children from low socio-economic backgrounds and children who are racial or ethnic minorities (Walton & Cohen, 2007, 2011) and negatively affects school performance later in life (Walton & Cohen, 2007; Yeager & Walton, 2011).

Another broader impact of this work is that it could provide a basic mechanism to explain a disconnect between in-group racial biases that occur in preschool aged children (Baron & Banaji, 2006; Kinzler & Spelke, 2011; Nosek, Greenwald, & Banaji, 2007) but not in 10-month olds or 2 ½ year olds, and the fact that—presumably—most families in the United States do not explicitly teach children to prefer in-groups. If infants are indeed sensitive to the affiliations of their caregivers, than it could provide one mechanism that may lead to in-group favoritism, such that witnessing one's parents positively

interacting over and over again with the same social group might lead to children's biases. This prediction is supported by the work that shows infants prefer to look at own-race faces, but only in racially homogenous environments (Bar-Haim, Ziv, Lamy, & Hodes, 2006).

Finally, this work will also inform fields that study autism spectrum disorders. Recent research suggests that people with autism have a deficit in social motivations rather than social cognition (Chevallier, Kohls, Troiani, Brodtkin, & Schultz, 2012). The theory argues that early deficits in these motivations leads to deficits in cognitive abilities such as having Theory of Mind, rather than the other way around (See Over, 2016 for review). Thus, understanding typical development of social motivations to approach or avoid others could help with early diagnosis and our understanding of autism spectrum disorders.

As a post-doctoral trainee, I will also continue building my strong record of (1) Mentoring 1st generation, and underrepresented students: I have mentored around 40 undergraduate students at UC Irvine, about half of whom are Latina. During this fellowship I will continue to mentor URM students in the Saxelab, which currently has funding to support underrepresented minority research assistant positions during summer terms. I will also continue to prioritize hiring research assistants who are underrepresented in the Spelke Lab. (2) Scientific communication to the broader public: I have co-authored an op-ed in the Washington Post, and have been interviewed in several nationally distributed news publications including Bloomberg News, and NPR about my work. Dr. Saxe and Dr. Spelke have impressive records in public dissemination, including profiles of Dr. Spelke in the New York Times, and a TedTalk by Dr. Saxe that has been viewed over 2.5 million times. We plan to broadly disseminate the results of this work to the general public through these media outlets. (3) Education and Outreach to Relevant Communities: Parents will want to learn how their actions toward others inform their children's feelings about others. I will participate in educational events through the Saxelab at parent-support centers such as the MIT work-life center, Wellesley mothers forum, Cambridge Science Festival, early Head Start programs where I can describe her findings to interested parents.

How this fellowship will advance fundamental scientific knowledge in the SBE sciences.

This project will build fundamental knowledge about how infants form new social relationships with people beyond their caregivers and how they maintain existing ones. Moreover, this work will inform theories about infant's early representations of social relationships, investigating changes in infant's abilities to represent social targets and social actors. Finally this work will build knowledge about the development of in-group biases that occur later in childhood.

The proposed work will also advance methodological approaches to studying social development. The studies use a combination of well validated measures including looking time and reaching behavior as well as a more novel, non-invasive brain imaging measure, functional Near-InfraRed Spectroscopy (fNIRS). At the moment, looking time and reaching behavior are two of the few tools we have to understand the minds of infants. Using fNIRS will allow us to test for neural signatures of social preference, on the one hand, and social interest on the other: tests that promise to shed light on *why* infants preferentially reach for or look longer at some stimuli over others, and whether these behaviors are indicative of infants' social motivations (I describe these indicators below). Thus, the use of this novel measure, which has been successfully piloted by the co-mentor Dr. Saxe, will allow us to expand the methods available to answer old questions, as well as expanding the range of questions we can ask. At the same time, the use of tried -and -true behavioral measures will provide a benchmark that increases the confidence the scientific community can invest in our findings and in the new methods.

D. Approach

The studies are divided into two series. In series one, we test the hypothesis that infants look to their caregivers as a 'reference' about whom to trust. Our reasoning is that in most circumstances, human's first relationship is one with their mother or other caregiver (see Hrady, 2009 for review) and that infants may pay attention to how their caregivers treat others to form their own social evaluations. We test this by asking whether infants prefer social others who are affiliated with their caregivers more than those who are not affiliated with their caregivers. To signify affiliation, we use imitation and comforting—both because they are common indicators of affiliation (Fiske & Haslam, 2005; Tomasello, 1999) and because

they are asymmetric, which will allow us to investigate whether there are developmental changes as to whether infants can keep track of social targets versus social actors. We measure preference by measuring infant's reaching behavior, preferential looking, and fNIRS, testing for activation in a brain region that signals affiliative motivations and social reward in adults.

In series two, we investigate whether infants and toddlers have a general motivation to see others affiliating. We test this motivation by comparing preferential reaching, preferential looking, and fNIRS, testing again for activation in a brain region that signals social reward. To convey affiliative behavior, we present characters whose actions are synchronized, because like imitation and comforting, synchronization is a common indicator of affiliation. We will also begin collecting data for studies that investigate whether this preference differs if the infants' caregivers had previous affiliative or non-affiliative interactions with those individuals.

fNIRS: fNIRS is a brain imaging technique that allows the measurement of blood flow related to neural activity in awake infants sitting comfortably on their parents' laps (Aslin, Shukla, & Emberson, 2015; Gervain et al., 2011; Lloyd-Fox, Blasi, & Elwell, 2010). We will use fNIRS as a dependent measure to test whether stimuli provide social value versus information value. We will only test 4 to 6-month olds using fNIRS because older infants are often non-compliant (they can and do take the fNIRS cap off), and because of successful pilot studies with this age group by Dr. Saxe and Dr. Powell. Specifically, we will compare activation in MPFC (medial prefrontal cortex) and the LPFC (lateral prefrontal cortex) when infants are shown stimuli. The MPFC shows greater activation when adults see stimuli that provide social value (Rushworth, Noonan, Boorman, Walton, & Behrens, 2011; Van Den Bos, McClure, Harris, Fiske, & Cohen, 2007) while the LPFC shows greater activation when adults plan, learn abstract patterns, or process novel information (Fuster & Bressler, 2015). We focus on the prefrontal components because they can be accessed by fNIRs simultaneously on infants. Dr. Lindsey Powell and Dr. Rebecca Saxe, (Dr. Powell will collaborate on these projects, and Dr. Saxe is a Co-Mentor) have had success in initial pilot testing of this method with infants (Powell, 2017 presented at CDS). In this pilot testing, they showed infants either a person saying nonsense syllables who was smiling and using infant-directed speech, or a person saying nonsense syllables who had a neutral expression and was not using infant-directed speech. They found that when infants looked at the person who had been smiling and using infant-directed speech, there was more activation in the MPFC than when infants looked at the person who had previously had a neutral expression, but not more activation in the LPFC. They also found that the magnitude of the response in the MPFC predicts infants' tendency to look at that person in a subsequent preference test. Therefore, if we find that certain stimuli results in greater activation of the MPFC, then we will have good evidence that infants are getting social value from specific stimuli rather than simply being curious or getting some other kind of information from the stimuli. This technique can also be used in future work to measure individual differences in infant's social preferences, and motivations to approach or avoid others.

Aim 1: Investigate whether infants prefer those who are affiliated with their caregivers

Study 1.0 Replication of the finding that infants prefer those imitate over those who do not imitate.

Pilot Testing Imitation Paradigms: Since these studies build off previous studies that used animated characters, we will first test whether infants prefer imitators over non-imitators when they see videos of puppets imitating their caregivers. To do this, we need to ensure that infants see specific imitative behaviors as signals of affiliation and that they are paying attention to the control and experimental conditions equally. We will begin by pilot-testing several imitative behaviors that infants could possibly interpret as signals of affiliation. However, using live actors presents a potential problem—infants may interpret the noises their caregivers and puppets make as speech (as opposed to noises in the case of animated characters). If they do, then responding to speech with imitation may not signal affiliation to the infants, as conversation partners often make different utterances (e.g. if I say, 'hi how are you?' it would be strange if you said, 'hi how are you?' back). To test for this possibility, we will pilot test the following paradigms (both the experimental and control conditions). Critically, we will ask

whether infants expect that imitators will approach their caregiver after imitating them. We do this by comparing looking times to scenes where the puppet approaches or does not approach the caregiver after imitating them, following the procedure in Powell, Spelke, 2017. Here we will also test whether infants will watch the entirety of both experimental and control videos at least 3 times. This is to ensure in subsequent experiments that the infants will pay attention to the control and experimental videos equally.

Type of Imitation	Experimental Condition	Control Condition
Vocal Nonsense Noises	Caregiver makes a nonsense noise (e.g. 'beep-beep' or 'whooooo'). One puppet makes the same noise, the other puppet will make the other noise. (These noises will be made by experimenters off stage)	Caregiver makes a nonsense noise; one object is shaken and makes the same noise, another object is shaken that makes the other noise.
Movement	Caregiver does a movement (e.g. she moves her body left to right, or she bends her head down on the table). Then, one puppet imitates the movement and the other puppet does the other action.	Puppets are manipulated from the outside, such that infants can see that human hands are making the puppets move in the same way as experimental condition.
Humming	Caregiver hums a three note 'tune' (e.g. fa-la-la versus 'do-rei-me'). One puppet hums the same tune the other puppet hums a different tune.	Caregiver hums a three note 'tune' (e.g. fa-la-la); one object is shaken and makes the same tune, another object is shaken that makes a different tune.
Clapping/Knocking	Caregiver either claps hands together or knocks on table. Then, one puppet does the same action as the caregiver and the other puppet does a different action.	Puppets are manipulated from the outside, such that infants can see that human hands are making the puppets move in the same way as in the experimental condition.

We will also pilot an experimental paradigm where caregivers are comforted, to see if we replicate the result that infants like those who comfort over those who do not (Spokes, Venkatesan & Spelke, 2017). Here, the caregiver will say, 'oh no!', put her hands over her face and head down as if in distress. Then, one puppet will comfort the caregiver, and another puppet will turn away from the caregiver. In the

control condition, a hand will comfort the caregiver holding an object and another hand will move an object away.

Procedure and Dependent Variables: Once we find an imitation and comforting paradigm that infants interpret as affiliation, we will then test for preferences. In the study descriptions in this series, we will assume that infants see 'Vocal Nonsense Noise' imitation as a signal of affiliation. Infants will be randomly assigned to either the control or experimental condition. Each infant will see both experimental conditions (comforting and imitating) or both the control videos, presented in a

counterbalanced order, with the choice procedure after each video with a short break between the two conditions. Each video will be repeated three times (see Kinzler, Dupoux, & Spelke, 2007). This is so infants attend to the videos equally across conditions. Any infant who does not watch the entirety of the videos will be excluded from the analysis. After watching one of the videos three times, the two puppets or objects will be presented to the infants. For 12-month-olds and 24-month-olds, they will be asked, 'Which one do you like?' and the dependent measure will be which puppet they reach for. For the four-month-olds, both puppets will be presented to the infant, and the dependent measure will be which puppet they spend the most time looking at.

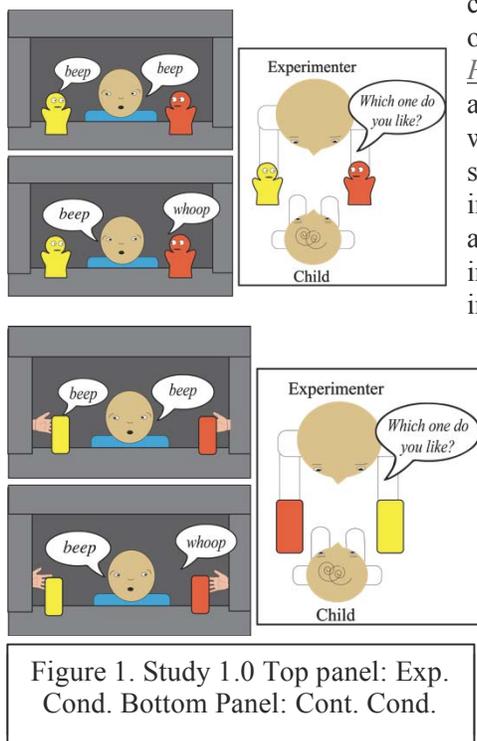


Figure 1. Study 1.0 Top panel: Exp. Cond. Bottom Panel: Cont. Cond.

Expected Outcomes. We expect infants to prefer the puppet that imitates or comforts their caregiver over the one who does not, but to show no preference in the control conditions.

fNIRS: A separate set of 4 to 6-month-old infants will be tested using fNIRS (older infants cannot be tested using this procedure because they can and do take the cap off: see above). After seeing one video three times, we will present the puppets or objects to the infants one at a time. We will test whether they show greater activation in the MPFC (but not the LPFC) when presented with a puppet who comforted or imitated the infant's caregiver, versus one that did not comfort or imitate their caregiver. We do not expect to find differences in MPFC activation when shown the objects from the videos.

Study 1.1 Do infants prefer a puppet who imitates or comforts their caregiver over one who imitates or comforts a stranger?

Next, we will investigate whether infants prefer an individual who imitates or comforts their caregiver over an individual who imitates or comforts a stranger. This experiment is meant to further probe our hypothesis that infants specifically look to their caregiver to see who is in their in-group.

Stimuli: The stimuli in Study 1.1 will be similar to that in Study 1.0, except there will be two people sitting at the table—one will be the participant's caregiver, one will be an experimenter. In the imitating

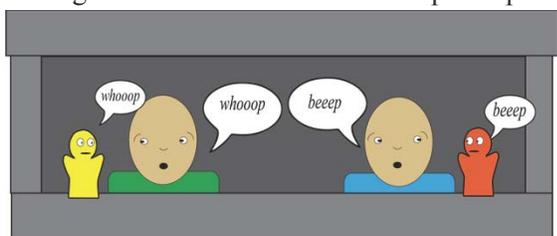


Figure 2. Study 1.1 Exp. Cond.

experimental video, infants will see a video in which one puppet imitates their caregiver, and another puppet imitates the experimenter (See Figure 2.) In the comforting experimental video, both the caregiver and experimenter will put their heads down as if in distress, one puppet will comfort one of the caregivers, and the other puppet will comfort the other caregiver. The control videos will be very similar to the experimental

videos except that in the imitating control video, one caregiver will make a noise followed by the other caregiver. Again, the hand will shake one object which will make the same noise as the caregiver, and the other hand will shake the other object, which will make the same noise as the experimenter. In the comforting control video, one hand will move one object toward the caregiver and will comfort her with the object in hand. This will be repeated with the other object toward the experimenter. (The order of these actions will be counterbalanced)

Procedure and Dependent Measures: As in Study 1.0, infants will be randomly assigned to the control or experimental conditions, and will see both experimental or control videos in a counterbalanced order with the choice procedure following each video.

Expected Outcomes: If infants can track the targets of social actions, differentiating between caregiver and stranger, and use their caregiver as a reference, then they should prefer those who comfort or imitate their caregiver over those who comfort or imitate the experimenter; but they should have no preference between the objects. If infants prefer any individuals who perform affiliative actions than they should have no preference for either puppet.

fNIRS: If infants get social value from those who affiliate with their caregivers, versus those who affiliate with strangers, then we should see greater activation in the MPFC (but not LPFC), when they are presented with the puppet who imitated their caregiver over the one who imitated the stranger. There should be no difference in activation in response to the objects from the control conditions.

Study 1.2 Do infants prefer those who are imitated by their caregivers over those who are not?

In this study, the infant's caregiver will be the social actor and the puppets will be the social targets. Here we investigate whether infants prefer an individual who is imitated/comforted by their caregiver over one who is not. In doing so, we investigate whether there are developmental differences in infants' ability to represent social targets. Another group of infants will be tested to see whether any preference we find, also applies when it is a stranger (another infant's caregiver) that is imitating or comforting puppets.

Stimuli: Each infant will be randomly assigned to either experimental or control conditions, and stranger or caregiver conditions. Each infant will see the two videos in each of the four conditions.

Caregiver Conditions: Following Study 1.0, the imitating caregiver video will begin with their caregiver sitting at a table facing the screen. Two puppets will appear on either side of the caregiver. One

puppet will be imitated by their caregiver and the other puppet will not be imitated by their caregiver. The comforting video will begin in the same way, except instead of making a noise, the two puppets will make a crying noise and will put their hands over their faces, as if in distress. The infant's caregiver will comfort one puppet and not comfort the other puppet.

Stranger Conditions: This video will be the same as the one described above, except that instead of the infant's caregiver, infants will see another infant's caregiver doing the same actions.

Control Conditions: In the imitating control conditions, the puppets will be replaced by objects. In the imitating conditions, a hand will shake each object, which will make a noise, and the caregivers in the video will either imitate one of the sounds. In the comforting conditions, the objects will make a siren noise, and the caregivers will approach one and turn it off. (See Figure 2, right panel)

Procedure: Infants will be randomly assigned to either control or experimental condition, and stranger or caregiver condition and will see both the comforting/imitating videos for each condition. For example, an infants in the experimental caregiver condition see either the imitating or control video three times with their caregiver, then are presented with the two puppets for the choice procedure. Then, after a short break, the infant sees the other video three times, and again will be presented with the two puppets from that video for the choice procedure.

Expected Outcomes: If infants can indeed represent both the social targets and social actors in affiliative interactions, then 4-month-old infants should look longer at the puppet that is imitated or comforted by their caregiver than a puppet who is ignored. If this preference is due to the social interaction between their caregiver and puppet, then they should not display this preference for objects that their caregiver interacted with. Based on findings in Powell & Spelke, 2017 we do not expect 4-month-olds to differentiate between puppets or objects interacting with strangers. On the other hand, if 4-month-olds cannot keep track of social targets at all then they should be at chance in all conditions.

Predictions for 12 and 24-month-olds are less clear. If both age groups have a general preference for individuals who are affiliated with others, they should prefer puppets who are imitated/comforted by their caregivers and those who are imitated/comforted by strangers. On the other hand, if this preference is driven by a motivation to find in-group members, they should prefer those who are imitated or comforted by their caregivers but not those who are imitated/comforted by strangers (see E. for hypotheses about age-related changes). Another possibility is that 24-month-olds see being imitated as a signal of social status and will prefer anyone who is imitated, but not anyone who is comforted (in line with results in Thomas et. al. in review). Thus, a possible pattern of results is that 4-month-olds fail to keep track of social targets and thus do not display a preference for those who interact with their caregivers or strangers; 12-month-olds do keep track of social targets but prefer only people who their caregivers affiliate with; and 24-month-olds like anyone who is imitated because it signals social status, prefer those who are comforted by their caregivers, but do not differentiate between those who are comforted or not by strangers.

fNIRS: Another set of 4 to 6-month-old infants will be tested using fNIRS. If they indeed prefer puppets who are imitated or comforted by their caregivers, and this is due to a social reward, they should show greater activation in the MPFC for the puppet who was comforted or imitated by their caregiver over ones that were ignored, less of a difference between puppets who interacted with strangers, and no difference between the objects from the control condition.

AIM 2: Investigate whether infants want to see others affiliating?

Here, we will explore whether infants prefer to watch others affiliating—specifically whether infants prefer to see others 'reunite' after being separated. Then we will begin testing whether this depends on whether their caregivers are shown to be affiliated with the individuals beforehand. If they have a general preference to watch others affiliate, this would be evidence that infants may feel the positive emotions that adults feel when they see others creating or strengthening affiliative relationships, a mechanism that could lead to forming affiliative relationships in general. If they only prefer to watch individuals affiliate whom their caregivers have shown affiliation with, but prefer to watch individuals separated whom their

caregivers avoided, it would be evidence that they have a general motivation to see their in-group affiliate with one another, which could lead to in-group biases.

Study 2.0 Do infants want to see affiliated others reunited?

Stimuli: Infants will be assigned to either the control condition or the experimental condition. In the experimental condition, infants will see a video of two animated characters facing one another and moving in synchrony. Then, an object will block the characters—separating them from one another. The characters will stop synchronizing their actions—they will continue to move but not in a synchronized pattern. Next, the barrier will be lifted and the characters will synchronize their actions again. This sequence will be repeated three times. For half of the infants, the video will end with the barrier in place. For half of the infants, the video will end with the barrier removed. In the control condition, infants will see a similar scene, except the characters will move in perceptually similar ways to the characters in the experimental condition, but the actions will not be coordinated with one another (as in Powell, 2013). The rest of the procedure will be the same. To test whether infants may have a preference for anything that is synchronized, we will show them very similar animations to the experimental condition, except the facial features will be scrambled.

Procedure and Expected Outcomes: We expect infants to display preferential looking to the scenes where the barrier is removed only in the experimental condition, but not in the control conditions.

fNIRS: We will use fNIRS to compare the difference in MPFC activation when infants see the experimental scene, with the a barrier in place, versus the experimental video with the barrier removed. This will allow us to test whether infants get a social reward when they see two characters who were affiliated reunited. We will compare this to control conditions, where we expect no difference in MPFC activation.

Study 2.1 Do infants show stronger preferences when their caregiver affiliates with the puppets beforehand?

In the next study, caregivers will either be shown affiliating with both pairs of puppets (i.e. will share food with them or sing the same song, we will have to pilot this) or will avoid them. Then, the infants will see the videos in Experiment 2.0, and we will record whether infants prefer to see the scene where the barrier is removed or in place. If infants' preference for seeing other affiliate is driven by a desire to strengthen or reinforce one's in-group, then infants should want to see those who their caregiver affiliated with reunite, but should not want to see those who their caregiver avoided reunite. Moreover, we should find activation in the MPFC that accords with these preferences. Infants should show more activation in the MPFC when they see others reunite that were affiliated with their caregiver. But they may also have more activation when they see others *separated* who their caregiver avoided. We plan to pilot this study in the last year of my fellowship.

E. Age Groups, Sample Sizes and General Dependent Variables

Age groups and Hypotheses about Changes: We will test three age groups: 4-month-olds, 12-month-olds, and 24-month-olds. Comparing the results of 4 and 12-month olds will allow us to investigate predictions made by hypotheses about the limitations and development of infants' core social knowledge. A recent hypothesis by Dr. Spelke proposed that infants may start with distinct concepts for 'social beings' and 'agents'. Agents act on objects efficiently, and cause them to change, while social beings perform social actions (like imitation or comforting) that show attention and affiliation, but do not cause changes to the mental states of their social targets (Spelke, 2016). Evidence for this hypothesis comes from the finding that infants expect imitators to approach who they imitated, but do not expect those who are imitated to approach the individual who imitated them (Powell & Spelke, 2017, see Spelke 2016). Thus, infants may see imitation/comforting as a signal of social attention and commitment, but only from the imitator. This is also in line with the finding that 3-month-olds prefer helpers, but do not expect the individuals who are helped to approach their helper (Kiley Hamlin, Wynn, & Bloom, 2010). It may not be until the age of 9-12 months that infants are able to put the concept of agent and social being together, such that they would expect that when their caregiver imitates, comforts or helps the puppet, it causes the puppet to feel affiliated with their caregiver. If this is true, then 4-month-olds might have no preference for those who are imitated by either their caregiver or a stranger, while 12-month-olds may prefer those who are

imitated/comforted by their caregiver, seeing them as good candidates for affiliative partners. This hypothesized change corresponds to what Tomasello calls the nine-month 'social revolution' in which infants between the ages of 9 and 12 months begin to understand other individuals as intentional beings whose experiences can be shared (Tomasello, 1999). For example infants begin to follow the gaze of others, follow gestures toward objects, and begin to use their caregivers as references about whether objects and situations are good or bad, all of which suggests a unique human capacity to see others as intentional beings whose experiences can be shared.

On the other hand, infants may understand imitation and comforting as actions that are caused by a relationship between the two individuals. This would suggest that one reason they don't expect social targets to approach social actors, is that they only pay attention to social targets when someone they have a relationship with is doing the social action. If this is true, then when infants see their caregivers comforting or imitating a novel individual, they may infer affiliation between the pair, and may prefer them. Testing 4-month olds, 12-month-olds, and 24-month-olds will allow us to investigate these alternative hypotheses at these three ages. If 12-month-olds and 4-month-olds fail to show a preference for those who are imitated or comforted by their caregivers, then testing 24-month-olds will help clarify why we find this lack of preference. For example, it might not be until even later than 12-months that infants can track social targets.

Sample Sizes and Planned Analysis

Preference Data: We will perform Bayesian binomial tests and contingency tests to calculate Bayes Factors using the Bayes Factor package in R (Morey, Rouder, & Jamil, 2014; Team, 2015). The Bayes factor is a ratio that contrasts the likelihood of the data fitting under the null hypothesis against the likelihood of the data fitting under the alternative hypothesis. For example, when we are testing to see if infants prefer one puppet or another, the null would be that infants are choosing one option 50% of the time, and the alternative hypothesis would be that they are not choosing the puppets at 50%. We will assume no prior preference between alternative and null. For example, if we have 16/18 infants choosing one puppet over the other, this would give us a Bayes Factor of about 90 in favor of the alternative hypothesis, meant that the data is 90 times more likely given the alternative hypothesis than the null. To compare across conditions, we will also use Bayesian contingency tables which compare the likelihood of data fitting under the null hypothesis that the frequency of choices is the same between groups compared to the alt. hypothesis that the frequency of choices is different across conditions. Our reasoning for using Bayesian analyses, is that unlike frequentist analyses, it allows for preferential stopping (Csibra, Hernik, Mascaro, Tatone, & Lengyel, 2016). However, we plan to test at least 18 infants in each age group in each condition, based on effect sizes in previous experiments.

fNIRS data: The raw fNIRS data recorded by the CW6 system will be preprocessed using the Homer2 package for MATLAB (Huppert, Diamond, Franceschini, & Boas, 2009). The preprocessing steps in this package are based on published analyses of infant and adult fNIRS data, and was used to successfully remove motion artifacts and other sources of noise while maintaining channel-specific hemodynamic responses differentiating stimulus conditions (Wilcox, Bortfeld, Woods, Wruck, & Boas, 2005) in the completed pilot studies from the Saxelab. In addition, all sessions will be videotaped so that infants' attention to the displays can be coded offline. Trials to which infants attended for less than two thirds of the duration will be excluded from further analyses, and infants who do not attend to at least 6 trials for each of the two main conditions in an experiment will be excluded from the sample. To compare the activation in the MPFC and DLPFC we will again use the Bayes Factor package in R to compare ANOVA models to see whether the data is more likely given a model that includes our variable of interest over one that does not.

Open Data and Open Science: All data and stimuli will be made publicly available during the time of publications, via the open science framework (<https://osf.io/>). All publications will be made freely available via the main author's website, upon request, and on e-scholar. We will also pre-register these studies via the open science framework.

Career Goals

My career goal is to become a tenured professor at a Research I University. One of my ultimate aims is to not only establish normal developmental trajectories for how humans represent social relationships, but also establish how these trajectories might be different across cultures, or in populations with atypical social development. Ultimately, I want to collaborate with colleagues in the field of developmental psychology and in related fields such as Anthropology and Clinical Psychology, to achieve the broad goal of understanding core social knowledge and how children (both typically developing and atypically developing) build onto that knowledge to interact with others in their specific environment or culture. This fellowship will be an important vehicle for achieving that goal.

During my time as a PhD student I established two distinct lines of research—one that focused on naïve sociology (children's understanding of social hierarchies) and one that focused on adult's moral cognition and how it interacts with social groups (e.g. parents versus non-parents and racial groups). My expertise in these areas is reflected in my publication history and in my conference presentations. In my work on infants' understanding of social hierarchy, I have a 7 study paper under revision, where my colleagues and I discovered that two-year-old infants prefer the winners of zero-sum conflicts, but only when they are deferred to, not win they win by force. Recently, we found that infants, ages 10-14 months prefer the puppet who defers and are investigating what changes in children's ability represent social relationships might correspond to this change in preference. This work also led to several other ongoing projects that investigate whether preschool aged children, expect leaders to act benevolently, prefer egalitarian groups versus those with leaders, and whether children act pro-socially when put in leadership positions themselves. The proposed project expands on this work by investigating infant's social evaluations that have to do with affiliations. Moreover, while I have experience studying 2-to 6-year-old children, I have less experience studying preverbal infants. To achieve my goal of understanding core social knowledge it is necessary that I get more experience with this population. The Saxelab and Spelke lab will be ideal settings for this goal.

During my post-doc I will gain invaluable experience studying pre-verbal infants with Dr. Spelke and Dr. Saxe who are leading scholars in the field of infant social cognition. Dr. Spelke is a leading expert in cognitive development, and for over thirty years has investigated the nature and early development of human knowledge by conducting behavioral research on infants and young children. A major part of this research has focused on people as social beings. Dr. Spelke's work and subsequent theory building has been highly influential in the field. In Dr. Spelke's lab I will develop expertise working with infants, will sharpen my experimental design skills, and will allow me to work with her to build theories about core social knowledge. The proposed work directly builds off ongoing and recent work from her lab about infants ability to understand people as social beings, including the recent work on infants ability to represent affiliative relationships including imitation and comforting, her work on infant's face perceptions, on infants preferences for speakers of their native language, and infants expectations about fairness and social groups (Cogsdill, Todorov, Spelke, & Banaji, 2014; Kinzler et al., 2012, 2009; K. R. Olson, Banaji, Dweck, & Spelke, 2006; K. Olson & Spelke, 2008; Powell & Spelke, 2013, 2016; Spelke, 2016; Spokes & Spelke, 2016).

I chose to work with Dr. Saxe because of her expertise in social developmental neuroscience and because she is also a leading scholar in the area of infant social cognition. Her expertise in this area will allow me to expand my skill set to include learning how to use fNIRS. A major part of her research is understanding areas in the brain that allow humans to have theory of mind. This experience will also give me the chance to learn the process of developing a new method in studying infant cognition. She has several papers that use neuroscience to investigate social cognition, including several papers on how neuroscience can expand our understanding of social cognition in infants (Cikara, Bruneau, & Saxe, 2011; Saxe, 2006a, 2006b; Saxe, Carey, & Kanwisher, 2004; Saxe & Haushofer, 2008; Saxe & Kanwisher, 2003; Saxe & Powell, 2006).

Harvard and MIT will also afford several opportunities to get input about the theories I hope to build from other faculty members, setting up potential collaborations in the future. Although my current adviser is an expert in cognitive development, I was her first trainee that focused on social development.

Thus, working closely with experts in social development and social cognition will allow me deepen my theoretical background in my specific field of interest. Working with Dr. Saxe and Dr. Spelke will be the ideal way to gain a deeper understanding of cognition in preverbal infants as well, as both have extensive experience working with such populations. In addition, Harvard and MIT is an intellectually rich environment, where there are several other graduate students, post-docs and faculty members interested in related topics such as Susan Carey, Laura Schulz, Jim Sidanius, Fiery Cushman, Mahzarin R. Banaji, and Mina Cikara.

To sum, I approached Dr. Saxe and Dr. Spelke to advise me on these projects because the proposed research builds off of ongoing work in their lab and because MIT and Harvard will provide the perfect environments for me to develop skills necessary to reach my long-term goals. The work and training plan laid out here will be essential in the transition to become an independent researcher, and in successfully developing a research program focused on understanding the development of social cognition.

Training Plan

Before I begin my post-doctoral fellowship, I will meet with both of my co-mentors in an in-depth meeting to discuss my training plan. This meeting will establish target dates for publications and conference presentations, future meeting dates, and we will identify the best places to begin my training. Throughout the fellowship, I will meet with both mentors on a weekly basis. In these meetings we will discuss the execution and completion of my work, including the writing and completion of manuscripts resulting from the studies in my project. During these meetings we will also discuss the ins and outs of being the principle investigator of a lab, including mentoring, administration, coordination, planning, execution, communication with the public, and problem-solving. I will also attend two weekly group meetings where I will have the opportunity to present my work and give others feedback on their work. The group meetings are standard lab meetings, which focus on discussing things such as results from projects and feedback on writing such as manuscripts or grants. I also plan to attend meetings for other labs on both the MIT and Harvard campuses. These include the Carey Lab (cognitive development) and Cushman Lab (Moral and Social Psychology) at Harvard and the Schulz lab (cognitive development) at MIT. I will also have the opportunity to attend colloquia, brown bags and other presentations on the Harvard and MIT campuses, and will have the opportunity to present my work to labs on several other campuses in the area. To keep track of the talks and relevant meetings I will add myself to relevant email lists. I will also continue to have bi-monthly skype meetings with Professor Alan Fiske whose theoretical work informs the proposed work. I also plan to attend conferences such as SRCD (Society for Research on Child Development), CDS (Cognitive Development Society), SPSP (Society for personality and social psychology); (Cognitive Neuroscience) as well as several others.

In addition to research, I have planned relevant coursework and mentoring activities to supplement my post-doctoral training. During year 1, I will expand my skillset through auditing *Empirical and Computational Approaches to Cognitive Development* taught by Prof. Spelke (Psy 2151); and *Developmental Neurobiology* with Nedivi and Heiman at MIT. During this time I will also take a course on the *Responsible conduct in Science* offered through MIT with Wilson.

In year 2, I will further expand my skill set by auditing courses at MIT including *Computational Cognitive Science* with Tenenbaum; and *Intergroup Relations* taught by Prof. Sidanius (PSY 2570).

Additionally, I will gain mentoring skills through mentoring graduate and undergraduate students on independent research. Dr. Spelke and Saxe places particular emphasis on the training of undergraduate research assistants, and currently the Saxlab has an REU to pay underrepresented minorities to gain research experience. I have experience successfully mentoring undergraduate research assistants, some of whom were funded by an REU to pay underrepresented minority students in the Sarnecka lab, and look forward to continuing this work. I will be able to work closely with research assistants, both training them in research methods and benefiting from their assistance in recruiting subjects and coding behavioral data.

I chose to work with Dr. Spelke and Dr. Saxe at Harvard and MIT in order to build expertise in studying the development of human's understanding of social relationships from infancy through age two.

Dr. Spelke and Dr. Saxe are an ideal set of mentors for the proposed research: They have extensive expertise in understanding core knowledge and subsequent development, and have a high success rate for job placement for their trainees. The resources and facilities in the Saxelab and Spelke Lab are exceptional places to carry out research with infants. I will be able to collect data efficiently in both of these well-funded labs. My post-doctoral work will surely benefit from working closely with these two leaders in our the field of cognitive development.

Year	Task	Aim 1			Aim 2	
		Study 1.0	Study 1.1	Study 1.2	Study 2.0	Study 2.1
1	Data Collection	x	x	x		
	Data Coding	x	x			
	Data Analysis & Write up	x				
2	Data Collection				x	x
	Data Coding			x	x	x
	Data Analysis & Write up		x	x	x	

Timeline for Training Activities

Year 1:

An in-depth meeting with both co-mentors to develop an individual development plan. This plan will include specific details of study designs, needed skill development and mentorship, possible coursework to supplement the research, target dates for publications and conference presentations.

Weekly 1:1 meetings with both mentors

Audit Courses: *Computational Approaches to Cognitive Development* taught by Prof. Spelke (Psy 2151); and *Developmental Neurobiology* with Nedivi. During this time I will also take a course on the *Responsible conduct in Science* offered through MIT with Wilson.

Weekly lab meetings

Mid-year check in meeting about development plan progress

Begin training on fNIRS

Year 2:

An in-depth meeting with both co-mentors to check in about progress and re-adjustments

Weekly 1:1 meetings with both mentors; Weekly lab meetings

Audit: *Computational Cognitive Science* with Tenenbaum; *Intergroup Relations* taught by Prof. Sidanius

Develop a plan at the end of year about finishing projects

Apply for NIH K-Award

Apply for faculty positions

References Cited

- Aslin, R. N., Shukla, M., & Emberson, L. L. (2015). Hemodynamic correlates of cognition in human infants. *Annual Review of Psychology*, *66*, 349–379.
- Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science*, *17*(2), 159–63. <https://doi.org/10.1111/j.1467-9280.2006.01679.x>
- Baron, A. S., & Banaji, M. R. (2006). The development of implicit attitudes. *Psychological Science*, *17*(1), 53–58. <https://doi.org/10.1111/j.1467-9280.2005.01664.x>
- Baumeister, R. F., & Leary, M. R. (1995). The need to belong: desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin*, *117*(3), 497–529. <https://doi.org/10.1037/0033-2909.117.3.497>
- Burns, M. P., & Sommerville, J. A. (2014). “I pick you”: The impact of fairness and race on infants’ selection of social partners. *Frontiers in Psychology*, *5*(FEB), 1–10. <https://doi.org/10.3389/fpsyg.2014.00093>
- Campos, J. J., Sorce, J. F., Emde, R. N., & Svejda, M. (2013). Emotions as behavior regulators: Social referencing in infancy. *Emotions in Early Development*, *57*.
- Carpenter, M., Uebel, J., & Tomasello, M. (2013). Being mimicked increases prosocial behavior in 18-month-old infants. *Child Development*, *84*(5), 1511–1518. <https://doi.org/10.1111/cdev.12083>
- Chevallier, C., Kohls, G., Troiani, V., Brodtkin, E. S., & Schultz, R. T. (2012). The social motivation theory of autism. *Trends in Cognitive Sciences*. <https://doi.org/10.1016/j.tics.2012.02.007>
- Cikara, M., Bruneau, E. G., & Saxe, R. R. (2011). Us and them intergroup failures of empathy. *Current Directions in Psychological Science*, *20*(3), 149–153.
- Cogsdill, E. J., Todorov, A. T., Spelke, E. S., & Banaji, M. R. (2014). Inferring character from faces: a developmental study. *Psychological Science*, *25*(5), 1132–9. <https://doi.org/10.1177/0956797614523297>
- Csibra, G., Hernik, M., Mascaro, O., Tatone, D., & Lengyel, M. (2016). Statistical treatment of looking-time data. *Developmental Psychology*, *52*(4), 521–536. <https://doi.org/10.1037/dev0000083>
- Durkheim, E. (1912). *The elementary forms of the religious life [1912]*. na.
- Evans, A., & Tomasello, M. (1986). Evidence for Social Referencing in Young Chimpanzees (Pan troglodytes). *Folia Primatol.*, *47*(1), 49–54. <https://doi.org/10.1017/CBO9781107415324.004>
- Feinman, S., & Lewis, M. (1983). Social Referencing at Ten Months : A Second-Order Effect on Infants’ Responses to Strangers. *Child Development*, *54*(4), 878–887.
- Fiske, A. P. (1991). *Structures of social life: The four elementary forms of human relations: Communal sharing, authority ranking, equality matching, market pricing*. Free Press.
- Fiske, A. P., & Haslam, N. (2005). The Four Basic Social Bonds. Structures for Coordinating Interaction. *Interpersonal Cognition*. Retrieved from http://books.google.com/books?hl=en&lr=&id=pbv35TUf1l8C&oi=fnd&pg=PP2&dq=Interpersonal+Cognition&ots=UJbUgC_qw-&sig=s90gD3hLIUszITnZDIZGV2JEIdI
- Fiske, A. P., Schubert, T. W., & Seibt, B. (2016). Kama muta” or “being moved by love”: A bootstrapping approach to the ontology and epistemology of an emotion. *Universalism without Uniformity: Explorations in Mind and Culture*.
- Fiske, A. P., Schubert, T. W., & Seibt, B. (2017). The Best Loved Story of All Time: Overcoming All Obstacles to Be Reunited, Evoking Kama Muta. *Evolutionary Studies in Imaginative Culture*, *1*.
- Fuster, J. M., & Bressler, S. L. (2015). Past makes future: Role of pFC in prediction. *Journal of Cognitive Neuroscience*.
- Gervain, J., Mehler, J., Werker, J. F., Nelson, C. A., Csibra, G., Lloyd-Fox, S., ... Aslin, R. N. (2011). Near-infrared spectroscopy: a report from the McDonnell infant methodology consortium. *Developmental Cognitive Neuroscience*, *1*(1), 22–46.
- Hamlin, J. K., Wynn, K., & Bloom, P. (2007). Social evaluation by preverbal infants. *Nature*, *450*(7169), 557–9. <https://doi.org/10.1038/nature06288>
- Hobbs, K., & Spelke, E. (2015). Goal attributions and instrumental helping at 14 and 24 months of

- age. *Cognition*, 142, 44–59. <https://doi.org/10.1016/j.cognition.2015.03.014>
- Hrdy, S. B. (2001). Mothers and Others. *Natural History*.
- Huppert, T. J., Diamond, S. G., Franceschini, M. A., & Boas, D. A. (2009). HomER: a review of time-series analysis methods for near-infrared spectroscopy of the brain. *Applied Optics*, 48(10), D280–D298.
- Killen, M., & Rutland, A. (2011). *Children and social exclusion: Morality, prejudice, and group identity*. John Wiley & Sons.
- Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2012). “Native” Objects and Collaborators: Infants’ Object Choices and Acts of Giving Reflect Favor for Native Over Foreign Speakers. *Journal of Cognition and Development*, 13(1), 67–81.
- Kinzler, K. D., Shutts, K., DeJesus, J., & Spelke, E. (2009). Accent trumps race in children’s social preferences. *Social Cognition*, 27(4), 623–634.
- Kinzler, K. D., & Spelke, E. S. (2011). Do infants show social preferences for people differing in race? *Cognition*, 119(1), 1–9. <https://doi.org/10.1016/j.cognition.2010.10.019>
- Kleiman-Weiner, M., Saxe, R., & Tenenbaum, J. B. (2017). Learning a commonsense moral theory. *Cognition*.
- Kuhlmeier, V. A., Wynn, K., & Bloom, P. (2003). Attribution of dispositional states by 12-month-olds. *Psychological Science*, 14(5), 402–408. <https://doi.org/10.1111/1467-9280.01454>
- Liberman, Z., Woodward, A. L., & Kinzler, K. D. (2017). Preverbal Infants Infer Third-Party Social Relationships Based on Language. *Cognitive Science*, 41, 622–634. <https://doi.org/10.1111/cogs.12403>
- Liberman, Z., Woodward, A. L., Sullivan, K. R., & Kinzler, K. D. (2016). Early emerging system for reasoning about the social nature of food. *Proceedings of the National Academy of Sciences*, 113(34), 9480–9485. <https://doi.org/10.1073/pnas.1605456113>
- Lloyd-Fox, S., Blasi, A., & Elwell, C. E. (2010). Illuminating the developing brain: the past, present and future of functional near infrared spectroscopy. *Neuroscience & Biobehavioral Reviews*, 34(3), 269–284.
- Mahajan, N., & Wynn, K. (2012). Origins of “Us” versus “Them”: Prelinguistic infants prefer similar others. *Cognition*, 124(2), 227–233. <https://doi.org/10.1016/j.cognition.2012.05.003>
- Morey, R. D., Rouder, J. N., & Jamil, T. (2014). BayesFactor: Computation of Bayes factors for common designs. *R Package Version 0.9*, 8.
- Nosek, B. A., Greenwald, A. G., & Banaji, M. R. (2007). The implicit association test at age 7: A methodological and conceptual review. In *Automatic processes in social thinking and behavior* (pp. 265–292).
- Olson, K. R., Banaji, M. R., Dweck, C. S., & Spelke, E. S. (2006). Children’s biased evaluations of lucky versus unlucky people and their social groups. *Psychological Science*, 17(10), 845–846. <https://doi.org/10.1111/j.1467-9280.2006.01792.x>
- Olson, K., & Spelke, E. (2008). Foundations of Cooperation in Young Children. *Cognition*, 108(1), 1–9. Retrieved from <http://www.sciencedirect.com/science/article/pii/S0010027707003228>
- Over, H. (2016). The origins of belonging: social motivation in infants and young children. *Phil. Trans. R. Soc. B*, 371(1686), 20150072. <https://doi.org/10.1098/rstb.2015.0072>
- Over, H., & Carpenter, M. (2009). Eighteen-month-old infants show increased helping following priming with affiliation. *Psychological Science*, 20(10), 1189–93. <https://doi.org/10.1111/j.1467-9280.2009.02419.x>
- Powell, L. J., & Spelke, E. S. (2013). Preverbal infants expect members of social groups to act alike. *Proceedings of the National Academy of Sciences*, 110(41), E3965–72. <https://doi.org/10.1073/pnas.1304326110>
- Powell, L. J., & Spelke, E. S. (2016). Human infants’ understanding of social imitation: Inferences of affiliation from third party observations. *bioRxiv*, 50385.
- Powell, L. J., & Spelke, E. S. (2018). Human infants’ understanding of social imitation: Inferences of affiliation from third party observations. *Cognition*, 170, 31–48.
- Pun, A., Birch, S. A. J., & Baron, A. S. (2016). Infants use relative numerical group size to infer social dominance. *Proceedings of the National Academy of Sciences*, 1–6.

<https://doi.org/10.1073/pnas.1514879113>

- Repacholi, B. M., & Gopnik, a. (1997). Early reasoning about desires: evidence from 14- and 18-month-olds. *Developmental Psychology*, 33(1), 12–21. Retrieved from <http://www.ncbi.nlm.nih.gov/pubmed/9050386>
- Rushworth, M. F. S., Noonan, M. P., Boorman, E. D., Walton, M. E., & Behrens, T. E. (2011). Frontal cortex and reward-guided learning and decision-making. *Neuron*, 70(6), 1054–1069.
- Saxe, R. (2006a). Uniquely human social cognition. *Current Opinion in Neurobiology*, 16(2), 235–239.
- Saxe, R. (2006b). Why and how to study Theory of Mind with fMRI. *Brain Research*. <https://doi.org/10.1016/j.brainres.2006.01.001>
- Saxe, R., Carey, S., & Kanwisher, N. (2004). Understanding other minds: linking developmental psychology and functional neuroimaging. *Annu. Rev. Psychol.*, 55, 87–124.
- Saxe, R., & Haushofer, J. (2008). For love or money: a common neural currency for social and monetary reward. *Neuron*, 58(2), 164–5. <https://doi.org/10.1016/j.neuron.2008.04.005>
- Saxe, R., & Kanwisher, N. (2003). People thinking about thinking people: the role of the temporoparietal junction in “theory of mind.” *Neuroimage*, 19(4), 1835–1842.
- Saxe, R., & Powell, L. J. (2006). It’s the thought that counts: specific brain regions for one component of theory of mind. *Psychological Science*, 17(8), 692–699.
- Sloane, S., Baillargeon, R., & Premack, D. (2012). Do infants have a sense of fairness? *Psychological Science*, 23(2), 196–204. <https://doi.org/10.1177/0956797611422072>
- Spelke, E. S. (2016). Core knowledge and conceptual change: A perspective on social cognition. In D. Barner & A. Baron (Eds.), *Core Knowledge and Conceptual Change*. New York City: Oxford University Press.
- Spokes, A. C., & Spelke, E. S. (2016). Children’s Expectations and Understanding of Kinship as a Social Category. *Frontiers in Psychology*, 7.
- Spokes, A. C., & Spelke, E. S. (2017). The cradle of social knowledge: Infants??? reasoning about caregiving and affiliation. *Cognition*, 159, 102–116. <https://doi.org/10.1016/j.cognition.2016.11.008>
- Spoke, A.C., Venkatesan, Spelke, E.S. (2017) 5-month-olds attend to responsive caregivers. Presented at the Cognitive Development Society Meeting, Portland, OR
- Team, R. C. (2015). R: A language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing.
- Thomas, A. J., Abramyam, M., Lukowski, A., Thomsen, L., & Sarnecka, B. W. (2016). Preferring the Mighty to the Meek: Toddlers Prefer Novel Dominant Agents. *Proceedings of the 38th Annual Conference of the Cognitive Science Society*.
- Thomsen, L., Frankenhuys, W. E., Ingold-Smith, M., & Carey, S. (2011). Big and mighty: Preverbal infants mentally represent social dominance. *Science*, 331(6016), 26–29. <https://doi.org/10.1126/science.1199198>
- Tomasello, M. (1999). *The Cultural Origins of Human Cognition. The cultural origins of human cognition* (Vol. 114).
- Tooby, J., & Cosmides, L. (2005). Conceptual Foundations of Evolutionary Psychology. *The Handbook of Evolutionary Psychology.*, 5–67. <https://doi.org/10.1017/S0140525X00025577>
- Van Den Bos, W., McClure, S. M., Harris, L. T., Fiske, S. T., & Cohen, J. D. (2007). Dissociating affective evaluation and social cognitive processes in the ventral medial prefrontal cortex. *Cognitive, Affective, & Behavioral Neuroscience*, 7(4), 337–346.
- Walton, G. M. (2014). The new science of wise psychological interventions. *Current Directions in Psychological Science*, 23(1), 73–82.
- Walton, G. M., & Cohen, G. L. (2007). A question of belonging: race, social fit, and achievement. *Journal of Personality and Social Psychology*, 92(1), 82.
- Walton, G. M., & Cohen, G. L. (2011). A brief social-belonging intervention improves academic and health outcomes of minority students. *Science*, 331(6023), 1447–1451.
- Wilcox, T., Bortfeld, H., Woods, R., Wruck, E., & Boas, D. A. (2005). Using near-infrared spectroscopy to assess neural activation during object processing in infants. *Journal of*

Biomedical Optics, 10(1), 11010–110109.

Woodward, A. L. (1998). Infants selectively encode the goal object of an actor's reach. *Cognition*, 69, 1–34. [https://doi.org/10.1016/S0010-0277\(98\)00058-4](https://doi.org/10.1016/S0010-0277(98)00058-4)

Yeager, D. S., & Walton, G. M. (2011). Social-psychological interventions in education: They're not magic. *Review of Educational Research*, 81(2), 267–301.

NSF Biographical Sketch

Ashley J. Thomas

(a) Professional Preparation

University of California	Berkeley	Architecture	B.A., 2008
University of California	Irvine	Psychology	M.A., 2015
University of California	Irvine	Psychology	PhD, 2018 (expected)

(b) Products

Thomas, Abramyan, Lukowksi, Thomsen, Sarnecka (2016). Preferring the Mighty to the Meek. Toddlers Prefer Novel Dominant Agents. Published in the *Proceedings of the 38th Annual Conference of the Cognitive Science Society*. Philadelphia, PA: Cognitive Science Society.

Thomas, Abramyan, Lukowksi, Thomsen, Sarnecka, (2017). Mighty or the meek: changes in social preferences across the first two years of life. Presented at the *Society for Research on Child Development Conference*, Austin TX

Thomas, Abramyan, Lukowksi, Thomsen, Sarnecka (2017). Mighty or the meek: changes in social preferences across the first two years of life. Presented at the *Budapest CEU Conference on Cognitive Development*, Budapest, Hungary

Thomas, Abramyan, Lukowksi, Thomsen, Sarnecka (2017). Mighty or the meek: Toddlers prefer novel, dominant individuals. Presented at the *Society for Personality and Social Psychology*, San Antonio, TX
*best poster award

Thomas, Piff, Sommerville, Sarnecka (2017). Everybody loves a winner, but nobody likes a bully. Presented at the *Developing Theories of Naive Sociology Pre-conference at the Cognitive Development Society Meeting*, Portland, OR.

Thomas & Sarnecka (2017). Children expect leaders to be benevolent. Presented at the at the *Cognitive Development Society Meeting*, Portland, OR

Thomas, Abramyan, Lukowksi, Thomsen, Sarnecka (2016). Preferring the Mighty to the Meek. Toddlers Prefer Superiors to Subordinates. 42nd annual *Society for Philosophy and Psychology*. Austin, TX

Thomas, & Sarnecka, (2015). Exploring the relation between people's theories of intelligence and beliefs about brain development. *Frontiers in psychology*, 6.

Thomas, Stanford, & Sarnecka, (2016). No Child Left Alone: Moral Judgments about Parents Affect Estimates of Risk to Children. *Collabra*, 2(1), 10

Thomas, Stanford, Sarnecka, No child left alone: Moral judgments about parents affect estimates of risk to children. Poster presented at *Society for Personality and Social Psychology Conference*, San Diego, CA

(d) Synergistic Activities

Co-chaired Developing Theories of Naive Sociology. This was a full day pre-conference at the *Cognitive Development Society Meeting*, Portland, Oregon. 2017. We had 13 speakers (7 faculty members including Susan Gelman, Kiley Hamlin, Renee Baillargeon, Alison Gopnik, Lawrence Hirschfeld, Alan Fiske, Lotte Thomsen, and 6 graduate students and postdoctoral students; 11 of the speakers were women). Three of the speakers were from other fields--Alan Fiske and Lawrence Hirschfeld from Anthropology and Lotte Thomsen from Sociology. The pre-conference was well attended and a popular event, it sold out in 3 days. This meeting has led to the creation of a listserv, and I plan to organize the pre-conference again in 2019.

Co-chaired The Powerful and Mighty: How Social Dominance shapes children's preferences, trust and social inferences. *The Society for Research on Child Development Conference*, Austin, TX. 2017. I organized this symposium with Lotte Thomsen.

I ran a writing workshop for graduate students. We met once a week, talked about our writing plan for the week and gave one another feedback on writing and presentations.

I have mentored 12 students who have received UROP (Undergraduate Research Opportunity Program) awards, which gives students money to run independent research projects, and SURP (Summer Undergraduate Research Program) awards, which gives undergraduate a stipend during summer months to work as research assistants. 8 of these students were Latina.

Biographical Sketch: Rebecca Saxe, Professor of Brain and Cognitive Sciences, MIT

a. Professional preparation

<u>Institution and Location</u>	<u>Degree</u>	<u>Year(s)</u>	<u>Field of Study</u>
Oxford University, Oxford, England	B.A.Hons	1997-2000	Psychology and Philosophy
Massachusetts Institute of Technology (MIT) Cambridge MA	Ph.D.	2000-2003	Cognitive Science

b. Appointments

2015-present	Professor, Dept. of Brain and Cognitive Sciences, MIT
2011-2015	Associate Professor, Dept. of Brain and Cognitive Sciences, MIT
2006-2011	Assistant Professor, Dept. of Brain and Cognitive Sciences, MIT
2003-2006	Junior Fellow, Harvard Society of Fellows, Harvard University

c. Publications

(i) Five related publications

1. Saxe, R., & Houlihan, S. D. (2017). Formalizing emotion concepts within a Bayesian model of theory of mind. *Current Opinion in Psychology*. 17, 15-21.
2. Kleiman-Weiner, M., Saxe, R., & Tenenbaum, J. B. (2017). Learning a commonsense moral theory. *Cognition*.
3. Powell, L. J., Deen, B., & Saxe, R. (2017). Using individual functional channels of interest to study cortical development with fNIRS. *Developmental Science*.
4. Saxe R, Carey S, Kanwisher N (2004) Understanding other minds: linking developmental psychology and functional neuroimaging *Annual Review of Psychology* 55:87-124
5. Saxe R (2006) Uniquely Human Social Cognition. *Current Opinion Neurobiology* 16(2):235-9

(ii) Five other publications

1. Saxe R, Kanwisher N (2003) People thinking about thinking people: fMRI studies of Theory of Mind. *Neuroimage*. 19(4):1835-42
2. Saxe, R. & Powell L. (2006) It's the thought that counts: specific brain regions for one component of Theory of Mind. *Psychological Science* 17(8):692-9
3. Baker CI, Saxe R, Tenenbaum JB (2009) Action understanding as inverse planning. *Cognition* 113(3):329-49
4. Young L, Camprodon JA, Hauser M, Pascual-Leone A, Saxe R (2010) Disruption of the right temporo-parietal junction with transcranial magnetic stimulation reduces the role of beliefs in moral judgments. *PNAS*, 107(15), 6753-8
5. Cikara M, Bruneau E, Saxe R (2011) Us and Them: Intergroup failures of empathy. *Current Directions in Psychological Science*. 20(3):149-53

d. Synergistic activities

1. Public lectures. My TED talk has been viewed by >2.5 million people, and translated into 31 languages. In addition, in the past 5 years I have given public lectures at the Boston IDEAS festival, the Cambridge Science festival, the regional Brain Bee competition, the Smithsonian Future is Here festival, the World Economic Forum, the Dubai Film Festival, the ASU Origins Project "Great Debate" series, the United States Institute for Peace, the Cambridge Science Festival, and multiple events at MIT.
2. Outreach to congress. I presented to congressmen and women at the Coalition for National Science Funding Exhibition and Reception on Capitol Hill, May 2013; and during a delegation visit to MIT in April 2014.
3. Media Coverage. My research has been covered by Scientific American, New Scientist, Discover Magazine, NPR, PBS, TVO, NOVA, the Smithsonian Magazine and Today.com. To help improve the

quality of national neuroscience reporting, I give an annual lecture on cognitive neuroscience to the MIT Knight Science Journalism Fellows.

4. Training graduate students from national and international institutions. I taught developmental cognitive neuroscience methods to almost 100 graduate students, including many URM students, at the Social Neuroscience Workshop (Belgium, 2011), the Latin American School on Education, Cognitive and Neural Science (Argentina, 2012), the University of Salzburg Summer School (2014), the Summer Institute in Cognitive Neuroscience (Santa Barbara, 2015), the Center for Minds Brains and Machines Summer Course (Woods Hole, 2015, 2016 and 2017), and the Neuroscience School for Advanced Studies (2017).

5. Organized Pre-Conference. At the national conference for the Child Development Society, Hilary Richardson (a graduate student in my lab) organized and hosted a day-long pre-conference, titled “Early development, conceptual change, and continuity: Insights from cognitive neuroscience”. Over eighty participants registered, and heard talks by 14 speakers, drawn from twelve universities and three disciplines, including seven junior researchers and ten women.

e. Collaborators and other affiliations

(i) Collaborators (Total: 20)

Ralph Adolphs, CalTech; Marina Bedny, Johns Hopkins University; Alfonso Caramazza, Harvard University; Mina Cikara, Harvard University; Danny Dilks, Emory University; Michael Frank, Stanford University; Evelina Fedorenko, MGH; John Gabrieli, MIT; Edward Gibson, MIT; Hyowon Gweon, Stanford University; Nancy Kanwisher, MIT; Joshua Knobe, Yale University; Kami Koldewyn, Bangor University; Alvaro Pascual-Leone, Harvard Medical School; Elizabeth Redcay, University of Maryland; Mark Sabbagh, Queen's University; Robert Spunt, CalTech; Jay van Bavel, NYU; Ed Vul, UCSD; Tal Yarkoni, University of Texas at Austin; Liane Young, Boston College

(ii) Graduate and postdoctoral advisors (Total: 2)

Nancy Kanwisher, MIT; Susan Carey, Harvard University.

(iii) Thesis advisor, thesis committee advisor, and postgraduate scholar sponsor

Total graduate students, thesis advisor: 7; thesis committee: 15

Thesis advisor: Liane Young (professor, Boston College), Jorie Koster-Hale (post-doctoral scholar), Ben Deen (post-doctoral scholar), Amy Skerry (engineer, Kahn Academy), Hilary Richardson (graduate student), Sean Dae Houlihan (graduate student), Heather Kosakowski (graduate student).

Thesis committee: Elizabeth Barrett-Bonawitz (assistant professor, Rutgers University); Mike Frank (professor, Stanford University); Hyowon Gweon (assistant professor, Stanford University); Jonathan Beier (assistant professor, University of Maryland), Adena Schachner (assistant professor, UCSD), Lindsey Powell (post-doctoral scholar), Todd Thompson, (scientist, MIT), Leon Bergen (Assistant Professor, UCSD), Chris Baker (post-doctoral scholar), David Osher (research scientist OSU), Zeynep Saygin (assistant professor, OSU), Yang Wu (graduate student), Julia Leonard (graduate student), Rachel Magid (graduate student), Max Klieman-Weiner (graduate student).

Total post-doctoral scholars sponsored: 10

Post-doctoral scholars: Liane Young (professor, Boston College), Hyowon Gweon (Assistant professor, Stanford University), Marina Bedny (Assistant professor, Johns Hopkins University), Mina Cikara (Assistant Professor, Harvard University), Elizabeth Redcay (Associate Professor, University of Maryland), Emile Bruneau (Research Fellow, UPenn), Stefano Anzelotti (post-doctoral scholar), Dorit Kliemann (post-doctoral scholar), Lindsey Powell (post-doctoral scholar), Livia Tomova (post-doctoral scholar).

NSF Biographical Sketch

Elizabeth S. Spelke

(a) Professional Preparation

Harvard University	Cambridge	Social Relations	AB 1971
Cornell University	Ithaca	Psychology	PhD 1978

(b) Products

1. Powell, L. J. & Spelke, E. S. (2017). Human infants' understanding of social imitation: Inferences of affiliation from third-party observations. *Cognition*, *170*, 31-48.
2. Spokes, A. C., & Spelke, E. S. (2017). The cradle of social knowledge: Infants' reasoning about caregiving and affiliation. *Cognition*, *159*, 102-116.
3. Spelke, E. S. (2016). Core Knowledge and Conceptual Change: A Perspective on Social Cognition. In D. Barner & A. S. Baron (Eds.), *Core Knowledge and Conceptual Change*. New York: Oxford University Press.
4. Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences*, *104*, 12577-12580.
5. Powell, L. J., & Spelke, E. S. (2013). Preverbal infants expect members of social groups to act alike. *Proceedings of the National Academy of Sciences*, *110*, E3965-E3972
6. Soley, G. & Spelke, E. S. (2016). Shared cultural knowledge. Effects of music on young children's social preferences. *Cognition*, *148*, 106-116.
7. Spelke, E. S., Bernier, E. P., & Skerry, A. E. (2013). Core social cognition. In M. R. Banaji & S. A. Gelman (Eds.), *Navigating the social world: What infants, children, and other species can teach us*. New York: Oxford University Press.
8. Spokes, A. C. & Spelke, E. S. (2016). Children's expectations and understanding of kinship as a social category. *Frontiers in Psychology*, *7*(440).
9. Mehr, S. A., Song, L. A., & Spelke, E. S. (2016). For five-month-old infants, melodies are social. *Psychological Science*.
10. Kinzler, K. D., Shutts, K., De Jesus, J., & Spelke, E. S. (2009). Accent trumps race in guiding children's social preferences. *Social Cognition*, *27*, 623-634.

(d) Synergistic Activities

1. Gender and science: Spelke's studies of the cognitive capacities at the foundations of learning of mathematics and science provide evidence for equal aptitude by male and female infants and young children (Spelke, 2005). Recent talks that build on these findings, and encourage talented and motivated young women to pursue STEM careers, include campus wide lectures at Central European U. (Budapest, May 2010), Rutgers U. (Newark, December 2010), Rice U. (Feb. 2013), and discussions in London (Guardian/BBC discussion on gender and the brain, November 2010), Seattle (SRCD symposium, April 2013), and Hamburg (Symposium on Science and Gender Equality, forthcoming in October, 2013).

2. Abstract knowledge in the brain: Spelke's studies of numerical cognition in infancy suggest new tools for shedding light on the origins and nature of abstract thinking and the brain systems that support it (Spelke, 2011). Recent efforts to convey this promise to a broader public include participation in the Charlie Rose Series on the Brain (PBS, February 2010) and participation in the Vatican Symposium, "Neuroscience and the human person" (Vatican City, 2012). Efforts to convey this promise to scientists across a broad range of disciplines include a Presidential Lecture, Society for Neuroscience (2009), co-editorship of a special issue of *Current Opinion in Neurobiology* (Platt & Spelke, 2009), and co-convenor, with Giorgio Vallortigara, of three symposia on Development and Evolution of Cognition at the Center for Mind/Brain Science (Rovereto, Italy, 2009, 2010, 2012).

3. Cognitive foundations of STEM education: Spelke's studies of infants' capacities to represent objects, number, and geometry suggest methods for improving education in mathematics and science. Recent efforts to convey this promise to educators include participation in a conference at the Pontifical Academy of Sciences on Neuroplasticity and Education (Vatican City, 2010), a conference at the Ministry of Education of the government of Singapore (Singapore, 2013), and participation in the 3rd Latin American School for Education, Cognitive and Neural Sciences (Comandatuba, Brazil, 2013).

4. Reverse engineering the infant mind: Attempts to build machines that can think intelligently in novel situations, and that can interact usefully with humans, can be illuminated by research that sheds light on the origins and early development of human cognitive capacities. In recent years, Spelke has attempted to convey this promise to a broader cognitive science community through talks (e.g., Cognitive Science Society Presidential Symposium, 2009; MIT150 Symposium on Brains, Minds and Machines, 2011; Cognitive Science Society Keynote Speaker, forthcoming 2013), classes (joint Harvard-MIT graduate seminar, co-taught with Josh Tenenbaum), and writings (e.g., Spelke, 2011).

E.

Graduate Advisors and Postdoctoral Sponsors

Eleanor Gibson and Ulric Neisser (Ph.D. Advisors, Cornell University)

Thesis Advisors and Postgraduate-Scholar Sponsors, 51 Total Advisees

Current Graduate Advisees: Hobbs, Kathryn; Skerry, Amy; Dillon, Moira; Cogsdill, Emily; Spokes, Ann; Afshordi, Narges (Harvard). *Past Graduate Advisees:* Schachner, Adena (Boston U.); Heiphetz, Larisa (Boston College); Ziv, Talee (Hebrew U.); Soley, Gaye (U. Barcelona); Bernier, Emily (Google, Inc.); Hyde, Daniel (U. Illinois); Beier, Jonathan (U. Maryland); Lamont, Kristin (McKinsey & Co.); Kinzler, Katherine (U. Chicago); Olson, Kristina (Yale); Shutts, Kristin (U. Wisconsin); Huang, Yi Ting (U. Maryland); Shusterman, Anna (Wesleyan); Lipton, Jennifer (Harvard); Shuman, Miles; Wood, Justin (USC); Barth, Hilary (Wesleyan); Wang, Ranxiao (U. Illinois); Van de Walle, Gretchen (Rutgers); Vishton, Peter (College of William and Mary); Hermer, Linda (U. Florida); Kim, In-Kyeong (La Sierra U.); Phillips, Ann (U. Michigan); Schmidt, Hilary (Rutgers); Baillargeon, Renee (U. Illinois); Landau, Barbara (Johns Hopkins); Jones, Susan (U. Illinois); Kellman, Philip (UCLA); Winkler-Rhoades, Nathan (MIT). *Current Postdoctoral Advisees:* Powell, Lindsey. *Past Postdoctoral Advisees:* Hyde, Daniel (U. Illinois); Lee, Sang Ah (U. Trento); Kim, Sunae (U. Wisconsin); de Hevia, Maria (Marie Curie Fellow, Paris); Izard, Veronique (CNRS, Paris); McCrink, Koleen (Barnard); Gilmore, Camilla (U. Nottingham); Barth, Hilary (Wesleyan); Condry, Kirsten (Rochester Institute of Technology); Xu, Fei (U.C. Berkeley); Hespos, Susan (Northwestern U.); Markson, Lori (Washington U.); Munakata, Yuko (U. Colorado); Molina, Michele (U. Rouen); Woodward, Amanda (U. Chicago); Starkey, Prentice (U.C. Berkeley).

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION Thomas Ashley				FOR NSF USE ONLY			
				PROPOSAL NO.	DURATION (months)		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Ashley Thomas				AWARD NO.	Proposed	Granted	
A. SENIOR PERSONNEL: PI/PI, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)				NSF Funded Person-months		Funds Requested By proposer	Funds granted by NSF (if different)
		CAL	ACAD	SUMR			
1.		0.00	0.00	0.00			
2.							
3.							
4.							
5.							
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)		0.00	0.00	0.00		0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)		0.00	0.00	0.00		0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)							
1. (0) POST DOCTORAL SCHOLARS		0.00	0.00	0.00		0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)		0.00	0.00	0.00		0	
3. (0) GRADUATE STUDENTS						0	
4. (0) UNDERGRADUATE STUDENTS						0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)						0	
6. (0) OTHER						0	
TOTAL SALARIES AND WAGES (A + B)						0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING \$5,000.)							
TOTAL EQUIPMENT						0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)						0	
2. INTERNATIONAL						0	
F. PARTICIPANT SUPPORT COSTS							
1. STIPENDS \$						54,000	
2. TRAVEL						0	
3. SUBSISTENCE						0	
4. OTHER						15,000	
TOTAL NUMBER OF PARTICIPANTS (0)				TOTAL PARTICIPANT COSTS		69,000	
G. OTHER DIRECT COSTS							
1. MATERIALS AND SUPPLIES						0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION						0	
3. CONSULTANT SERVICES						0	
4. COMPUTER SERVICES						0	
5. SUBAWARDS						0	
6. OTHER						0	
TOTAL OTHER DIRECT COSTS						0	
H. TOTAL DIRECT COSTS (A THROUGH G)						69,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (Rate: , Base:)							
TOTAL INDIRECT COSTS (F&A)						0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						69,000	
K. SMALL BUSINESS FEE						0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)						69,000	
M. COST SHARING PROPOSED LEVEL \$ 0				AGREED LEVEL IF DIFFERENT \$			
PI/PI NAME Ashley Thomas				FOR NSF USE ONLY			
ORG. REP. NAME* Ashley Thomas				INDIRECT COST RATE VERIFICATION			
		Date Checked	Date Of Rate Sheet	Initials - ORG			

SUMMARY PROPOSAL BUDGET

YEAR **2**

ORGANIZATION Thomas Ashley				FOR NSF USE ONLY			
				PROPOSAL NO.	DURATION (months)		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Ashley Thomas				AWARD NO.	Proposed	Granted	
A. SENIOR PERSONNEL: PI/PI, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)				NSF Funded Person-months		Funds Requested By proposer	Funds granted by NSF (if different)
				CAL	ACAD	SUMR	
1.				0.00	0.00	0.00	
2.							
3.							
4.							
5.							
6.	(0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)			0.00	0.00	0.00	0
7.	(1) TOTAL SENIOR PERSONNEL (1 - 6)			0.00	0.00	0.00	0
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)							
1.	(0) POST DOCTORAL SCHOLARS			0.00	0.00	0.00	0
2.	(0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)			0.00	0.00	0.00	0
3.	(0) GRADUATE STUDENTS						0
4.	(0) UNDERGRADUATE STUDENTS						0
5.	(0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)						0
6.	(0) OTHER						0
TOTAL SALARIES AND WAGES (A + B)							0
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)							0
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)							0
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING \$5,000.)							
TOTAL EQUIPMENT							0
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)							0
2. INTERNATIONAL							0
F. PARTICIPANT SUPPORT COSTS							
1.	STIPENDS \$		54,000				
2.	TRAVEL		0				
3.	SUBSISTENCE		0				
4.	OTHER		15,000				
TOTAL NUMBER OF PARTICIPANTS (0)				TOTAL PARTICIPANT COSTS			69,000
G. OTHER DIRECT COSTS							
1. MATERIALS AND SUPPLIES							0
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION							0
3. CONSULTANT SERVICES							0
4. COMPUTER SERVICES							0
5. SUBAWARDS							0
6. OTHER							0
TOTAL OTHER DIRECT COSTS							0
H. TOTAL DIRECT COSTS (A THROUGH G)							69,000
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) (Rate: , Base:)							
TOTAL INDIRECT COSTS (F&A)							0
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)							69,000
K. SMALL BUSINESS FEE							0
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)							69,000
M. COST SHARING PROPOSED LEVEL \$ 0				AGREED LEVEL IF DIFFERENT \$			
PI/PI NAME Ashley Thomas				FOR NSF USE ONLY			
ORG. REP. NAME* Ashley Thomas				INDIRECT COST RATE VERIFICATION			
		Date Checked	Date Of Rate Sheet	Initials - ORG			

SUMMARY PROPOSAL BUDGET Cumulative

ORGANIZATION Thomas Ashley				FOR NSF USE ONLY			
				PROPOSAL NO.	DURATION (months)		
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR Ashley Thomas				AWARD NO.	Proposed	Granted	
A. SENIOR PERSONNEL: PI/PI, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)				NSF Funded Person-months		Funds Requested By proposer	Funds granted by NSF (if different)
		CAL	ACAD	SUMR			
1.		0.00	0.00	0.00			
2.							
3.							
4.							
5.							
6. () OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)		0.00	0.00	0.00		0	
7. (0) TOTAL SENIOR PERSONNEL (1 - 6)		0.00	0.00	0.00		0	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)							
1. (0) POST DOCTORAL SCHOLARS		0.00	0.00	0.00		0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)		0.00	0.00	0.00		0	
3. (0) GRADUATE STUDENTS						0	
4. (0) UNDERGRADUATE STUDENTS						0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)						0	
6. (0) OTHER						0	
TOTAL SALARIES AND WAGES (A + B)						0	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)						0	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)						0	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING \$5,000.)							
TOTAL EQUIPMENT						0	
E. TRAVEL 1. DOMESTIC (INCL. U.S. POSSESSIONS)						0	
2. INTERNATIONAL						0	
F. PARTICIPANT SUPPORT COSTS							
1. STIPENDS \$						108,000	
2. TRAVEL						0	
3. SUBSISTENCE						0	
4. OTHER						30,000	
TOTAL NUMBER OF PARTICIPANTS (0)				TOTAL PARTICIPANT COSTS		138,000	
G. OTHER DIRECT COSTS							
1. MATERIALS AND SUPPLIES						0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION						0	
3. CONSULTANT SERVICES						0	
4. COMPUTER SERVICES						0	
5. SUBAWARDS						0	
6. OTHER						0	
TOTAL OTHER DIRECT COSTS						0	
H. TOTAL DIRECT COSTS (A THROUGH G)						138,000	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)							
TOTAL INDIRECT COSTS (F&A)						0	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)						138,000	
K. SMALL BUSINESS FEE						0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)						138,000	
M. COST SHARING PROPOSED LEVEL \$ 0				AGREED LEVEL IF DIFFERENT \$			
PI/PI NAME Ashley Thomas				FOR NSF USE ONLY			
ORG. REP. NAME* Ashley Thomas				INDIRECT COST RATE VERIFICATION			
		Date Checked	Date Of Rate Sheet	Initials - ORG			

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

BUDGET JUSTIFICATION: YEAR 1

A. EQUIPMENT

N/A Equipment such as video cameras, monitors, fNIRS equipment in the Spelke and Saxelabs will be available to use.

B. TRAVEL

Thomas will travel to one professional conference in Y1 and two professional conferences in Y2 (e.g., Society for Research in Child Development; Cognitive Development Society; International Congress of Infant Studies) to disseminate the results of the project. Requesting \$1,800 to offset cost including roundtrip coach airfare, and hotel.

Requesting a total of \$1800 in Y1

C. MATERIALS AND SUPPLIES

Items for stimuli development (e.g., stage, puppets) are requested to be spent in Y1 \$2000 for the entire project.

Requesting \$130 in Years 1 and 2 to cover the cost of copying human subjects related documents (i.e., consent and assent forms) needed to recruit and test subjects for the project.

Requesting \$2700 in Y1 to cover the cost of a computer for analyzing and coding data.

Requesting a total of \$4830 in Y1

D. PUBLICATION COSTS

N/A Funds for publication costs (color figures, journal articles) are requested in the amount of \$1,500 in Y2 to cover the cost of reproduction of reference materials required for accomplishing the proposed scope of work.

E. OTHER COSTS

We will need to test approximately 627 subjects over two years. Funds are requested to cover the cost of human subject payments for participant at the rate of \$20/session for \$13140. (Approximately 5,570 in Y1 and 7570 in Y2). We also need to recruit infants to test using the fNIRS, needing materials for mailers, advertisements, and tabling events for \$2800 per year.

Requesting a total of 8370 in Y1

Y1 Total: $1800+4830+8370=\$15,000$

BUDGET JUSTIFICATION: YEAR 2

A. EQUIPMENT

N/A Equipment such as video cameras, monitors, fNIRS equipment in the Spelke and Saxelabs will be available to use.

B. TRAVEL

Thomas will travel to one professional conference in Y1 and two professional conferences in Y2 (e.g., Society for Research in Child Development; Cognitive Development Society; International Congress of Infant Studies) to disseminate the results of the project. Requesting \$1,800 to offset cost including roundtrip coach airfare, and hotel.

Requesting a total of \$3600 in Y2

C. MATERIALS AND SUPPLIES

Items for stimuli development (e.g., stage, puppets) are requested to be spent in Y1 \$2000 for the entire project.

Requesting \$130 in Years 1 and 2 to cover the cost of copying human subjects related documents (i.e., consent and assent forms) needed to recruit and test subjects for the project.

Requesting \$2700 in Y1 to cover the cost of a computer for analyzing and coding data.

Requesting a total of \$130 in Y2

D. PUBLICATION COSTS

Funds for publication costs (color figures, journal articles) are requested in the amount of \$1,500 in Y2 to cover the cost of reproduction of reference materials required for accomplishing the proposed scope of work.

Requesting a total of \$1500 in Y2

E. OTHER COSTS

We will need to test approximately 627 subjects over two years. Funds are requested to cover the cost of human subject payments for participant at the rate of \$20/session for \$13140. (Approximately 5,570 in Y1 and 6970 in Y2). We also need to recruit infants to test using the fNIRS, needing materials for mailers, advertisements, and tabling events for \$2800 per year.

Requesting a total of 9770 in Y2

Y1 Total: $3600+130+1500+9770=\$15,000$

Current and Pending Support

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

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

Investigator: Ashley Thomas	Other agencies (including NSF) to which this proposal has been/will be submitted. NIH
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input checked="" type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title: Finding one's social circle: How caregivers influence the social evaluations of infants.	
Source of Support: NIH Total Award Amount: \$ 0 Total Award Period Covered: 09/01/18 - 06/01/20 Location of Project: Harvard Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Summ:	

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

Current and Pending Support

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

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.	
Investigator: Rebecca Saxe	Other agencies (including NSF) to which this proposal has been/will be submitted. NIH
Support: <input checked="" type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title: Neural measures of social reward and information value in infants Source of Support: NSF Total Award Amount: \$ 600,000 Total Award Period Covered: 07/15/16 - 06/30/19 Location of Project: MIT Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title: Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title: Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title: Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title: Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Summ:	

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

Current and Pending Support

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

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

Investigator: Elizabeth Spelke	Other agencies (including NSF) to which this proposal has been/will be submitted. NIH
Support: <input checked="" type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title: Core Systems for Learning Mathematics	
Source of Support: NSF Total Award Amount: \$ 1,478,161 Total Award Period Covered: 04/01/14 - 03/30/19 Location of Project: Harvard Person-Months Per Year Committed to the Project. Cal:0.00 Acad: 0.00 Sumr: 0.00	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:	
Support: <input type="checkbox"/> Current <input type="checkbox"/> Pending <input type="checkbox"/> Submission Planned in Near Future <input type="checkbox"/> *Transfer of Support Project/Proposal Title:	
Source of Support: Total Award Amount: \$ Total Award Period Covered: Location of Project: Person-Months Per Year Committed to the Project. Cal: Acad: Summ:	

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

Facilities, Equipment, and Other Resources

Spelke Lab

An 8-room laboratory on a single floor of William James Hall is available for piloting of all the experiments to be conducted in online or field experiments with infants and toddlers up to the age of 2 years. For decades, the laboratory has been actively engaged in research on infants' and toddlers' understanding of objects' mechanical interactions, agents' object-directed actions, people's social engagements and interactions, as well as infants' sensitivity to number and the transformations of arithmetic, and to geometric forms and their transformations of orientation, size and reflection. Thus, this lab has both the facilities and the experienced personnel to pursue this research project. The building has an adjacent parking lot in which we hold dedicated spaces for parents and children. Two rooms are connected by closed-circuit video to a third, sound-attenuated coding room where observers watch infants over video during the running of an experiment, coding their responses without hearing nor seeing any displays or events related to the displays. One room is used to conduct behavioral studies with toddlers using reaching and object manipulation, pointing, and verbal measures. There are two lab offices used for scheduling participants and for other administrative aspects of our research, and one office for a Research Associate. There is also a play space for children and families, shared by my lab and that of my colleague Susan Carey.

A 9-room laboratory in Vanserg Hall is available for piloting of all the experiments with children aged 3 years and up. For decades, the laboratory has pursued research on social cognition in children, including preschool children's sharing decisions, social preferences based on language, accent, race, and gender, mental state inferences, and understanding of kinship relations. Currently, it is also the site of research for a different project assessing short-term effects of math games interventions on the numerical and spatial abilities of primary school children. Thus, this lab also has both the facilities and the experience needed to pursue the present project. The building has an adjacent parking lot in which we hold dedicated spaces for parents and children. When closed, two testing rooms have invisible doors, symmetrical lighting and no orienting features, making them suitable for experiments on navigation. These rooms open onto a separate coding room, where parents and coders observe the experiment over closed-circuit video. Three additional testing rooms are used in other experiments on social, numerical, and spatial cognition using multiple measures. Vanserg Hall also has a play space/waiting room for children and parents, an RA office where all data are kept secure, and an open-plan hall with computer stations for scheduling participants and coding data.

The PI's laboratory is housed within the Laboratory of Developmental Studies (LDS), a rich environment for research in developmental cognitive science within Harvard's Department of Psychology, with offices for the P.I., post-doctoral students, and graduate students, located on the same floor as the laboratory. The department has weekly research seminars in Developmental, Cognitive, and Social Psychology that complement the weekly lab meetings. In crafting, conducting and analyzing the research in this project, Ashley will benefit from the suggestions and criticisms of renowned faculty in cognitive, social, and developmental psychology, including Susan Carey, Jesse Snedeker, Steven Pinker, Sam Gershman, Alfonso Caramazza, Mina Cikara, Josh Greene, Fiery Cushman, Paul Harris, Mahzarin Banaji, and Jim Sidanius. At least once every two years (and usually more often), a joint research seminar is taught by an LDS faculty member (often Spelke) and a faculty member in the Department of Brain and Cognitive Sciences at MIT (in the past, seminars have been taught with Nancy Kanwisher, Rebecca Saxe, Laura Schulz, and Josh Tenenbaum). A number of the research findings that animate the studies that the present proposal builds from, germinated in these Harvard-MIT joint seminars, which bring together postdocs and graduate students from the two institutions around research connecting behavior to brain imaging and/or computational modeling. Recently, contacts between Harvard and MIT have intensified with the founding of the NSF-supported Center for Minds, Brains, and Machines, with which Spelke's lab and Saxe's labs are associated. Finally, Spelke is a member, and former co-Director, of Harvard's Inter-faculty Initiative in Mind, Brain and Behavior. This initiative supports graduate student interdisciplinary research, travel, and lab rotations, and it organizes seminars that bring students and postdocs in Psychology together with their counterparts in Neurobiology, the Center for Brain Science, and the Departments of Human Evolutionary Biology, Linguistics, Philosophy, Anthropology, and Education.

SaxeLab

Dr. Saxe's Social Cognitive Neuroscience Laboratory is located in Building 46 of the MIT campus, which jointly houses the Department of Brain and Cognitive Sciences, the Picower Center for Learning and Memory, and the McGovern Institute for Brain Research, which house the fNIRS facilities used by the PI and members of her lab. The PI's dedicated lab space occupies 1202 ft² in the Department of Brain and Cognitive Sciences wing of this building. The main laboratory space contains four workstations for the preparation of neuroimaging study materials and data analysis. There are attached offices with workstations for a total of five personnel, as well as two subject testing rooms, one off the main laboratory space and one across the hall. The PI's office is adjacent to the main laboratory space, as well as an additional office with workstations for four postdoctoral associates or other research personnel. All workstations are equipped with Apple or PC computing equipment according to the researcher's OS requirements and preferences. There are also three MacBook Pros available for general lab uses such as stimulus development and behavioral and neuroimaging data collection, two video cameras for recording testing sessions, and one laptop devoted specifically to stimulus presentation for fNIRS studies. The laboratory group currently consists of one undergraduate research assistants, one full time research assistant, one full time graduate student, one visiting graduate student, three post-doctoral researchers, a post-baccalaureate research fellow, a pediatric recruitment and research coordinator, and a Master's level laboratory manager.

McGovern Institute for Brain Research. The proposed research would be conducted at the McGovern Institute for Brain Research (MIBR) at MIT, where the Dr. Saxe is an Associate Faculty Member. The MIBR consists of separate testing suites for a number of different neuroimaging technologies, and will provide resources to participating families including free parking adjacent to the building, a comfortable main waiting room, and a family room with a nursing chair and a variety of toys available for older siblings who may accompany infant participants to study appointments.

Developmental Neuroimaging Suite. The MIBR's NIRS system is located (along with a mock scanner) in a room devoted exclusively to developmental neuroimaging. The room is decorated in a child-friendly style, and is set up for infant care and play, including a changing table and diapering supplies as well as a playspace with a soft carpet and infant-appropriate toys.

NIRS System. The MIBR houses a continuous wave NIRS system (CW6 model produced by TechEn, Inc.) purchased in 2013 by the Simons Center for the Social Brain, an internal organization at MIT with which the PI is also an associated investigator. The system has 8 source optodes, each emitting a 690 nm laser at 12 mW and an 830 nm laser at 6 mW, and 16 detector optodes that collect light intensity data at a rate of up to 50 Hz. These optodes are held in configuration by custom 3D-printed plastic holders, produced by Techen upon request according to the optimal array design for a given experiment. The holders are padded for infant comfort and attached to infants' heads with a nylon headband and chin strap. The NIRS system is housed on a cart along with a dedicated PC with the capability to both control data collection through the CW6 and process and analyze fNIRS data generated by the system.

Peripheral equipment. The developmental neuroimaging suite also houses equipment necessary for infant NIRS and behavioral testing that is property of the PI's laboratory. This includes a 21" monitor for displaying video-based and animated stimuli during both fNIRS and behavioral experiments, external speakers, and a monitor that can be attached to the recording video camera and used by an experimenter to engage in online coding of an infant's looking behavior while remaining out of the infant's line of sight and blind to the particular visual characteristics of a test display.

NIRS Technical Support. Techen Inc., the manufacturer of the MIBR's NIRS system, is a company based within an hour's drive of MIT in Milford, MA. The PI's lab maintains an ongoing relationship with the company personnel, who have assisted with headgear production and data collection strategy consultations a number of times over the last two years. Techen is highly responsive to requests for assistance, and has routinely (1) scheduled consultations, both over the phone and in person, and (2) produced and shipped custom 3D-printed optode holders within a week of initial contact. Although users

have not yet experienced technical difficulties with any component of the CW6 system, we are confident that Techen would respond promptly to requests for maintenance service and replacement parts.

Computing Hardware and Software

General IT resources. The project staff's personal workstations have access to software packages useful for the development, presentation and data analysis required NIRS research including MATLAB, PsychToolbox, iMovie or other video editing software, E-Prime, PsyScope, XHAB or other software for coding infant behavior, SPSS, and R. Where not freely available, access to these resources is provided to students, staff and faculty by MIT Information Systems and Technology. In addition, the PI's lab also has access to two computing clusters that provide data storage, processing capacity, and software resources: MindHive, located at MIT, and OpenMind, located in Holyoke, MA. Oversight for both clusters is provided by TechSquare.

fNIRS data storage and analysis. Data files for fNIRS are much smaller than those associated with other forms of neuroimaging (typically < 10 MB per session), and are easily stored on computers and/or external hard drives associated with project staff's personal workstations. Video files from fNIRS and behavioral testing sessions require a larger amount of storage space. Videos for studies in active phases of data analysis are stored on a dedicated 1 TB external hard drive. Videos for both active and completed studies are stored via the MindHive computing cluster, where the PI's lab has 94 TB of dedicated storage space. Preprocessing of fNIRS data is performed using Homer2, a freely available MATLAB-based package developed by researchers at Massachusetts General Hospital's Martinos Center for Biomedical Imaging who maintain an active discussion and troubleshooting forum to support Homer2 users. Data analysis, including novel functional channel of interest approaches, are implemented using in-house MATLAB scripts developed by lab personnel.

Data Management Plan

The following types of data will be generated by the proposed research:

- Video of infants participating in both fNIRS and behavioral testing sessions
- Behavioral data generated from researcher coding of video
- Demographic data (participant age and sex)
- Functional NIRS data

The following types of data will be generated by recruitment efforts:

- Infant personal and demographic data (name, date of birth, sex, parent or legal guardian identity)
- Personal contact information (name, phone number, and email address for parent or legal guardian)

Data Standards

Behavioral data

Demographic data. The research coordinator in both labs, maintain an updated list of participants in all studies that associates participant codes (but not any personal or identifying information) with demographic information relevant to aspects of data analysis, including sex and age on the date of participation.

Recruitment data. Information about participants (including names and dates of birth) and parents/legal guardians (including e-mail and mailing addresses and phone numbers) is stored in a secure digital database created with Filemaker Pro. The database does not log participants' study IDs in connection with personally identifiable information.

Access Policies

Files containing fNIRS data and behavioral coding of infant behavior (< 10 MB per file), none of which will include any identifying information, and videos of fNIRS and behavioral testing sessions will be stored on a dedicated server with 50 TB of space on the MindHive computing cluster. Access to the server is restricted to lab personnel, as authenticated via individual user account names and passwords. Security of the cluster is overseen by TechSquare. Original copies of fNIRS data files that have not been subject to any preprocessing or analysis will also be kept on the computer associated with the CW6 system and an external hard drive in the PI's laboratory space, password protected in both locations.

The Filemaker Pro database storing recruitment-related personal information is stored on a computer workstation in the main laboratory space secured by a locked door and requires a username and password for access, both of which are known solely by the research coordinator in primary contact with families.

Consent forms are kept in a locked cabinet in dedicated laboratory space protected by a locked door and accessible only to lab personnel.

Redistribution Policies

Both labs are committed to making experimental protocols and results accessible to other researchers for the purposes of replication and cumulative progress in science (and indeed, Dr. Saxe was a co-author on Open Science Collaboration (2015) *Estimating the reproducibility of psychological science*. Science, 349(6251)). Dr. Spelke and Dr Saxe and their institutions will hold the copyright for the data generated by the proposed research, but will redistribute to any investigator wishing to use the data for novel research purposes. Finalized protocols (for both experimental design and analysis) and processed data sets will be archived on the Open Science Framework (<https://osf.io>). The OSF project system will allow us to quickly and easily provide access to all relevant information to any qualified researcher. Stimuli from published projects are additionally made available on Dr. Saxe's website (<http://saxelab.mit.edu/stimuli.php>).

Archiving and Preservation Plans

Metadata on the outcome of our experiments will be shared via the Database for Infant NIRS (<https://sites.google.com/site/dbifnirs/>). Raw data will be maintained on secure servers; we have no plans to erase any type of digital dataset as the storage capacity of the systems we use is extensive and able to be increased as needed. All processed data sets will be archived on Open Science Framework for examination and use by other researchers.

Functional NIRS data.

The CW6 system used for fNIRS acquisition automatically saves collected data as a structured .nirs file, in which all recorded aspects of the acquired data are stored in dedicated fields.

The same file format is used as input for the Homer2 analysis package for MATLAB that will be used for data preprocessing. Copies of both the original output files and versions subjected to preprocessing and additional analysis steps will be saved. Aggregate data and statistical results of data analyses will be saved as SPSS or Excel files, and graphs and other data visualization will be generated with MATLAB or Excel.

Infant videos. Participant videos will be exported off the video camera used to record sessions and deleted from the camera's memory card within 2 days of each experimental session. The exported videos will be converted using HandBrake and stored as .mp4 files compatible with a number of common video playback and editing software packages, including Quicktime, Windows Media Player, Final Cut Pro and iMovie.

Mentorship Plan for Ashley J. Thomas; Mentor Dr. Elizabeth Spelke; Co Mentor: Rebecca Saxe Overview

The co-mentors Elizabeth Spelke and Rebecca Saxe have read and approve of the proposal prepared by Ashley J. Thomas. The project and training plan in Ashley's proposal will help her achieve her career goal of becoming a tenured Professor at a Research I University. Ashley has a strong background in cognitive and social development, as evidenced by her innovative projects in her dissertation about how infants and children represent social hierarchy. The current proposal thoughtfully builds off and expands on that line of research by investigating how infants and children represent affiliative relationships. The proposed work and training plan will allow Ashley to continue enhancing the research skills she developed as a PhD student, including experimental design and methodologies for social development, and theory building in the field of developmental psychology. It will also allow her to expand her skill set including learning how to use fNIRS. Ashley is already recognized by her colleagues and mentors as a promising young scholar. She has built an impressive cross-disciplinary network of collaborators, including in Anthropology (Alan Fiske), Philosophy (P. Kyle Stanford), Social Psychology (Pete Ditto, Paul Piff) along with those within the field of developmental psychology (Lotte Thomsen and Jessica Sommerville). This proposed research and training plan will put Ashley in a great position to achieve her career goals, especially given the current interest in infant's understanding of social relationships. This interest was apparent when Ashley recently organized a pre-conference on 'naïve sociology' at the Cognitive Development Society, that had to be expanded because of how quickly it sold-out. The proposed work is grounded in theoretically interesting questions and will be of great interest to this sub-field of social cognitive development, and to the larger fields of developmental and social psychology. This fellowship will allow Ashley to deepen her theoretical knowledge of social development, continue to build her methodological skills in social development, and further expand her network of collaborators and mentors.

We have been discussing and developing these studies and the training plan with Ashley, through email and skype during the past several months after Ashley approached the two of us with the idea for the project. Ashley also has met in person with Dr. Lindsey Powell during the meeting for Cognitive Development Society this month. Dr. Powell is a postdoctoral scholar in the Saxelab, a former member of the Spelke Lab and will help train Ashley during Year 1 on the fNIRS project.

Ongoing work and support in the Saxelab and Spelke Labs: The proposed studies build off ongoing work in both the Spelke Lab and the Saxelab. In the Spelke Lab, Ashley's work will build off the recent work in the lab that is part of a larger research program investigating infants' core social knowledge. For example, there is ongoing work about infants' expectations about caregiving relationships in novel individuals (Spokes & Spelke, 2017) and work on infant's expectations about individuals who imitate others or synchronize their actions with others (e.g. Powell & Spelke, 2013; Powell & Spelke, 2017; Powell & Spelke, 2018). The work will also be an integral part of the larger research program to investigate social core cognition (Cogsdill, Todorov, Spelke, & Banaji, 2014; Kinzler, Dupoux, & Spelke, 2007; Kinzler, Shutts, DeJesus, & Spelke, 2009; Kinzler & Spelke, 2011; Olson & Spelke, 2008). This work expands on this research, by investigating how infants own social motivations are influenced by how their caregivers interact with others, and whether children have a basic desire to see others affiliate.

The proposed work will also build off ongoing work in the Saxelab being conducted by Dr. Powell and Dr. Saxe, who have been developing fNIRS as a method for investigating *why* infants prefer to look at social stimuli—i.e. whether they get a social reward or informational value from it. The Saxelab is currently funded through an NSF grant “*Neural measures of social reward and information value in infants*” to carry out this work using fNIRS. The proposed work will build off these pilot studies, and, again, will be integral in Dr. Saxe's larger research program of understanding neural mechanisms of social cognition in infants (e.g. Kleiman-Weiner, Saxe, & Tenenbaum, 2017; Saxe, 2006a, 2006b; Saxe, Carey, & Kanwisher, 2004; Saxe & Haushofer, 2008; Saxe & Kanwisher, 2003; Saxe & Powell, 2006; Saxe & Wexler, 2005; Young, Cushman, Hauser, & Saxe, 2007).

The behavioral work in this proposal has a high likelihood of success because it builds off protocols that we have already used successfully in experiments with infants. However, Ashley has also

shown keen insight in developing ways to address issues that are specific to her study design to answer important and novel questions. The fNIRS work in the proposal also has a high likelihood of success because it builds off successful pilot studies in the Saxelab. Ashley's work will take important next steps in understanding infant's own social motivations. Moreover, the NSF grant in the Saxelab and the private funding in the Spelke lab means that Ashley will have the necessary resources to carry out this work. The work does not overlap with any proposals that are under review or that have been proposed by either of the mentors. Ashley will be working primarily with the co-mentors, Rebecca Saxe and Elizabeth Spelke, but will also work with Dr. Lindsey Powell who will be a post-doctoral scholar during Ashley's first year and will, alongside Dr. Saxe, will train Ashley to learn fNIRS methodology.

Ashley will carry out the behavioral studies in the Spelke lab and the fNIRS studies in the Saxelab. The Spelke lab will have two post-doctoral scholars, and three PhD students during Ashley's fellowship. Each of these scholars have expertise in methods involved in studying infant cognition. Although Ashley will begin her fellowship with prior expertise in testing infants, the expertise of the other lab members will compliment Ashley's existing knowledge. Similarly, the Saxelab will have 3-4 graduate students and 2 post-doctoral scholars during Ashley's fellowship. Again, their expertise will compliment Ashley's existing methodological knowledge. Moreover, working closely with Rebecca Saxe and Dr. Powell on developing fNIRS as a new method, will also provide the opportunity for Ashley to learn how to develop new methodologies and set up a lab that can use fNIRS. This will be important in the success of one of Ashley's eventual goals, which is to develop gaze-controlled stimuli for infants. Both the Spelke Lab and the Saxelab have access to a large database of infants and have lab managers to schedule testing sessions. We will also pair Ashley with research assistants to assist her in carrying out data collection.

Although Ashley's proposal builds on the work that is ongoing in the Spelke and Saxelab, the proposed studies will provide the foundation for a larger research program that Ashley can take with her to subsequent research positions. Any of this work that is not completed in the two years, or projects that come about because of this work can be taken with Ashley to subsequent positions.

Planned Interactions with Mentors and Trainee: Before Ashley begins her fellowship, she will have a meeting with both co-sponsors so we can plan her training. This meeting will involve setting target dates for publications and conference presentations. During this time, she will also get an orientation of the ins and outs of our labs (e.g. how to schedule babies, equipment, databases). During her fellowships, both mentors will interact with Ashley on a regular basis, including weekly individual mentoring sessions. A major focus of these meetings will be on the execution and completion of Ashley's proposed studies, including the writing and completion of at least three manuscripts resulting from the studies in this proposal (though we also anticipate it will lead to more work). Ashley will also gain first-hand experience of how to be the principle investigator of a lab, including mentoring, administration, coordination, planning, execution, and problem-solving. Ashley will also attend two weekly group research team meetings where Ashley will have the opportunity to present her work. The group meetings are standard lab meetings, which focus on discussing things such as study designs, results from a project, writing manuscripts or grants. This allows the lab members to engage in in-depth conversations around theoretical, methodological, and dissemination issues. In addition to Ashley's regular meetings with us, we will also ensure that Ashley is involved with other relevant labs on both the MIT and Harvard campuses. These include the Carey Lab (cognitive development) and Cushman Lab (Moral and Social Psychology) at Harvard and the Shulz lab (cognitive development) at MIT. Given Ashley's past success in building collaborative relationships and networking with colleagues, we are sure that she will excel in such an environment. Dr. Spelke and Dr. Saxe are also committed to improving research practices, Ashley and the two mentors have discussed issues of replicability and transparency, and plan to pre-register the proposed studies and to use Bayesian Analysis which is less prone to p-hacking.

Past Success of Mentors: The environment in the Spelke and Saxe labs, which includes a high-level of interaction between lab members has been quite successful in training scholars and producing scholars who have high impact in Developmental Psychology. This success is due to providing trainees with the opportunity to get constructive feedback and support, and to build professional relationships with

one another, both of which are integral to success in academia. It should also be pointed out that the Saxe and Spelke labs have an established relationship with one another, for example successfully co-mentoring Dr. Lindsey Powell during her time as a post-doctoral scholar. The success of the environment in the Spelke and Saxe Lab is reflected in the consistent dissemination of high-profile publications from members of our labs, including in recent years in Proceedings of the National Academy of Sciences, Psychological Science, Cognition, Nature, Science, as well as conference presentations at major meetings such as those of the SRCD and the Cognitive Development Society. The success of this environment is also reflected in the number of scholars that are currently faculty members at top research universities (e.g. Stanford, Boston College, Harvard, University of Maryland).

Additional Training: Ashley's training plan will focus on developing skills necessary for Ashley to become an independent researcher. This includes broadening Ashley's theoretical understanding of social cognition, and expanding Ashley's methodological skills. In addition to the meetings discussed above, this will be accomplished through coursework at Harvard and MIT, individualized hands-on training, and a reading list that will be prepared by both mentors. Ashley will also work closely with the co-mentors to develop theories about the development of infants understanding of social relationships. The purpose of these activities is to give Ashley the tools she needs to successfully carry out the proposed projects, and to prepare Ashley to continue this line of research once the fellowship is completed. This deepening of theoretical knowledge will also allow Ashley to anchor her findings in broader literatures. Ashley will also expand her skillset and theoretical knowledge through auditing several graduate seminars. During Ashley's first year we will focus on developing and deepening her theoretical background of theories about social relationships and infant cognition. She will audit *Empirical and Computational Approaches to Cognitive Development* taught by Prof. Spelke (Psy 2151); and *Developmental Neurobiology* with Nedivi, Heiman. During this time, Ashley will also take a course on the *Responsible conduct in Science* offered through MIT with Wilson.

During Ashley's second year of the fellowship, she will further expand her skill set by auditing courses at MIT including *Computational Cognitive Science* with Tenenbaum; and *Intergroup Relations* taught by Prof. Sidanius (PSY 2570). Over the two years, these courses, which will be supplemented by regular meetings with both of us, will provide Ashley with a comprehensive plan to further develop her theoretical knowledge and skills.

Finally, the environment at Harvard and MIT is an intellectually stimulating one. Ashley will have the opportunity to attend several symposia, brown-bags and talks directly related to her proposed studies with people who are doing cutting-edge research.

Given Ashley's prior expertise and innovative experiments, and the environment and resources available in the Spelke and Saxe Labs, we are sure that Ashley will succeed if given the opportunity to carry out this work.

Skills	Activities Planned
Research Development -Theory Building -Infant behavioral research methodologies -fNIRS methodologies	Weekly, one on one meetings with Dr. Spelke and Dr. Saxe. Weekly lab meetings in the Spelke Lab, and weekly lab meetings in the Saxe lab. Coursework: <i>Developmental Neurobiology</i> with Nedivi; <i>Computational Approaches to Cognitive Development</i> with Spelke. Hands on Training for fNIRS
-Ethics	Coursework: <i>Responsible conduct in Science</i> with Wilson.
Professional Development -dissemination of research findings to academic audiences -communicating research findings to the public -Ins and outs of being a PI in a lab -Grant-Writing	-Weekly, one on one meetings with Dr. Spelke and Dr. Saxe. -Weekly lab meetings in the Spelke Lab, and Saxe lab. -talks at nearby Universities -Participation in local education events for the general public -Mentoring for K-award applications -Mentoring in Faculty position applications
Mentoring	Supervise three undergraduate research assistants per quarter, including summer months

Dissertation Abstract

Social hierarchies (i.e., relationships between individuals who differ in rank or status) are found across animal species and throughout human society. In most animal species, rank is derived from being able to inflict harm on others. However, for humans, rank can also be derived from providing benefits (Fiske, 1992; Henrich & Gil-White, 2001; van Vugt & Tybur, 2014). In order to live successfully with others, social animals, including humans, must be able to navigate social hierarchies. Indeed, human infants can detect relative rank, expecting individuals who are larger or who have more allies to prevail in conflicts (Pun, Birch, & Baron, 2016; Thomsen, Frankenhuis, Ingold-Smith, & Carey, 2011) and older children infer who is 'in charge' from various cues (Charafeddine et al., 2015). However, it is unknown how social rank influences motivations and behaviors of infants and children. Moreover, it is unknown how children expect those who are either high or low ranking to act.

In part (1) I investigate infant's social preferences based on relative social rank. In one seven-part experiment, I provide evidence that two-year-old children prefer high-ranking individuals to low-ranking individuals, but only when those individuals are deferred to, not when they get their way through force. In the next experiment, I show that one-year-old children prefer the individuals who defer. Next, we investigate whether this change in preference correlates with developments in language and motor ability.

In part (2) I investigate how children, ages 4 to 7 years old, represent social hierarchy. In the first set of experiments, I provide evidence that children expect high-ranking individuals to be benevolent—children expect them to protect others in their group and do not expect them to act aggressively toward others. In the next set of experiments, I show how children behave when put in leadership positions themselves—children seem to be less willing to share stickers with others, but do spend more time on a boring task. Finally, I provide evidence that children prefer groups that have a non-hierarchical organization over groups that have a hierarchical organization.