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

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

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

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

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
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Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
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PI/PD Name: Brian Habing

Gender: ☒ Male ☐ Female

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

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

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

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

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

SUGGESTED REVIEWERS:

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Bruno Zumbo, Measurement, Evaluation, and Research Methodology Program, University of British Columbia (zumbo@ubc.ca).

REVIEWERS NOT TO INCLUDE:

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TITLE OF PROPOSED PROJECT **Item Response Theory Models for Mixtures of Dominance and Proximity Items**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 143,227	24 months	08/01/07	

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

☐ BEGINNING INVESTIGATOR (GPG I.A)
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PI/PD DEPARTMENT	PI/PD POSTAL ADDRESS
Department of Political Science	University of South Carolina Columbia, SC 29208 United States
PI/PD FAX NUMBER 803-777-6795	

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CO-PI/PD				
CO-PI/PD				
CO-PI/PD				

Electronic Signature

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

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

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

Drug Free Work Place Certification

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

Debarment and Suspension Certification

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

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

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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.

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

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME **Debra J Wingard**	**Electronic Signature**	**Jan 16 2007 3:38PM**

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER
803-777-7093	**dwingard@gwm.sc.edu**	**803-777-4136**

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Project Summary: Item Response Theory Models for Mixtures of Dominance and Proximity Items

The proposed research involves the development, testing, application, and dissemination of a group of latent variable models for analyzing mixtures of dominance and proximity items in an item response theory (IRT) framework. Dominance (or *monotone*) items are those for which a stronger agreement or higher score on the item or question is directly related to the respondent having a higher value on the underlying latent trait; proximity (or *unfolding*) items are those where the relationship between the strength of the response and the value of the underlying latent trait is non-monotonic, depending instead on the distance between the location of the item and the respondent on the same latent continuum. At present, only ad-hoc rules of thumb are available for classifying items of uncertain type. Moreover, there is currently no method for simultaneously analyzing instruments that contain both a full range of monotone items and a full range of unfolding items, forcing analysts either to choose only subsets of items or risk incorrect and misleading results.

The research will proceed in three overlapping phases. Phase I of the research will involve the development and testing of the proposed models and their estimation. Phase II will consist of the replication of three recent, representative studies which utilized one of the two models, while phase III will apply the models developed to experimental data specifically designed to contain both types of items. Dissemination of the research findings will take place through an integrated plan of scholarly publications, software development, pedagogical activities, and web-based resources.

Intellectual Merit

The proposed research will simultaneously and substantially advance the state of scientific knowledge in both statistics and the social sciences. The class of models we develop will serve as an important "bridge" between monotone and unfolding models – two subsets of IRT models which, to date, have largely evolved separately and in parallel with one another – and will further the development of mixture-based approaches to IRT models more generally. In the social sciences, the wide availability and easy implementation of models for identifying and analyzing mixtures of dominance and proximity items will give applied researchers an important tool for the analysis of survey items, roll-call and other voting data, and a host of other choice-based phenomena. Moreover, by integrating insights from the parallel literatures on IRT models in statistics and the social sciences, our work will increase awareness by statisticians of the uses of IRT models in the social sciences, promote the better-informed use of those models by those within the social sciences, and prompt greater collaboration between members of the statistics and social science communities.

Broader Impacts

The broader impacts of this work will be scientific, pedagogical, and infrastructure-based. Scientifically, it will allow for practitioners to directly test theories concerning the processes generating data across a wide range of fields, reconciling methods that have been at odds for the better part of a century. Yet another significant benefit will be in the area of pre-testing, where the methods developed will allow researchers to assess *ex ante* the data generating process underlying particular items. The pedagogical impact of the proposed work is also considerable; graduate students involved in the project will, at its conclusion, be fully integrated members of both the statistics and social science research communities, and the short courses developed will disseminate the models to a wide audience of active social scientists. Finally, the software and web resources developed and maintained by the PIs will represent an important contribution to the infrastructure of research in the social and behavioral sciences.

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

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

Introduction

For nearly a half century, models based on item response theory (IRT) have been a lynchpin of psychometric analyses. Broadly speaking, IRT defines a class of models that map the attributes of individual respondents and items to a probability space over discrete outcomes. Beyond their widespread application in quantitative psychology, the use by social scientists of IRT models has grown appreciably over the past two decades. Item response models have been used to address questions ranging from airline punctuality (Caulkins et al. 1993) to the effectiveness of graduate admissions committees (Jackman 2004) in disciplines as diverse as law (e.g., John and Weitz 1998; Martin et al. 2005; Epstein et al. 2006), sociology (e.g., Schaeffer 1988; Thissen and Mooney 1989; MacIntosh 1998; Morgan and Sørensen 1999; Raudenbusch et al. 2003), economics (e.g., Bechtel 1985; Cook and Evans 2000; Freeman and Waldfogel 2001), and political science (e.g., Delli Carpini and Keeter 1993; Poole and Rosenthal 1997; Londregan 2000; Poole 2001; Bailey 2001).

An issue of central importance in the use of such models is the question of the form of the underlying data generating process. In his seminal (1964) work, Clyde Coombs distinguished between "dominance" (or "order") relations and "proximity relations." As a practical matter, dominance relations imply that the item response function (IRF) – that is, the function that maps from the position of the respondent in the latent dimension to the probability of an observed positive item response – is monotonic. The classic example is from educational testing, where the latent dimension represents the respondent's "ability," and higher values correspond to higher probabilities of a positive (correct) response. In some psychological applications, negatively-phrased items can be reverse-scored and modeled in the same manner (e.g., effectively changing "I don't often feel blue" to "I often feel blue" on a measure of depression). By contrast, proximity relations are those in which the item response function is nonmonotonic; moving away from the respondent's (item's) position in the latent space decreases the probability of the item receiving (respondent giving) a positive response. An common example is in polytomous choice situations, where a respondent chooses from items along some latent continuum according to which is "closest" to his/her preferred point on that dimension (e.g., "I sometimes feel blue").

Within psychometrics, models for dominance relationships have a long history (cf. Guttman 1950; Rasch 1980; Birnbaum 1968; Mokken 1971), and the assumption of a monotonic IRF underlies most current IRT models. Conversely, models for proximity relations have seen comparatively little attention in psychometrics (Davidson 1977; DeSarbo and Hoffman 1986; Poole 1984, 2000; Luo 1998; Roberts et al. 2000), though (as we discuss below) such models predominate in the social sciences. For that reason alone, the development of models which integrate the analysis of proximity and dominance items is of value. More important, application of dominance models to data which arise from a proximity process (or vice versa) will, in most instances, lead to faulty inferences and incorrect conclusions. As a practical matter, this forces analysts to pre-screen questions by type, removing those that do not conform to their preferred model.

To take one example, consider the application of item response models to the votes of justices in the U.S. Supreme Court (Martin and Quinn 2002; Martin et al. 2005). Such analyses typically pool votes on both procedural and substantive issues; for example, they treat identically issues of standing, mootness, ripeness, etc. and more directly substantive/policy issues such as free speech, regulatory takings, etc. On one hand, the propensity of Supreme Court justices to vote consistently with a proximity model in cases involving substantive policy issues is well established (cf. Segal and Spaeth 2002). At the same time, however, justiciability standards almost always consist of "threshold" issues; for example, the broad standard for mootness is that an "actual controversy" must exist both at the time of the initiation of the suit and, where applicable, at all stages of appellate review (*U.S. v. Munsingwear, Inc.* 340 U.S. 36 (1950)). Such threshold standards – where we might think of the probability of a vote against declaring the case as a function of the (latent) level of "actual controversy" for the case in question – clearly imply a monotonic IRF. As a result, analyses which fail to account for the different forms of the IRFs across the two types of cases votes are problematic. Moreover, our preliminary analysis of all cases decided by the Court between 1953 and 2005 indicates that nearly 18 percent of all votes are on such procedural issues, and that substantial numbers of cases – more than 300 during the period in question – contain issues of both types.

As an example of the second type of item uncertainty, consider a recent study by Roberts et al. (2000) in which 750 subjects were asked to agree or disagree with a series of statements regarding abortion. In some instances, the test items clearly suggest a proximity process: for example, disagreement with the statement "My feelings about abortion are very mixed" could come from individuals with strong opinions on either side of the debate. In other instances, however, the nature of the item is not so clear. For some (relatively extreme) items, either a dominance or a proximity model would, in practice, fit the data equally well; there are likely to be few respondents in the sample for whom a statement such as "Abortion could destroy the sanctity of motherhood," would be insufficiently pro-life/anti-abortion to warrant a negative response, making the difference between models untestable statistically. With both of these types of questions fitting a proximity model, the questionnaire designer was necessarily forced to exclude items such as "I am more pro-life than pro-choice" that would clearly be dominance items.[1]

In this proposal, we outline a plan of research for the development, testing, application, and dissemination of a group of latent variable models for analyzing mixtures of dominance and proximity items in an IRT framework; we refer to these as "mixed unfolding-monotone models" (MUMMs). The research will take the form of a two-year collaborative project between members of the USC departments of Statistics (Habing) and Political Science (Zorn), and will consist of three broad phases: the development and testing of the models described

[1] In fact, our preliminary analysis of the Roberts et al. (2000) abortion data show that out of the full set of 50 items, 24 could be fit by either monotone or unfolding models, while 26 were clearly proximity-based items. Using actual responses to simulate a clear pro-life versus pro-choice item and adding that item to the existing fifty caused both models to fail to converge.

via Monte Carlo simulations, a reanalysis of data from three prominent existing studies in psychometrics and political science, and a series of original, web-based experimental studies of the performance of the models developed. Importantly, the research conducted would contribute significantly and equally to both statistics and the social sciences. In the former case, the proposed work would integrate two important but heretofore separate classes of models from item response theory. In the social sciences, the models developed would provide applied researchers with a means of assessing *ex post* whether the questions they employ belong to the class of dominance or proximity items, and with a unified means of analyzing groups of questions which contain items of both types. Our proposal also outlines a multifaceted plan for dissemination of both the research itself and associated pedagogical and technological innovations, both of which are designed to achieve the broadest potential exposure of the research in question to scholars and practitioners in the social, behavioral, and mathematical sciences.

Background: IRT Models for Dominance and Proximity Scales

Monotone IRT Models for Dominance Scales

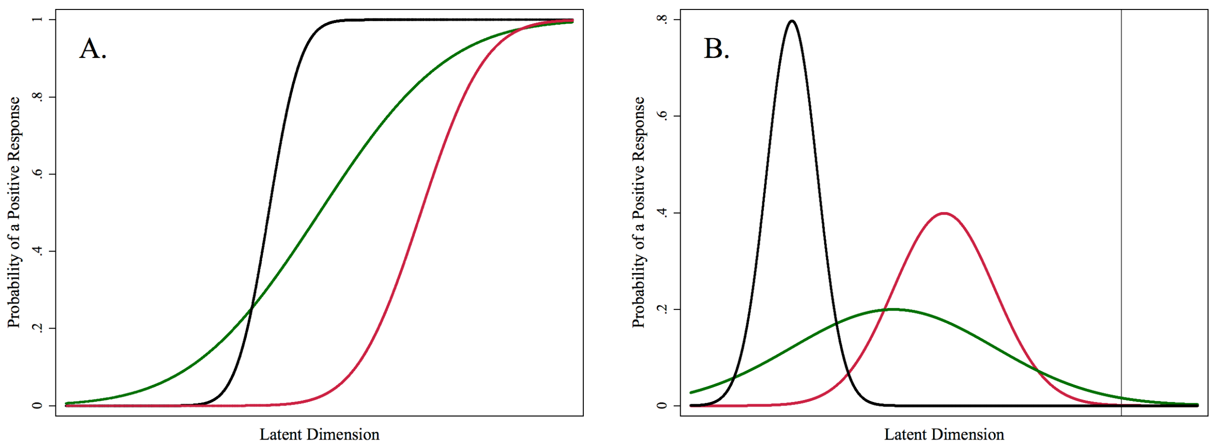
IRT models are generally defined by specifying the item response functions (IRFs) that link the probability of observing a given response on the item to to the individual respondents value on an underlying latent trait. The most commonly studied class of IRT models are the monotone homogeneity models (Mokken 1971) for dichotomous/binary data. The three assumptions defining these models are that the underlying latent trait (θ) is unidimensional, that the probability of a correct response is a monotone increasing function of θ, and that the item responses are locally independent (conditionally independent given θ). Three sample monotone IRFs are shown in Figure 1A; in each case the probability of a positive response for each item is increasing with the level of the latent trait. This monotonicity is equivalent to the items forming a dominance scale (subject to the possible need to reverse code some items).

In practice, the particular parametric form of the IRFs is often specified as a special case of Birnbaum's (1968) three-parameter logistic (3PL) model:

$$\Pr[Y_{ij} = 1 | \theta_j, (\alpha_i, \beta_i, c_i)] \equiv \pi_{ij} = c_i + (1 - c_i) \frac{\exp[D\alpha_i(\theta_j - \beta_i)]}{1 + \exp[D\alpha_i(\theta_j - \beta_i)]} \quad (1)$$

In this formulation $Y_{ij} \in \{0, 1\}$ is the response of subject $j \in \{1, 2, ...J\}$ to item $i \in \{1, 2, ...N\}$. The item is specified by its slope ("discrimination") parameter α_i, location ("difficulty") parameter β_i, and lower asymptote ("guessing") parameter c_i, while each examinee is specified by its ability or trait value θ_j. A scaling parameter $D = 1.7$ is often included to make the scale of the logistic form similar to that of the normal-ogive model formed by replacing the logistic function with the standard normal cumulative distribution function. Setting c_i to zero produces the two-parameter logistic model (2PL), and setting both c_i to zero and fixing α_i to be constant across items produces the one-parameter logistic

Figure 1: Monotone and Nonmonotone IRFs



Note: Panel A presents three monotone (dominance) IRFs, panel B shows three nonmonotone (proximity) IRFs.

(1PL) or Rasch model. The Rasch model has a variety of statistical and philosophical properties that make it of special interest (e.g. Fischer and Molenaar 1995). A four-parameter (4PL) form is created by adding an upper-asymptote to allow for a "ceiling" or slippage effect.

Estimation of the 3PL model is typically carried out using a Bayesian extension of marginal maximum likelihood (MML; Bock and Aitkin 1981) due to Mislevey (1986). In this approach the EM algorithm is utilized to obtain estimates of the item parameters. The unobserved θ values are removed during the expectation step using numerical integration, and the item parameters are solved for in the subsequent maximization step. These two steps are repeated iteratively until convergence is achieved. The respondent θ parameters are then estimated by treating the item parameters as known and using a method such as maximum likelihood or Bayesian EAP. These procedures are describe in detail by Baker and Kim (2004). Markov Chain Monte Carlo (MCMC) estimation methods have also been applied to IRT models (cf. Albert 1992). The large amount of additional computation restricts its regular application to more complicated (4PL, hierarchical, or multidimnesional) models or when it is desired to perform posterior predictive model checking (Patz and Junker 1999; Sinharay 2005). While IRT models are typically recommended for samples of at least 400-500 respondents, Swaminathan et al. (2003) investigated the MML estimation of item parameters for samples as small as 100 respondents and 21 items, finding that even in this small-sample case the the root mean squared error was 0.41 for the β parameters and 0.11 for the αs. While this level of precision would likely be unacceptable for making high-stakes educational decisions, it is still of value in settings where more general descriptive theories are being investigated.

Polytomous versions of dominance models are those in which the ordered response categories ($k \in \{0, 1, 2, ...K\}$) of each item correspond to increasingly higher levels of the latent trait. Data of this form are often informally described in terms of specific classes of models for analyzing them, e.g., Likert scale, partial credit, or graded response. One class of IRT models for polytomous responses are the divide-by-total ("partial credit") models. The item responses are specified in terms of the item step response functions, as in Muraki's (1992) generalized partial credit model (GPCM):

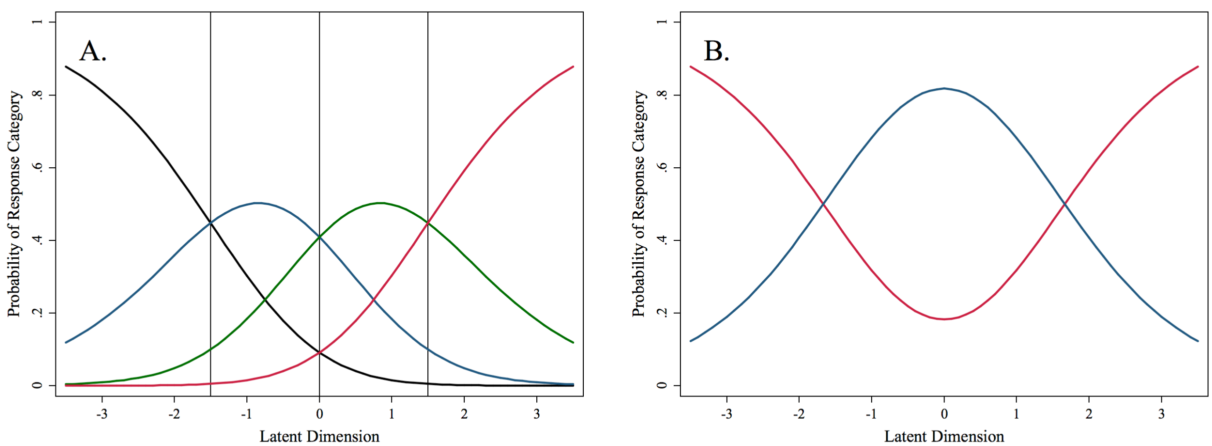
$$\Pr(Y_{ij} = k | Y_{ij} = k \text{ or } Y_{ij} = k - 1; \theta_j, (\alpha_i, \beta_{i0}, \dots \beta_{ik})) = \frac{\exp(D\alpha_i(\theta_j - \beta_{ik}))}{1 + \exp(D\alpha_i(\theta_j - \beta_{ik}))} \tag{2}$$

In this formulation, α_i is a discrimination parameter, β_{i0} is set to 0, and β_{ik} indicates the ability threshold where a response of k becomes more likely than a response of $k - 1$. The item category response function (that is, the probability of responding to a given category) can be written as:

$$\Pr(Y_{ij} = k | \theta_j, (\alpha_i, \beta_{i0}, \dots \beta_{ik})) = \frac{\exp(\sum_{v=0}^{k} D\alpha_i(\theta_j - \beta_{iv}))}{\sum_{w=0}^{K} \exp(\sum_{v=0}^{w} D\alpha_i(\theta_j - \beta_{iv}))} \tag{3}$$

The item category response functions for an item following the GPCM is shown in Figure 2A; the locations where the adjacent response categories cross are given by the location parameters. The GPCM is commonly estimated analogously to the dichotomous models discussed above (e.g. Muraki 1997).

Figure 2: GPCM and GGUM Item Category Response Functions



Note: The crossing of the ICRFs in panel A occur at $\beta_{i1} = -1.5, \beta_{i2} = 0$ and $\beta_{i3} = 1.5$. The blue ICRF in panel B is the sum of the two central (blue and green) ICRFs in panel A; the red ICRF in panel B is the sum of the two outer (red and black) ICRFs in panel A.

An alternative representation that is less similar to the dichotomous model formulations, but used in motivating the unfolding IRT models below, is formed by setting $D = 1$, and writing $\beta_{ik} = \delta_i - \tau_{ik}$ where $\tau_{i0} = 0$ and $\sum_{k=1}^{k=K} \tau_{ik} = 0$; this yields:

$$\Pr(Y_{ij} = k|\theta_j, (\alpha_i, \delta_i, \tau_{i0}, \ldots \tau_{iK})) = \frac{\exp\left\{\alpha_i \left[k(\theta_j - \delta_i) - \sum_{v=0}^{k} \tau_{ik}\right]\right\}}{\sum_{w=0}^{K} \exp\left\{\alpha_i \left[w(\theta_j - \delta_i) - \sum_{v=0}^{w} \tau_{ik}\right]\right\}} \tag{4}$$

In this case, the δ_is represent the overall location of the items and the τ_{ik}s represent the location of the category thresholds relative to the item location. Setting the $\alpha_i \equiv \alpha$ to be constant across all items produces Master's (1982) partial credit model; the additional restriction that the $\tau_{ik} \equiv \tau_k$ are constant across all items results in Andrich's (1978) rating scale model. Both of these special cases belong to the Rasch family of models. The relationship of the partial credit models to alternative families of polytomous models is discussed in Hemker et al. (1997).

Unfolding IRT Models for Proximity Scales

The modeling of proximity scale or ideal point items requires the removal of the monotonicity assumption underlying the previously discussed IRT models. For example, each of the response functions in Figure 1B corresponds to an item with a different ideal point; subjects with a high level of the latent trait (for example, a subject located at the vertical line on the right of the figure) has a high probability of responding negatively to all three items. Several unfolding IRT models have been proposed (e.g. Andrich 1988; Hoijtink 1990).

The generalized graded unfolding model (GGUM; Roberts et al. 2000) is constructed assuming an unobserved GPCM model explains the responses. Assume each proximity scale item has possible responses $k \in \{0, 1, 2, ...K\}$, where 0 corresponds to the strongest possible negative response and K corresponds to the strongest positive response. Each of these responses could be due to examinees trait location being above the item's location parameter or below it. We could therefore conceptualize an unobserved GPCM model scored $k^\star \in \{0, 2, ...(2K + 1)\}$ where a response of 0 corresponds to the strongest negative response due to examinee trait being below the item location, and $2K + 1$ corresponding to the strongest negative response due to the examinee trait being above the item location. Similarly a response of K would be the strongest positive response due to an examinee being located below the item location and $K + 1$ would be the strongest positive response due to an examinee being located above the item. The observed unfolding model is thus formed by combining the response categories of the underlying GPCM; this is illustrated by the GPCM item in Figure 2A and the corresponding GGUM item in Figure 2B.

With the simplifying assumption that the corresponding unobserved score categories are symmetric, the item category response function for the unfolding model can be written as:

$$\Pr(Y_{ij}=k|\theta_j,(\alpha_i,\delta_i,\tau_{i0},\dots\tau_{iK}))=$$

$$\frac{\exp\left\{\alpha_i\left[k(\theta_j-\delta_i)-\sum_{v=0}^{k}\tau_{ik}\right]\right\}+\exp\left\{\alpha_i\left[(2K+1-k)(\theta_j-\delta_i)-\sum_{v=0}^{k}\tau_{ik}\right]\right\}}{\sum_{w=0}^{K}\left\{\exp\left\{\alpha_i\left[w(\theta_j-\delta_i)-\sum_{v=0}^{w}\tau_{ik}\right]\right\}+\exp\left\{\alpha_i\left[(2K+1-w)(\theta_j-\delta_i)-\sum_{v=0}^{w}\tau_{ik}\right]\right\}\right\}} \quad (5)$$

The left portion of each sum in (5) corresponds to the lower response category of the underlying GPCM (as in Eq. 4), and the right portion corresponds to the upper category. A symmetry restriction sets $\tau_{ik}=\tau_{i(2K+1-k)}$.

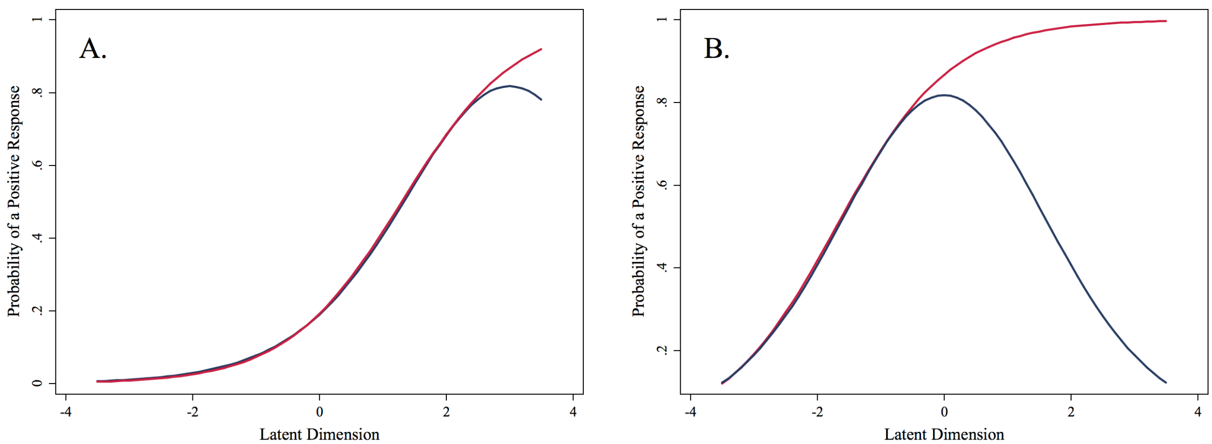
As with the GPCM, the GGUM is also estimated using the MML procedure mentioned above. Roberts et al. (2002) report obtaining accurate item parameter estimates for the full GGUM model with 750 respondents, and accurate subject trait estimates with 15 six-category items. For samples as small as 200 respondents the average correlation between the simulated and true item parameters exceeded 0.8, and the correlation between the true and estimated respondent trait values was 0.94 on average for the five-item exam. Roberts et al. (1999) also report good parameter recovery for as few as 100 participants and 15 graded response items for the simplified graded unfolding model (GUM). While there are no extensive results for application of the GGUM model to dichotomous items and small sample sizes, Luo (2000) reported reasonable results for samples of 50 respondents and positive results for 100 respondents using the related hyperbolic-cosine model (Andrich 1988) and joint maximum likelihood. Johnson and Junker (2003) have investigated the use of MCMC for estimating the hyperbolic-cosine model.

Mixed Unfolding-Monotone Models

As discussed in Andrich (1996) the tension between dominance models and proximity models traces back at least as far as Likert's (1932) construction of monotone scales in response to the proximity approach of Thurstone (1927). Recent investigations of the issue such as Roberts et al. (1999) and Post et al. (2001) also fail to completely reconcile the differences between the two types of models. To summarize, increasing dominance items with large positive location parameters and decreasing dominance items with low negative location parameters can generally be fit using an unfolding model (see Figure 3A). Similarly, unfolding items with large/positive location parameters and reverse coded unfolding items with low/negative location parameters can generally be fit using a monotone model. However, currently there is no method for analyzing combinations of dominance items and unfolding items, all having moderate location parameters (as in Figure 3B).

There have been a variety of models proposed for mixtures in IRT, but this work has focused on different (unobserved) groups of subjects whose responses follow separate models. In one early example, Rost (1990) examined a mixture Rasch model, where the respondents belonged to differing latent classes, each with their own set of item parameters. Mislevy and Verhelst (1990) discussed a widely used general framework for estimating similar models (although not restricted to the Rasch case) using the EM algorithm. For example, they

Figure 3: Mixtures of Dominance and Proximity IRFs



Note: The IRFs in panel A differ only for subjects with extremely high values of the latent trait, who in practice are observed with extremely low probability.

account for guessing by modeling some respondents as using a 2PL model and others as using pure guessing. More recently, Roberts (2006) has examined a mixture-unfolding model where each class responds to item response functions with the same location, but different discriminations, to take into account varying "latitudes of acceptance."

The proposed mixed unfolding-monotone model (MUMM) for allowing both unfolding and monotone items in a single instrument can be thought of in terms of the methodology of Mislevy and Verhelst (1990). Specifically, it can be viewed as a restricted mixture of subjects, where all subjects choose the same response model (dominance or proximity) for each item, but where "strategy switching" across items is involved. Alternatively, it can be more directly viewed as a mixture of items rather than subjects. The model can be specified in terms of the probability of respondent j selecting response category k on item i:

$$\Pr(Y_{ij} = k | \theta_j, \phi_i, \boldsymbol{\psi}_i) = f_0(k, \theta_j, \psi_{i0})^{\phi_i} f_1(k, \theta_j, \psi_{i1})^{1-\phi_i} \tag{6}$$

Here ϕ_i is the model type indicator (0=unfolding, 1=proximity) for item i, f_1 is the ICRF form given in (4) (allowing for negative α_i parameters), f_0 is the ICRF form given in (5), and the ψ_{i0} and ψ_{i1} are the vectors of item parameters corresponding to the two models.

Treating ϕ_i as Bernoulli random variables, initial estimates of $\pi_i = \Pr[\phi_i = 1]$ will be generated using formalized versions of the heuristics given in Post et al. (2001), with clearly defined items (Figure 3B) being fixed at 0 or 1 respectively. Initial item parameter values for form (4) will be carried out using MML as implemented by Muraki (1997) for all items with $\pi \neq 0$, using reverse coding as needed, and for form (5) using the algorithm of Roberts et.al. (2000) for all items with $\pi \neq 1$. Estimation will then proceed as described in Mislevy and Verhelst (1990).

Because of the similarity in form between the two models for extreme items, and the resulting possibility of confounding lack of fit of the parametric form with that of the choice between unfolding and dominance type IRFs, model checking will be of particular importance. This will require the development of statistics designed to detect the specific differences between the forms in these cases (see Figure 3A). It is likely that issues of appropriate conditioning variables will make these most easily implemented in the context of posterior predictive model checking (Sinharay 2005). As such, we will also implement the estimation of the model using Markov Chain Monte Carlo methods (e.g., Johnson and Junker 2003), as this approach produces the posterior distribution sampling required for such checking.

Plan of Work

We request funding for two years to conduct an integrated program of research, dissemination of findings, and pedagogical innovation. The research will proceed in three overlapping phases, beginning in August 2007. Phase I of the research will extend from August 2007 through July 2008, and will involve the derivation and testing of the proposed model(s), including Monte Carlo evaluations of their properties under a range of practically-relevant conditions. Specifically, the PIs will conduct Monte Carlo analyses of the MUMM, varying four parameters: the proportion of items corresponding to each type of data-generating process (dominance or proximity, five levels of variation), the number of items/test length (four levels), the number of respondents/subjects (three levels), and the source of the item parameters used for generating the simulated items (three levels). Combinations of the first three factors are outlined in Table 1. An important aspect of this Monte Carlo testing will be to examine the properties of the models developed in situations where the ratio of items to subjects is relatively large. While comparatively rare in psychometrics, such situations are far more common in applications in the social sciences (e.g., Londregan 2000; Bailey 2001). As a result, assessing the behavior of our models under such conditions is critical to their potential usefulness.

The item parameters used in the Monte Carlo simulations will be based on the ICRFs estimated via the single-model methods on the data used in the three studies replicated in Phase II. In each of those studies, either a dominance or a proximity model was fit. Those estimated parameters will be used in the simulations. Additionally, a corresponding opposite-type item will be generated in each case, by matching each "half" of the proximity items' ICRF to the best-fitting dominance model ICRF and vice-versa (see Figure 3 for a graphical representation).

Phase II of the research will commence in the spring of 2008, and extend through the end of the grant period. It will involve the replication of three recent, important studies which utilize IRT models: Roberts et al.'s (2000) analysis of abortion attitudes in a college popu-

Table 1: $3 \times 4 \times 5$ Design, Monte Carlo Analyses

Fraction of Items	$J = 250$	$J = 1000$	$J = 10000$
All Proximity	$N = 10/20/40/80$	$N = 10/20/40/80$	$N = 10/20/40/80$
0.90 Proximity	$N = 10/20/40/80$	$N = 10/20/40/80$	$N = 10/20/40/80$
0.50 Proximity/Dominance	$N = 10/20/40/80$	$N = 10/20/40/80$	$N = 10/20/40/80$
0.90 Dominance	$N = 10/20/40/80$	$N = 10/20/40/80$	$N = 10/20/40/80$
All Dominance	$N = 10/20/40/80$	$N = 10/20/40/80$	$N = 10/20/40/80$

lation, Smits et al.'s (2004) study of verbal aggression, and Clinton et al.'s (2004) analysis of non-unanimous roll-call votes in the 106th U.S. House of Representatives. The PIs have acquired access to the data from all three studies. We selected these studies for replication based on a series of rationales. First, they represent a range of substantive applications of IRT models, including the two most important non-psychometric applications in the social sciences to date: the analysis of survey items and the study of roll call voting in the U.S. Congress (cf. Bailey 2001; Clinton and Mierowitz 2001; McCarty et al. 2001; Clinton 2006). Second, we endeavored to select applications that provided a mix of expectations regarding item types; we anticipate that – in general – items from the Smits et al. study will conform to a dominance relation,[2] those from Clinton et al. will fit a proximity model, and the abortion items from Roberts et al.'s study (augmented by derived forced-choice questions) will comprise a mixture of the two types of data generating processes. The purpose of these reanalyses will be to demonstrate how our MUMM approach can provide an encompassing model for both types of items, in that it can simultaneously provide results equivalent to the most widely-used monotone or unfolding models when the data are homogenous with respect to type, while at the same time yielding more valid findings when the data are a mixture of item types.

Phase III of the research will apply the models developed to experimental data collected by the PIs. Beginning in the fall term of 2008, the researchers will draw upon the University of South Carolina Department of Psychology's Participant Pool to conduct a series of online surveys (`http://usc.experimentrak.net/`). The purpose of these surveys will be to assess the functionality of the models in distinguishing between proximity and dominance items in a real-world setting, by experimentally manipulating the type (dominance versus proximity), latent-space location, test length, and subject pool size of a questionnaire based upon Roberts et al.'s (2000) 50-item survey on attitudes toward abortion. Drawing on the Monte Carlo results from Phase I, the PIs will develop surveys that combine monotone and non-monotone items in fractions similar to those in column one of Table 1, and that represent possible item positions across the range of the latent ideological space. The key aspect of this phase of the study will be the varying, across randomized groups, of the mixture of dominance and proximity items in each questionnaire.

[2]Note, for example, that the Smits et al. study was used as a running example in De Boeck and Wilson (2004), which focuses exclusively on dominance models.

To get a sense of the sorts of questions which will comprise the surveys, consider two related binary (agree/disagree) statements:

Form A: "It is acceptable to have an abortion in order to save the life of the woman in question."

Form B: "Abortion should be illegal, except to save the life of the woman in question."

Note that the relative "location" of both items in the latent ideological space is similar. The key difference is that the Form A item clearly invokes a dominance relation in the item response: one would expect that "pro-choice" respondents will be more likely to agree with the statement, while "pro-life" respondents will be more likely to disagree. In contrast, the Form B item invokes a proximity relationship: both extreme "pro-life" and extreme "pro-choice" respondents are likely too disagree with the statement, the former because they believe all abortions should be illegal, the latter because they feel all abortions should be legal. The PIs will create similar pairs of items across the range of the latent space, and then combine those items on the surveys. The surveys will then be analyzed using conventional single-model methods on the dominance and unfolding items separately as well as using the MUMM on the entire survey. The results will provide insight into the reliability with which each item conforms to its designated type, and thus will offer heuristic guidance for future analysts in the creation of mixed item-type instruments.

Throughout all three phases of the project, the PIs will work closely with two Ph.D. students on the project, one in statistics, the other in political science. Both students will be retained for the entire two-year life of the project, and will be selected by the PIs from among Ph.D. candidates in the respective departments on the basis of their interests and abilities in IRT modeling; each will be funded under the project for one year, with the respective departments providing funding in the other year. *These students will be considered full members of the research team.* During Phase I, the two will assist the PIs in the development of the models and the implementation of the Monte Carlo simulations. In Phase II, the students will work closely with the PIs on the application of the models to the three sets of example data, and in the analysis of those findings. Finally, the students' involvement in Phase III will involve assisting in the creation and conduct of the internet survey, and in the subsequent data analysis. In addition to increasing their facility in applying the models developed, this activity will help familiarize them with current technology and practices for web-based survey methods and data collection techniques. More broadly, the Ph.D. students involved will participate in the presentations of the research findings at all professional conferences, will co-teach with the PIs in the proposed short courses, and will receive co-authorship on publications arising from the project. All of these activities will be designed to facilitate the students' intellectual development as truly interdisciplinary scholars, equally at home in both statistics and the social sciences, and equally capable of conducting innovative, important research in either field.

Dissemination of Results

We plan a multifaceted approach to the dissemination of our research, one that includes standard professional practices (professional conferences, publications) as well as software development, pedagogical innovations and outreach, and the development of web-based resources. One or both PIs will present the research findings at the 2009 Political Methodology summer meeting, and to the 2009 annual meetings of the American Political Science Association, the Psychometric Society, and the American Educational Research Association. At the same time, articles based on the research will be submitted for publication review to leading journals in statistics and the social sciences, including *Psychometrika*, *Applied Psychological Measurement*, and the *American Journal of Political Science*. Importantly, a key part of our publication strategy is to focus on what are now viewed as "non-standard" applications of the models. For example, we will integrate examples and data from political science into the papers submitted to *Psychometrika* and *APM*, the goal of which will be to expose the statistics community to the broad range of potential applications of (and developments in) IRT models outside of psychometrics.

We will also develop and distribute software for MUMM estimation. This software will be developed for the R computing environment, using dynamically linked libraries where necessary for computational efficiency, and will be distributed through the Comprehensive R Archive Network (CRAN). R is a free, open-source language and environment for statistical computing and graphics that is widely used in the physical, mathematical, and social sciences. Additionally, the PIs will integrate the MCMC implementation of MUMMs into the NSF-supported `MCMCpack` package for the R environment (Martin and Quinn 2006). Further, during the summer of 2009 one or both of the PIs will demonstrate the software at the (planned) useR! meeting. useR! is the largest gathering of users and developers of the R computing environment in the world, and regularly attracts participants from all fields of science, technology, engineering, and mathematics. It is therefore the ideal environment in which to achieve the broadest possible exposure, both for the software and for the underlying models we will develop.

Beyond these efforts, the PIs will develop and teach a series of short courses on the application of IRT models in the social sciences. We will propose these courses to be taught during the 2009 terms of the Interuniversity Consortium for Political and Social Research's (ICPSR) Summer Program at the University of Michigan, and at the Economic Social and Research Council's Spring School at Oxford University. The length and content of the courses will be tailored to the specific context; in every instance, however, the emphasis will be on the application and potential value of the latent class models developed, and on the use of the software described above. Both PIs have had experience teaching in such settings, and one of the PIs (Zorn) is a continuing instructor in the ICPSR summer program, and also taught at the Oxford Spring School during its 2005 term. We have already begun discussions with the current ICPSR Summer Program director about offering such a course. Moreover, as we note above, IRT models are among the fastest-growing statistical applications in sociology, political science, and other fields. We are therefore confident that our proposal for a short course will be positively received and supported by these institutions, thus requiring no additional NSF funds.

Finally, the PIs will maintain a web-based archive of publications, software, teaching materials, and other resources related both to the models developed under the auspices of the grant and to the broader class of IRT models in general. This archive will be located on the College of Liberal Arts and Sciences web server at the University of South Carolina, and would be maintained in perpetuity by the PIs, with the support of USC's Division of University Technology Services.

Intellectual Merit

The proposed research will simultaneously and substantially advance the state of scientific knowledge in both statistics and the social sciences. As we note above, latent class methods are an increasingly important tool for the analysis of data generated by heterogenous processes. In addition to furthering our knowledge of latent class approaches to IRT models, MUMMs will serve as an important "bridge" between models with monotone IRFs and unfolding models – two classes of IRT models which, to date, have been treated as separate and mutually exclusive entities despite their mathematical similarities. In the social sciences, the wide availability and easy implementation of models for identifying and analyzing mixtures of dominance and proximity items will give applied researchers an important additional tool for the analysis of survey items, roll-call and other forms of voting data, and a host of other choice-based phenomena.

In addition, the methods we will develop offer the potential to provide new insights into a number of important theoretical debates. Consider for example the ongoing colloquy in political science between the proponents of "proximity" and "directional" models of voter choice. The former – which include nearly all formal theoretical treatments of the topic (cf. Enelow and Hinich 1984; Laslier 2006) – begin with the assumption that voters and candidates can be represented by points in a Euclidean policy space, and that in elections voters choose the candidate(s) who are closest to them; that is, according to a proximity model. In the past two decades, however, a number of scholars have advanced an alternative theory: that voters prefer candidates "who are 'on their side,' and the more on their side, the better" (Lewis and King 2000, 23). In other words, these authors claim that voting is in fact governed by a dominance relation in the policy space (e.g. Rabinowitz and MacDonald 1989; Merrill 1993; MacDonald et al. 1998).

But while the debate between the two camps has been heated, existing approaches have been largely unable to resolve the question empirically; one set of commentators summed up the state of the literature by noting that "the alternative possible methods used to relax the most questionable of (the theories') assumptions are far from innocuous" (Lewis and King 2000, 31). Our proposed approach offers at least the potential for informing and potentially resolving this debate. In particular, the methods we will develop will allow researchers to assess not only which of the two alternative perspectives better "fits" voter choice, but also whether and which elections and issues are more likely to be seen in (say) proximity terms. Moreover, the methods will allow them to do so using existing data, including widely-available individual-level results from multi-race and multi-issue ballots. This represents an important benefit for this debate, since many of the voting data in question would be prohibitively expensive (and, in the case of historical elections, impossible) to recollect.

Beyond the intrinsic value of the work to the fields mentioned, the benefits to both statistics and the social sciences from the proposed collaboration are several. In particular, by integrating insights from the parallel literatures on item response models that have developed in statistics and the social sciences, we will bring each of those bodies of work to the attention of scholars in the other field. The result will be a simultaneously greater awareness by statisticians of the uses of IRT models in the social sciences (outside of psychology), and better-informed use of those models by those within the social sciences. That awareness, in turn, will prompt greater collaboration between members of the statistics and social science communities, as statisticians grow increasingly aware of the sorts of issues that arise with the application of such models to social scientific questions.

To take but one example, a key assumption of nearly all IRT models is that of *local independence* across items; in a social scientific context, this requires that the choices comprising the "item" analogues are conditionally independent of one another. Statisticians have long understood the potential for violating local independence in the context of educational testing and surveys (cf. Hattie 1985), and that recognition has in turn led to the development of a host of methods for detecting and dealing with such violations (e.g., Yen 1984; Stout et al. 1996; Glas 1999; Thissen and Wainer 2001; Wang and Wilson 2005), including in the unfolding case (Habing et al. 2005). The same is true in the social sciences, where across a host of potential applications the likelihood of local item dependence is high; to take but a few examples, legislators' often engage in "logrolling" of votes on different bills in a legislative session (Stratmann 1992), citizens' belief systems can structure and constrain their responses to survey items (Converse 1964), and *stare decisis* limits judges' abilities to reach certain outcomes in cases they are deciding (Segal and Spaeth 1996). But while social scientists studying all of these these phenomena have begun utilizing IRT models, to date none has considered (let alone addressed) the issue of local independence.

Conversely, a number of works outside of psychometrics have yielded substantial innovations in IRT modeling, including advances in such areas as higher-dimensional proximity models (Poole 2001), dynamic parameter estimation (Martin and Quinn 2002), and model interpretation and presentation (Bafumi et al. 2005). Yet this body of research remains largely separate from mainstream psychometric literature. Our efforts to bring together these two disparate intellectual communities – for the benefit of both – are, we believe, very much in keeping with the purpose and the spirit of the MMS program.

Broader Impacts

Beyond its significant intellectual value, we believe that the broader impacts of the proposed work are also substantial. For example, one significant benefit will be in the area of instrument construction, where – in fields such as educational testing and survey research design – the methods used here offer the potential for assessing the underlying data generating process each proposed item conforms to. Such diagnostic tests, conducted prior to the administration of the survey or test, would help ensure that only similar classes of items were grouped and analyzed using either monotone or unfolding models, while also allowing the use of mixed types if desired. At the same time, application of MUMMs will also permit practitioners in the fields of survey administration, educational testing, and other areas where IRT models are employed to revisit existing studies where items may have been excluded from analyses due to conflict with the methodology chosen at the time.

The pedagogical impact of the proposed work is also considerable. The graduate students involved in the project will, at its conclusion, be fully integrated into both the statistics and social science research communities, and will be excellently positioned both to use item response methods in their own research and to become innovators in that area. To a somewhat lesser extent, the same will be the case for the numerous students who will receive instruction in the PIs' short courses. We also hope to serve as a model of pedagogical collaboration between statistics and the social sciences, and are contemplating the joint authorship of a text on the application and use of IRT models to social science questions.

Finally, the proposed work will represent an important contribution to the infrastructure of research in the social and behavioral sciences. The software developed by the PIs will, we believe, be widely adopted, and will become the *de facto* standard method by which the models developed are implemented in applied research. In addition, we anticipate that the web archive created under the auspices of the project – and maintained in perpetuity by the PIs – will serve as an important clearinghouse for the application of IRT models in the social sciences.

References

Albert, James H. 1992. "Bayesian Estimation of Normal Ogive Item Response Curves Using Gibbs Sampling." *Journal of Educational Statistics* 17:251-269.

Andrich, David. 1978. "A Rating Formulation for Ordered Response Categories." *Psychometrika* 43:561-573.

Andrich, David. 1988. "The Application of an Unfolding Model of the PIRT Type to the Measurement of Attitude." *Applied Psychological Measurement* 12:33-51.

Andrich, David. 1996. "A Hyperbolic Cosine Latent Trait Model For Unfolding Polytomous Responses: Reconciling Thurstone and Likert Methodologies." *British Journal of Mathematical and Statistical Psychology* 49:347-365.

Bafumi, Joseph, Andrew Gelman, David K. Park, and Noah Kaplan. 2005. "Practical Issues in Implementing and Understanding Bayesian Ideal Point Estimation." *Political Analysis* 13:171-87.

Bailey, Michael. 2001. "Ideal Point Estimation with a Small Number of Votes: A Random-Effects Approach." *Political Analysis* 9:192-210.

Baker, Frank. B., and Seock-Ho Kim. 2004. *Item Response Theory: Parameter Estimation Techniques* (2nd Edition). New York: Marcel Dekker, Inc.

Bechtel, Gordon B. 1985. "Generalizing the Rasch Model for Consumer Rating Scales." *Marketing Science* 4:62-73.

Birnbaum, Allan. 1968. "Some Latent Trait Models and their Use in Inferring an Examinee's Ability." In F. M. Lord and M. R. Novick, eds. *Statistical Theories of Mental Test Scores.* Reading, MA: Addison-Wesley.

Bock, R. Darrell, and Murray Aitken. 1981. "Marginal Maximum Likelihood Estimation of Item Parameters: Application of an EM Algorithm." *Psychometrika* 46:443-459.

Caulkins, Jonathan P., Arnold Barnett, Patrick D. Larkey, Yuehong Yuan, and Jesse Goranson. 1993. "The On-Time Machines: Some Analyses of Airline Punctuality." *Operations Research* 41:710-20.

Clinton, Joshua. 2006. "Representation in Congress: Constituents and Roll Calls in the 106th House." *Journal of Politics* 68:397-409.

Clinton, Joshua, Simon Jackman, and Douglas Rivers. 2004. "The Statistical Analysis of Roll Call Data." *American Political Science Review* 98:1-16.

Clinton, Joshua D., and Adam Mierowitz. 2001. "Agenda Constrained Legislator Ideal Points and the Spatial Voting Model." *Political Analysis* 9:242-59.

Converse, Philip E. 1964. "The Nature of Belief Systems in Mass Publics." In David E. Apter, Ed. *Ideology and Discontent.* New York: Free Press.

Cook, Michael D., and William N. Evans. 2000. "Families or Schools? Explaining the Convergence in White and Black Academic Performance." *Journal of Labor Economics* 18:729-54.

Coombs, Clyde H. 1964. *A Theory of Data.* New York: Wiley.

Davison M. L. 1977. "On a Metric, Unidimensional Unfolding Model for Attitudinal and Developmental Data." *Psychometrika* 42:523-548.

De Boeck, Paul, and Mark Wilson. 2004. *Explanatory Item Response Models: A Generalized Linear and Nonlinear Approach.* New York: Springer-Verlag.

Delli Carpini, Michael X., and Scott Keeter. 1993. "Measuring Political Knowledge: Putting First Things First." *American Journal of Political Science* 37:1179-1206.

DeSarbo, W. S., and D. L. Hoffman. 1986. "Simple and Weighted Unfolding Threshold Models for the Spatial Representation of Binary Choice Data." *Applied Psychological Measurement* 10:247-264.

Enelow, James, and Melvin Hinich. 1984. *The Spatial Theory of Voting.* Cambridge, Cambridge University Press.

Epstein, Lee, Andrew D. Martin, Jeffrey A. Segal, and Chad Westerland. 2006. "The Judicial Common Space." *Journal of Law, Economics, and Organization*, forthcoming.

Fischer, Gerhard H., and Ivo W. Molenaar, eds. 1995. *Rasch Models: Foundations, Recent Developments, and Applications.* New York: Springer-Verlag.

Freeman, Richard B., and Jane Waldfogel. 2001. "Dunning Delinquent Dads: The Effects of Child Support Enforcement Policy on Child Support Receipt by Never Married Women." *Journal of Human Resources* 36:207-25.

Glas, Cees A. W. 1999. "Modification Indices for the 2-PL and the Nominal Response Model." *Psychometrika* 64:273-294.

Guttman, Louis. 1950. "The Basis for Scalogram Analysis." In Stouffer et al. Eds. *Measurement and Prediction: The American Soldier*, Vol. IV. New York: Wiley

Habing, Brian, Holmes Finch, and James S. Roberts. 2005. "A Q_3 Statistic for Unfolding Item Response Theory Models. *Applied Psychological Measurement* 29:457-471.

Hattie, John. 1985. "Methodology Review: Assessing Unidimensionality of Tests and Items." *Applied Psychological Measurement* 9:139-164.

Hemker, Bas T., Klaas Sijtsma, Ivo W. Molenaar, and Brian W. Junker. 1997. "Stochastic Ordering Using the Latent Trait and the Sum Score in Polytomous IRT Models." *Psychometrika* 62:331-347.

Hoijtink, Herbert. 1990. "A Latent Trait Model for Dichotomous Choice Data." *Psychometrika* 55:641-656.

Jackman, Simon. 2004. "What Do We Learn from Graduate Admissions Committees? A Multiple Rater, Latent Variable Model, with Incomplete Discrete and Continuous Indicators." *Political Analysis* 12:400-24.

John, George, and Barton A. Weitz. 1988. "Forward Integration into Distribution: An Empirical Test of Transaction Cost Analysis." *Journal of Law, Economics, and Organization* 4:337-55.

Johnson, Matthew S., and Brian W. Junker. 2003. "Using Data Augmentation and Markov Chain Monte Carlo for the Estimation of Unfolding Response Models." *Journal of Educational and Behavioral Statistics* 28:195-230.

Laslier, Jean-François. 2006. "Spatial Approval Voting." *Political Analysis* 14:160-85.

Lewis, Jeffrey B. and Gary King. 2000. "No Evidence on Directional vs. Proximity Voting." *Political Analysis* 8:21-33.

Likert, Rensis. 1932. "A Technique for the Measurement of Attitudes." *Archives of Psychology* No. 140.

Londregan, John. 2000. "Estimating Legislators Preferred Points." *Political Analysis* 8:35-56.

Luo, Guanzhong. 1998. "A General Formulation for Unidimensional Unfolding and Pairwise Preference Models: Making Explicit the Latitude of Acceptance." *Journal of Mathematical Psychology* 42:400-417.

Luo, Guanzhong. 2000. "Joint Maximum Likelihood Estimation for the Hyperbolic Cosine Model for Single Stimulus Responses." *Applied Psychological Measurement* 24:33-49.

MacDonald, Stuart Elaine, George Rabinowitz, and Ola Listhaug. 1998. "On Attempting to Rehabilitate the Proximity Model: Sometimes the Patient Just Can't Be Helped." *Journal of Politics* 60:653-690.

MacIntosh, Randall. 1998. "Global Attitude Measurement: An Assessment of the World Values Survey Postmaterialism Scale." *American Sociological Review* 63:452-64.

Martin, Andrew D., and Kevin M. Quinn. 2002. "Dynamic Ideal Point Estimation via Markov Chain Monte Carlo for the U.S. Supreme Court, 1953-1999." *Political Analysis* 10:134-53.

Martin, Andrew D., and Kevin M. Quinn. 2006. "Applied Bayesian Inference in R using MCMCpack." *R News* 6:2-7.

Martin, Andrew D., Kevin M. Quinn, and Lee Epstein. 2005. "The Median Justice on the U.S. Supreme Court." *North Carolina Law Review* 83:1275-1321.

Masters, Geofferey N. 1982. "A Rasch Model for Partial Credit Scoring." *Psychometrika* 47:149-174.

McCarty, Nolan, Keith T. Poole, and Howard Rosenthal. 2001. "The Hunt for Party Discipline in Congress." *American Political Science Review* 95:673-87.

Merrill, Samuel. 1993. "Voting Behavior Under the Directional Spatial Model of Electoral Competition." *Public Choice* 77:739-756.

Mislevy, Robert J. 1986. "Bayes Modal Estimation in Item Response Models." *Psychometrika* 51:177-195.

Mislevy, Robert J., and Norman Verhelst. 1990. "Modeling Item Responses When Different Subjects Employ Different Strategies." *Psychometrika* 55:195-215.

Mokken, Robert J. 1971. *A Theory and Procedure of Scale Analysis with Applications in Political Research.* New York: De Gruyter.

Morgan, Stephen L., and Aage B. Sørensen. 1999. "Parental Networks, Social Closure, and Mathematics Learning: A Test of Coleman's Social Capital Explanation of School Effects." *American Sociological Review* 64:661-81.

Muraki, Eiji. 1992. "A Generalized Partial Credit Model: Application of an EM Algorithm." *Applied Psychological Measurement* 16:159-176.

Muraki, Eiji. 1997. "A Generalize Partial Credit Model." In W. van der Linden & R.K. Hambleton, *Handbook of Modern Item Response Theory.* New York: Springer-Verlag.

Patz, Richard J., and Brian W. Junker. 1999. "Applications and Extensions of MCMC in IRT: Multiple Item Types, Missing Data, and Rated Responses." *Journal of Educational and Behavioral Statistics* 24:342-366.

Poole, Keith T. 1984. "Least Squares Metric, Unidimensional Unfolding." *Psychometrika* 49:311-23.

Poole, Keith T. 2000. "A Non-Parametric Unfolding of Binary Choice Data." *Political Analysis* 8:211-37.

Poole, Keith T. 2001. "The Geometry of Multidimensional Quadratic Utility in Models of Parliamentary Roll Call Voting." *Political Analysis* 9:211-26.

Poole, Keith T., and Howard Rosenthal. 1997. *Congress: A Political-Economic History of Roll Call Voting*. New York: Oxford University Press.

Post, Wendy J., Marijtje A. J. van Duijn, and Berna van Baarsen. 2001. "Single-Peaked or Monotone Tracelines? On the Choice of an IRT Model for Scaling Data." In A. Boomsma, M.A.J. van Duijn, and T.A.B. Snijders, *Essays on Item Response Theory.* New York: Springer-Verlag.

Rabinowitz, George, and Stuart Elaine Macdonald. 1989. "A Directional Theory of Issue Voting." *American Political Science Review* 83:93-121.

Rasch, Georg. 1980 (1960). *Probabilistic Models for Some Intelligence and Attainment Tests.* Chicago: The University of Chicago Press.

Raudenbush, Stephen W., Christopher Johnson, and Robert J. Sampson. 2003. "A Multivariate, Multilevel Rasch Model with Application to Self-Reported Criminal Behavior." *Sociological Methodology* 33:169-211.

Roberts James S. 2006. *Alternative Mixtures of the Generalized Graded Unfolding Model and Applications to Attitude Measurement.* Presentation at the New Directions in Psychological Measurement with Model Based Approaches Conference, Georgia Institute of Technology, Atlanta Georgia, February 17, 2006.

Roberts, James S., John R. Donoghue, and James E. Laughlin. 2000. "A General Item Response Theory Model for Unfolding Unidimensional Polytomous Responses." *Applied Psychological Measurement* 24:3-32.

Roberts, James S., John R. Donoghue, and James E. Laughlin. 2002. "Characteristics of MML/EAP Parameter Estimates in the Generalized Graded Unfolding Model." *Applied Psychological Measurement* 26:192-207.

Roberts, James S., James E. Laughlin, and Douglas H. Wedell. 1999. "Validity Issues in the Likert and Thurstone Approaches to Attitude Measurement." *Educational and Psychological Measurment* 59:211-233.

Rost, Jürgen. 1990. "Rasch Models in Latent Classes: An Integration of Two Approaches to Item Analysis." *Applied Psychological Measurement* 3:271-282.

Schaeffer, Nora Cate. 1988. "An Application of Item Response Theory to the Measurement of Depression." *Sociological Methodology* 18:271-307.

Segal, Jeffrey A., and Harold J. Spaeth. 1996. "The Influence of Stare Decisis on the Votes of United States Supreme Court Justices." *American Journal of Political Science* 40:971-1003.

Segal, Jeffrey A., and Harold J. Spaeth. 2002. *The Supreme Court and the Attitudinal Model Revisited*. New York: Cambridge University Press.

Sinharay, Sandip. 2005. "Assessing Fit of Unidimensional Item Response Theory Models Using a Bayesian Approach." *Journal of Educational Measurement* 42:375-394.

Smits, D. J. M., Paul De Boeck, and K. Vansteelandt. 2004. "The Inhibition of Verbally Aggressive Behavior." *European Journal of Personality* 18:537-555.

Stout, William, Brian Habing, Jeff Douglas, Hae Rim Kim, Louis Roussos, and Jinming Zhang. 1996. "Conditional Covariance Based Nonparametric Multidimensionality Assessment." *Applied Psychological Measurement* 20:331-54.

Stratmann, Thomas. 1992. "The Effects of Logrolling on Congressional Voting." *American Economic Review* 82:1162-1176.

Swaminathan, Hariharan, Ronald K. Hambleton, Stephen G. Sireci, Dehui Xing, and Saba M. Rizavi. 2003. "Small Sample Estimation in Dichotomous Item Response Models: Effect of Priors Based on Judgmental Information on the Accuracy of Item Parameter Estimates." *Applied Psychological Measurement* 27:27-51.

Thissen, David, and Jo Ann Mooney. 1989. "Loglinear Item Response Models, with Applications to Data from Social Surveys." *Sociological Methodology* 19:299-330.

Thissen, David, and Howard Wainer. 2001. *Test Scoring*. New York:Lawrence Erlbaum Associates.

Thurstone, Louis L. 1927. "A Law of Comparative Judgement." *Psychological Review* 34:278-286.

Wang, Wen-Chung, and Mark Wilson. 2005. "Exploring Local Item Dependence Using a Random-Effects Facet Model." *Applied Psychological Measurement* 29:296-318.

Yen, Wendy M. 1984. "Effects of Local Item Dependence on the Fit and Equating Performance of the Three-Parameter Logistic Model." *Applied Psychological Measurement* 8:125-145.

Biographical Sketch: Christopher Zorn

Professional Preparation

Ph.D., Political Science. Ohio State University, Columbus, Ohio, 1997.
B.A., Northeast Missouri State University, Kirksville, Missouri, 1991.

Appointments

· Associate Professor, Department of Political Science, University of South Carolina. 2005-present.

· Program Director, Law and Social Science Program, National Science Foundation. 2003-2005.

· Associate Professor and Winship Distinguished Research Professor, Department of Political Science, Emory University. 2002-2005 (on leave, 2003-2005).

· Assistant Professor, Department of Political Science, Emory University. 1997-2002.

Publications Related to This Proposal

1. Zorn, Christopher, and Gregory A. Caldeira. 2007. "Measuring Supreme Court Ideology: An IRT-Based Approach." Working paper: Ohio State University.

2. Zorn, Christopher. 2006. "Comparing GEE and "Robust" Standard Errors for Conditionally Dependent Data." *Political Research Quarterly* 59:329-41.

3. Zorn, Christopher. 2005. "A Solution to Separation in Binary Response Models." *Political Analysis* 13:157-70.

4. Zorn, Christopher. 2001. "Estimating Between- and Within-Cluster Covariate Effects, with an Application to Models of International Disputes." *International Interactions* 27:433-45.

5. Zorn, Christopher. 2001. "Generalized Estimating Equation Models for Correlated Data: A Review with Applications." *American Journal of Political Science* 45:470-90.

Other Significant Publications

1. Zorn, Christopher. 2007. *Count Data Models for the Social and Behavioral Sciences: Theory and Applications*. Under contract, Cambridge University Press.

2. Giles, Micheal W., Christopher Zorn, Virginia Hettinger, and Todd C. Peppers. 2007. "The Etiology of the Occurrence of En Banc Review in the U.S. Courts of Appeals." *American Journal of Political Science* 51:forthcoming.

3. Giles, Micheal W., Thomas G. Walker, and Christopher Zorn. 2006. “Setting A Judicial Agenda: The Decision To Grant En Banc Review In The U.S. Courts Of Appeals.” *Journal of Politics* 68:852-66.

4. Iqbal, Zaryab, and Christopher Zorn. 2006. “Sic Semper Tyrannis? Power, Repression, and Assassination Since the Second World War.” *Journal of Politics* 68:489-502.

5. Box-Steffensmeier, Janet M., and Christopher Zorn. 2001. “Duration Models and Proportional Hazards in Political Science.” *American Journal of Political Science* 45:972-88.

Synergistic Activities

· Editor, *Political Analysis*, 2007-2010.

· Executive Council, Midwest Political Science Association, 2005-2008.

· Instructor, ESRC Oxford Spring School in Quantitative Methods for Social Research, Oxford University, March 2005.

· Lecturer, ICPSR Summer Methods Program, University of Michigan. 2000-2003; 2006-present.

· Conference Organizer and Co-Host, Eighteenth Annual Political Methodology Meeting, July 18-22, 2001, Emory University, Atlanta, Georgia.

Collaborators in the Past 48 Months

Janet Box-Steffensmeier (Ohio State University), Gregory Caldeira (Ohio State University), Clifford Carrubba (Emory University), Michael Crespin (University of Georgia), Micheal Giles (Emory University), Jeff Gill (UC-Davis), Paul-Henri Gurian (University of Georgia), Audrey Haynes (University of Georgia), Virginia Hettinger (University of Connecticut), Alex Hicks (Emory University), Zaryab Iqbal (University of South Carolina), Erik Naft (Jones Day LLP), Susan Navarro (Emory University), Todd Peppers (Roanoke College), Jessica Perry (Reed Smith LLP), Dan Reiter (Emory University), Steven Van Winkle (University of Wyoming), Katherine Vigilante (Emory University), Richard Vining (Emory University), Thomas Walker (Emory University), John Wright (Ohio State University), Amy Yuen (Emory University).

Graduate Advisors

Gregory Caldeira, Lawrence Baum (Ohio State University), Dean Lacy (Dartmouth College).

Thesis Advisees in the Past Five Years

None.

Biographical Sketch: Brian Habing

Professional Preparation

Ph.D., Statistics. University of Illinois at Urbana-Champaign, 1998.
M.S., Mathematics. University of Illinois at Urbana-Champaign, 1994.
B.S., Mathematics. University of Illinois at Urbana-Champaign, 1991.

Appointments

- Associate Professor, Department of Statistics, University of South Carolina, 2004-present
- Assistant Professor, Department of Statistics, University of South Carolina, 1998-2004

Publications Related to This Proposal

1. Habing, Brian, Terry Ackerman, Hua-Hua Chang, and Louis Roussos. 2007. *Item Response Theory*. Under contract, Springer Science+Business Media, Inc.
2. Habing, Brian, Holmes Finch, and James S. Roberts. 2005. "A Q_3 Statistic For Unfolding Item Response Theory Models." *Applied Psychological Measurement* 29:457-71.
3. Habing, Brian, and Louis Roussos. 2003. "On the Need for Negative Local Item Dependence." *Psychometrika* 68:435-52.

Other Significant Publications

1. Froelich, Amy G., and Brian Habing. "Conditional Covariance Based Subtest Selection for DIMTEST". *Applied Psychological Measurement*: forthcoming.
2. Finch, Holmes, and Brian Habing. 2005. "Comparison of NOHARM and DETECT in Item Cluster Recovery: Counting Dimensions and Allocating Items." *Journal of Educational Measurement* 42:149-69.
3. Habing, Brian. 2001. "Nonparametric Regression and the Parametric Bootstrap for Local Dependence Assessment." *Applied Psychological Measurement* 25:221-33.
4. Douglas, Jeff, Hae Rim Kim, Brian Habing, and Furong Gao. 1998. "Investigating Local Dependence with Conditional Covariance Functions." *Journal of Educational and Behavioral Statistics* 23:129-51.
5. Stout, William, Brian Habing, Jeff Douglas, Hae Rim Kim, Louis Roussos, and Jinming Zhang. 1996. "Conditional Covariance Based Nonparametric Multidimensionality Assessment. *Applied Psychological Measurement*, 20:331-54.

Synergistic Activities

- Organizer and co-teacher (with Amy Froelich) of the "Multidimensional Item Response Theory Training Session" at the 2005 Annual Meeting of the National Council on Measurement in Education.
- Co-chair of the 2004 Annual Meeting Program Committee for Division D of the American Educational Research Association
- Statistical Methodology Editor for the *Journal of the First Year Experience and Students in Transition*, 1998-2004.

Collaborators in the Past 48 Months

Terry Ackerman (UNC - Greensboro), Arthur Alterman (University of Pennsylvania), Daniel Bolt (University of Wisconsin), John Cacciola (University of Pennsylvania), Hua-Hua Chang (University of Illinois), Tammiee Dickenson (University of South Carolina), John R. Donoghue (ETS), Holmes Finch (Ball State University), Amy Froelich (Iowa State University), Sarah Hartz (University of Iowa), Huynh Huynh (University of South Carolina), Louis Roussos (University of Illinois), Ratna Nandakumar (University of Delware), James S. Roberts (Georgia Tech), Dorota Staniewska (ETS).

Graduate Advisors

William Stout (University of Illinois) and John R. Donoghue (ETS).

Dissertation Advisees in the Past Five Years

Roland Deutsch (in progress), Tammiee Dickenson (University of South Carolina), Holmes Finch (Ball State University), Meng Wu (in progress), Litong Zhang (in progress).

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **University South Carolina Research Foundation**				FOR NSF USE ONLY PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Christopher Zorn**				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Christopher Zorn - none	0.00	0.00	1.00	$ 11,263	$	
2. Brian Habing - none	0.00	0.00	1.00	7,927		
3.						
4.						
5.						
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	19,190		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (1) GRADUATE STUDENTS				17,500		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				36,690		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,139		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				40,829		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				2,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				2,000		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				6,720		
TOTAL OTHER DIRECT COSTS				8,720		
H. TOTAL DIRECT COSTS (A THROUGH G)				51,549		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Eligible Direct Costs (Rate: 44.0000, Base: 44829)**						
TOTAL INDIRECT COSTS (F&A)				19,725		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				71,274		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 71,274	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					
PI/PD NAME **Christopher Zorn**				FOR NSF USE ONLY INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Debra Wingard**				Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY **YEAR 2**
PROPOSAL BUDGET

ORGANIZATION **University South Carolina Research Foundation**	**FOR NSF USE ONLY** PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Christopher Zorn**	AWARD NO.		

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Christopher Zorn - none**	0.00	0.00	1.00	$ 11,601	$
2. **Brian Habing - none**	0.00	0.00	1.00	8,165	
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.00	19,766	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (1) GRADUATE STUDENTS				18,000	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				37,766	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,257	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				42,023	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				0	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				0	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				7,120	
TOTAL OTHER DIRECT COSTS				7,120	
H. TOTAL DIRECT COSTS (A THROUGH G)				52,143	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Eligible Direct Costs (Rate: 44.0000, Base: 45023)**					
TOTAL INDIRECT COSTS (F&A)				19,810	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				71,953	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 71,953	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $		
PI/PD NAME **Christopher Zorn**	**FOR NSF USE ONLY** INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME* **Debra Wingard**	Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET
Cumulative

ORGANIZATION: University South Carolina Research Foundation				FOR NSF USE ONLY — PROPOSAL NO.	DURATION (months) Proposed	Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Christopher Zorn				AWARD NO.		
A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)	
1. Christopher Zorn - none	0.00	0.00	2.00	$ 22,864	$	
2. Brian Habing - none	0.00	0.00	2.00	16,092		
3.						
4.						
5.						
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0		
7. (2) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	4.00	38,956		
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)						
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0		
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0		
3. (2) GRADUATE STUDENTS				35,500		
4. (0) UNDERGRADUATE STUDENTS				0		
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0		
6. (0) OTHER				0		
TOTAL SALARIES AND WAGES (A + B)				74,456		
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				8,396		
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				82,852		
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)						
TOTAL EQUIPMENT				0		
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				5,000		
2. FOREIGN				0		
F. PARTICIPANT SUPPORT COSTS						
1. STIPENDS $ 0						
2. TRAVEL 0						
3. SUBSISTENCE 0						
4. OTHER 0						
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0		
G. OTHER DIRECT COSTS						
1. MATERIALS AND SUPPLIES				2,000		
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0		
3. CONSULTANT SERVICES				0		
4. COMPUTER SERVICES				0		
5. SUBAWARDS				0		
6. OTHER				13,840		
TOTAL OTHER DIRECT COSTS				15,840		
H. TOTAL DIRECT COSTS (A THROUGH G)				103,692		
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)						
TOTAL INDIRECT COSTS (F&A)				39,535		
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				143,227		
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0		
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 143,227	$	
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $					

PI/PD NAME: Christopher Zorn	FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*: Debra Wingard	Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Justification

Salary

PIs request one month of summer salary at 100% effort in each year, during which time they will conduct the simulations, estimate the models, write up the findings for journal submission, build and debug the `MCMCpack` code for the models described, and prepare and conduct the short courses. Salary rates are calculated based on actual 2006-2007 nine-month salaries, and include cumulative 3% increases in 2007-2008 and 2008-2009.

Graduate Student Support

PIs request support for one graduate student research assistant in each year of the study. We calculate nine month graduate student stipends at $15,000 for 2007-2008 and $15,500 for 2008-2009. We also include summer support for the student in each year, at $2,500 per summer.

Fringe Benefits

Fringe benefits on faculty salaries were calculated at the University of South Carolina's standard rate of 20.0%. Fringe benefits on graduate salaries are calculated at 0.60% of base for academic year support, and at 8.45% of base for summer support.

Supplies

We request $2,000 for the purchase of a desktop computer and peripherals for estimating the simulations and the empirical models.

Travel

The PIs request $1,000 per PI per year, to help defray the costs of travel to the Political Methodology summer meeting, and to the annual meetings of the American Political Science Association, the Psychometric Society, and the American Educational Research Association, for the presentation of the research findings. The PIs also request an additional $1,000 in the second year to support conference travel for the graduate student assistant on the project.

Other

According to the policy of the USC Office of Sponsored Awards Management, "(D)epartments will request in-state tuition appropriate for the student's discipline when requesting support for a graduate assistant on an externally-funded project, unless sponsor policy prohibits use of the funds for tuition." Accordingly, we request tuition abatements for one graduate student per year, at the rate of $6,720 per year for 2007-2008 and $7,220 per year for 2008-2009.

Indirect Costs

Indirect costs were calculated at the negotiated rate of 44% of modified total direct costs. No indirect costs were calculated on funds for tuition abatements.

Current and Pending Support

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

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

Investigator: **Christopher Zorn**

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

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Decision Making in the Federal Judicial Hierarchy**

Source of Support: **National Science Foundation**
Total Award Amount: $ **157,274** Total Award Period Covered: **08/01/07 - 07/31/09**
Location of Project: **University of South Carolina**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.92**

Support: ☐ Current ☒ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title: **Item Response Theory Models for Mixtures of Dominance and Proximity Items**

Source of Support: **National Science Foundation**
Total Award Amount: $ **143,227** Total Award Period Covered: **08/01/07 - 07/31/09**
Location of Project: **University of South Carolina**
Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **1.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support
Project/Proposal Title:

Source of Support:
Total Award Amount: $ Total Award Period Covered:
Location of Project:
Person-Months Per Year Committed to the Project. Cal: Acad: 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 GPG Section II.C.2.h for guidance on information to include on this form.)

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

Investigator: **Brian Habing**

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

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

Project/Proposal Title: **Item Response Theory Models for Mixtures of Dominance and Proximity Items**

Source of Support: **National Science Foundation**

Total Award Amount: $ **143,227** Total Award Period Covered: **08/01/07 - 07/31/09**

Location of Project: **University of South Carolina**

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

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

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

 USE ADDITIONAL SHEETS AS NECESSARY

FACILITIES, EQUIPMENT & OTHER RESOURCES

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

Laboratory: **The University of South Carolina's Department of Psychology maintains an experimental subject pool, with a focus on on-line experiments (at http://usc.experimentrak.net/). The PIs will have access to this resource for the experimental part of the project.**

Clinical:

Animal:

Computer: **The departments of Political Science and Statistics provide computer support to the PIs as part of their employment contracts.**

Office: **The departments of Political Science and Statistics provide office space, office supplies, peripherals, and other miscellaneous support to the PIs as part of their employment contracts.**

Other:

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

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

Continuation Page:

LABORATORY FACILITIES (continued):