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Capturing Stereotypes: Developing a Scale to Explore U.S. College Students' Images of Science and Scientists

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ABSTRACT
The purpose of this study was to develop a contemporary measure of undergraduates' stereotypes of scientists that will make it possible to examine similarities and differences across time, place, culture, and demographics. The Stereotypes of Scientists (SOS) Scale is intended to be a catalyst for research that explores the degree to which college students' current stereotypes of scientists vary by their gender, ethnicity, country, education level, and academic major. The research was designed to identify the character and content of contemporary college students' images of scientists, both what they 'do' in their day-to-day work and who they 'are' as people. The majority of participants (n = 1,106) were college students. Fifty-seven possible items were generated from several sources. Results of exploratory factor analyses for the Stereotypes of Scientists (SOS) Scale indicate a twenty-two item, two-factor solution with the constructs of Professional Competencies (13 items) and Interpersonal Competencies (9 items). Further analyses of the SOS Scale found no effect of participants' gender on the construct validity or reliability of the scale. Thus, in the sample, women and men had similar responses to the items. A review of the items in the two factors suggests that students have complex, and sometimes contradictory, images of scientists, which resonate with but do not neatly reproduce an alignment between images of 'scientists' and Western norms related to masculinity.

Keywords
Attitude Measures; Gender and Science; Images of Scientists; Science Careers; Science Education; Scientists; SOS Scale; Stereotypes; Student Attitudes; Women in Science

Capturing Stereotypes: Developing a scale to explore U.S. college students' images of science and scientists[1]

INTRODUCTION

Feminist analyses of women's representation in science have hypothesized that women have been tacitly excluded by an underlying history and philosophy that privileges Western concepts of masculinity in definitions of the quintessential scientist (Birke, 1986; Harding, 1991; Keller, 1977; Rosser, 1990). There is some empirical support for this from collected images of scientists, most famously demonstrated in the children's Draw-A-Scientist Test (DAST) (Chambers, 1983). This association between Western concepts of masculinity and science appears to exist for children and undergraduate students both in the U.S. and internationally (Dikmenli, 2010; Fung, 2002; Matthews & Davies, 1999; Newton & Newton, 1998; Rubin & Cohen, 2003; She, 1995; Steinke et al., 2007). However, there is also evidence that this association plausibly changes with experience or by cultural context, international setting, or educational circumstances (Harding, 1993; Kahle, Parker, Rennie, & Riley, 1993; NSB, 2010; Traweek, 1992).

The general and long-established image of a scientist was that of a white male wearing a lab coat and glasses (Beardslee & O'Dowd, 1961; Chambers, 1983; Mead & Métraux, 1957; Newton & Newton, 1998). On the one hand, scientists were seen positively as dedicated, intelligent, altruistic, and driven; on the other hand, scientists were also described negatively as uninteresting, asocial, mad, dull, secretive, demanding, dangerous, unsociable, isolated from the world, and working long hours (Chambers, 1983; Dikmenli , 2010; Lips, 1992; Mead & Métraux, 1957; Rahm & Charbonneau, 1997). Though men and women alike perceive science as a masculine occupation, this has been reported to be especially pronounced among women college students (Hughes, 2002; Lips, 1992; Thomas, Henley, & Snell, 2006). In addition, several U.S. research studies have suggested that men perceive scientists more positively than do women (Catsambis, 1995; Sax, 2001; Weinburgh, 1995). Other theories and studies suggest students' images of science are linked to gender roles and norms (Diekman & Eagly, 2000; Eagly, 1987; Lent, Brown, & Hackett, 1994; Matyas & Dix, 1992; McLean & Kalin, 1994; Morgan, Isaac, & Sansone, 2001; Schoon, 2001). However, male and female students may hold similar images of scientists, as measured by early scales such as the Image of Science and Scientists Scale (ISSS) and Women in Science Scale (WiSS) (Erb & Smith, 1984; Krajkovich & Smith, 1982; Wyer 2003a; 2003b). Thus, there is mixed support for the related hypotheses that science is perceived to be a male occupation and men and women have different perceptions of it as a career option.

Taken together, these studies suggest the salience of stereotypes as a factor in understanding the under-representation of women in science, though the studies rely on different populations, different methods, and different definitions of the stereotypes of interest. This study is designed to develop and provide a tool that can be utilized to identify contemporary stereotypes of scientists and to compare how (or if) stereotypes differ by gender. This article describes the processes, methods, analyses, and results of the development and testing of this tool.

U.S. Women's Representation in S&E Fields

According to the U.S. National Science Board's *Science and Engineering Indicators* (2010), there has been a steady increase in women's representation in S&E fields; however, gender segregation within some S&E fields persists. Internationally, the number of people entering careers and pursuing degrees in S&E fields continues to grow. Since S&E doctoral degrees are thought to be indicative of who will become the world's future S&E leaders, innovators, researchers, and educators, and the data include women's increasing presence, there appears to be a pronounced decline in barriers to women becoming scientists. In raw numbers for 2006, the U.S. awarded more S&E doctoral degrees than any other country (30,000 degrees), followed by China (23,000), Russia (20,000), Germany (10,000), and the United Kingdom (10,000). There is also a modest rise in the number of S&E doctoral degrees in countries such as India, Japan, South Korea, and several European countries (NSB, 2010).

Women earn roughly 40% of the S&E doctoral degrees in the U.S., which is comparable to women S&E doctoral degree earners in countries such as Australia, Canada, Mexico, and the European Union (NSB, 2010). In some countries, women earn more than half of the S&E doctoral degrees (Iceland, 63%; Portugal, 56%); however, women still earn less than a quarter of S&E doctoral degrees in countries such as the Netherlands (20%), Poland (24%), South Korea (17%), and Taiwan (14%). These statistics suggest promising if uneven growth for women in S&E throughout the world. Given that the U.S. produces the greatest number of S&E doctorates, the U.S. provides a useful starting point for understanding perceptions of scientists (NSB, 2010), (See Figure 1).

The dramatic growth in the presence of women in U.S. science degree programs during the last forty years suggests a striking shift in women's presence across fields. In 1966, only 12% of U.S. life science doctoral degrees were awarded to women; however, by 2008, over half (53%) of the life science doctoral degrees went to women (National Science Foundation, Division of Science Resources Statistics [NSF SRS], 2008; 2009a). Even in the fields slowest to incorporate women, engineering and physical sciences, women's representation as doctoral degree-earners grew from 0.3% of engineering doctoral degrees in 1966 to 22% in 2008 and 4.5% of physical science doctoral degrees in 1966 to 28% degrees in 2008 (NSF SRS, 2008; 2009a). Furthermore, in 2007, women represented 40% of all science and engineering doctoral degrees, 46% of master's degrees, and 50% of bachelor's degrees (compared to 8%, 13%, and 25% respectively in 1966) (NSF SRS, 2009b). Perhaps as a companion phenomenon, there are even a growing number of depictions of women as scientists and engineers in various popular U.S. and U.K. media and television outlets (Barbercheck, 2001; Haran, Chimba, Reid & Kitzinger, 2008; Mendick, Moreau, & Hollingworth, 2008; Steinke, Long, Johnson, & Ghosh, 2008).[2]

Despite this rosier picture, gender discrepancies persist even at the first university degree level. Compared to 1966, U.S. women in 2006 are well represented as bachelor's degree earners in certain S&E fields, such as psychology (77%), biological and agricultural sciences (60%), and social sciences (54%) (NSF SRS, 2008). However, they remain under-represented in other S&E fields. For instance, women account for just one-fifth of U.S. bachelor degrees in physics (21%), computer sciences (20%), and engineering (20%) (NSF SRS, 2008), (See Figure 2). These discrepancies are also apparent cross-culturally (NSB, 2010).

Given the global rise in the number of women in S&E fields in the context of uneven gains (Glover, 2000), it is an opportune time to explore whether women and men have different images of scientists. If they do have different images, the theory that women's stereotypes of scientists discourage their interest in STEM education will have continuing salience. Understanding those images is a necessary analytic step in advancing knowledge about the dynamics of gender in S&E education and in refining and tailoring the development of interventions.

Whether the uneven representation of women in science is a cause or a consequence of stereotypes, the sheer number of women who are becoming scientists is on the rise. However, in the absence of a methodically reliable and valid description of stereotypes of scientists, our understanding of how women and men may differ in their images of scientists, how cultures and countries differ in predominant images of scientists, or how these images may impact the flow of talent into or away from science is unlikely to advance.

Figure 1. Percentage of S&E doctorate degrees awarded to women, selected countries, 2006[3]

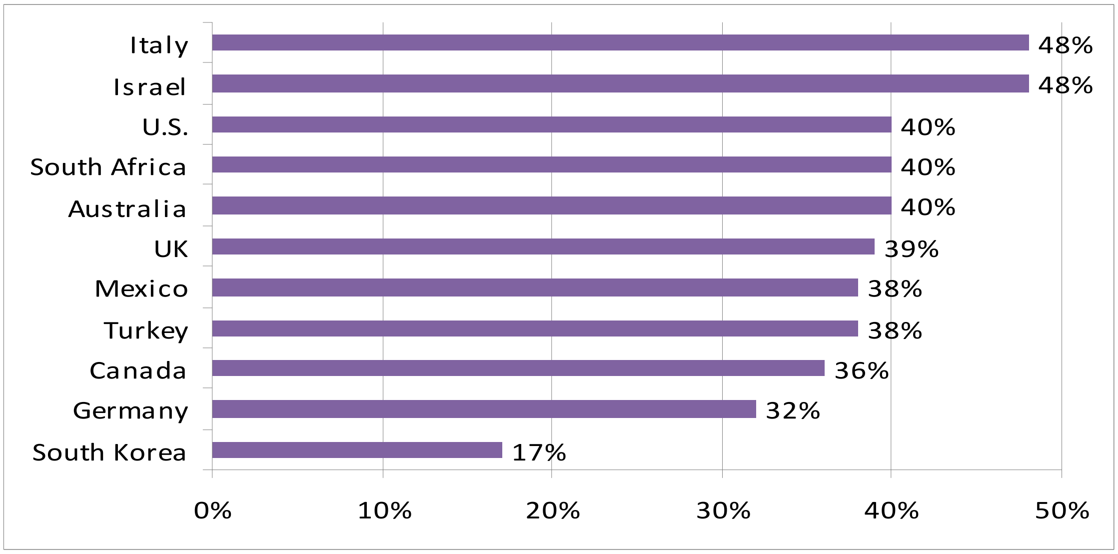
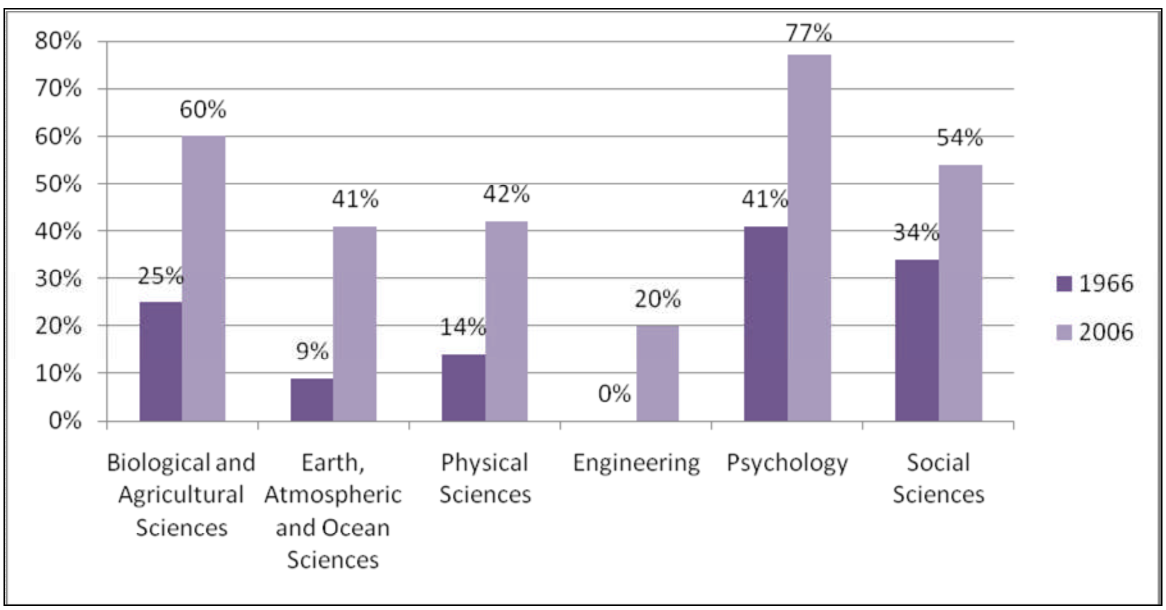


Figure 2. Percentage of U.S. bachelor's degrees awarded to women, by major field: 1966 and 2006[4]



Stereotypes
There is no shortage of explanations for why academic fields continue to be gender segregated. Proposed reasons range from girls' and women's lack of academic preparedness; lack of confidence; lack of encouragement or guidance; socialization by gender, interest and career aspirations; educational and cultural institutions; peers/parents/teachers; experiences of discrimination/prejudice; and, an unwelcoming university climate (Eccles, 1994, Jacobs, Finken, Griffin, & Wright, 1998; Meinster & Rose, 2001; Morgan, Isaac, & Sansone, 2001; Xie and Shauman 1997). In general, these explanations rest on either the 'deficit' or the 'difference' model to understand women's educational outcomes (see Sonnert & Holton, 1995). However, a possibly pervasive component of all these individual, educational, social, and environmentally related explanations may be stereotypes about scientists. For the purposes of this study, stereotypes are defined as shared beliefs and attitudes (both positive and negative) about groups of people that are presumed to exist independent of their accuracy (Hilton & von Hippel, 1996). Stereotypes are thought to be developed and maintained from a multitude of factors, contexts, and influences that occur continually throughout an individual's lifespan (Ashmore & Del Boca, 1981; Schneider, 2004). Thus, stereotypes are examined here as a component or root for many of the explanations for women's under-representation in some S&E fields.

Indeed, social studies of science have long noted that the ideas about who can and cannot be scientists (i.e. what characteristics are needed to be scientists or are most desirable) have shaped norms of professionalism in the scientific community. One hallmark of excellence within the scientific community is a presumed absence of cultural influence or biases [see *Beamtimes and Lifetimes* (Traweek, 1992) and *The Sociology of Science* (Merton, 1973)]. This distinctive norm expresses as a professional ideal that scientists are disinterested in, inattentive to, or inept at, social interactions. Since ideas about appropriate behavior for men and women have varied by history and culture, it is plausible that ideas about the abilities of men and women to be scientists are historically and culturally contingent (Harding, 1998; Lips, 2005; Mitter & Rowbotham, 1995; Saunders, 2003).

Cultural stereotypes have marked educational choices in the past and may be at play in the present. As argued by theorists from several perspectives (i.e. role congruity theory, social role theory, gender schema theory, Eccles' model of achievement related choices, etc.), gender stereotypes have encouraged (1) the majority of women to seek careers in fields traditionally associated with the historically feminine ideals of caring, cooperation, and interdependence and (2) the majority of men to seek careers that demonstrate historically masculine ideals of rationality, competitiveness, and independence (Bem, 1993; Cejka & Eagly, 1999; Diekman & Eagly, 2000; Eagly, 1987; Eagly & Karau, 2002, Eagly & Steffen, 2006; Eccles, 1987, 1994; Glick, Wilk & Perreault, 1995; White & White, 2006). Feminist analyses of the sciences have linked these social ideals about gender to the historical and contemporary under-representation of women in science, arguing that the professional qualities most valued in science are antithetical to the acceptable social behaviors prescribed to women (Bleier, 1984; Fausto-Sterling, 1992; Keller, 1985; Rosser, 1990; Schiebinger, 1999). However, the power of these social ideals in shaping educational choices today is an open question.

Social scientists have built a compelling empirical case that individual and social beliefs about women's abilities and interests are related to women's under-representation in S&E via occupational stereotypes. Since these stereotypes influence occupational choices, undergraduate students perceive S&E professions in light of stereotypes about women and men and thus they make gender-appropriate choices of majors associated with those professions accordingly (Beyer, 1999; Glick, Wilk & Perreault, 1995; Hughes, 2002; Kinicki & Griffeth, 1985; Lightbody & Durndell, 1996; Lips, 1992; Luhaorg & Zivian, 1995; McLean & Kalin, 1994; White, Kruczek & Brown, 1989). It follows then that stereotypes about scientists and about women present female students interested in science with a negotiation of contradictory identities (see Abes, Jones, & McEwen; Carlone & Johnson, 2007).

Undergraduate students' academic performance and persistence are key determinants of educational attainment in professions that require advanced training (Pascarella & Terenzini, 1991; 2005). However, students' academic performance and persistence take place within an educational environment filled with racial, ethnic, and gender stereotypes that have tangible effects. Negative stereotypes have a well-established negative impact on undergraduate students' performance on standardized tests (Quinn & Spencer 2001; Steele 1997; Steele & Aronson 1995). Indeed, negative stereotypes have their most pronounced impact on high achievers who strongly identify with the domain of the stereotype (Wheeler & Petty, 2001). In environments where negative stereotypes about an "outgroup" are widespread, removing allusions to these stereotypes within a classroom boosts performance of those who identify with the outgroup (Oswald & Harvey, 2001). There are few studies on positive effects of stereotypes, but they have been linked to "boosts" in performance and persistence (Kray, Reb, Galinsky, & Thompson, 2004; Shih, Pittinsky & Ambady 1999). Wyer (2003a) found that, for biology and engineering majors, positive images of science and scientists are associated with high degree aspirations and high career commitment, regardless of gender.

Stereotypes about science/scientists embed social messages about the work that scientists do and who can, or cannot, do that work (Hilton & von Hippel, 1996). The growth in the representation of women among STEM degree earners suggests that (to the extent that stereotypes influence behavior) social messages about science and scientists have changed. However, much of the most persuasive empirical evidence about the influence of stereotypes (Steele & Aronson, 1995; Steele, 1997; Shih, Pittinsky, & Ambady, 1999) relies on implied and global stereotypes rather than specific contents. Though we may have good inferential evidence of the effects of the U.S. stereotypes that "Asians are good at math," and "Women are bad at math," and "African Americans are not interested in math," we have few details about how (or whether) these perceptions relate to students' perceptions of scientists (Lee, 2008; Shih, Pittinsky & Ambady 1999; Steele, 1997). Because stereotypes can carry positive and affirming images as well as negative ones, it is plausible that the longstanding influence of beliefs about science as a "white males only" club has eroded (Kray, Reb, Galinsky, & Thompson, 2004; Shih, Pittinsky & Ambady 1999). Little is known about the elements of contemporary stereotypes about science/scientists among today's undergraduate students, many of whom are majoring in the sciences and many of whom are not white men.

Past Measures of Stereotypes of Scientists

Despite the potential value of stereotypes to understanding women's under-representation in science, there is a dearth of empirical research to document current college students' stereotypes of scientists in detail. Studies that have described general stereotypes of science were done decades ago and stemmed from Mead & Métraux's (1957) qualitative study of 35,000 high school students. Using an essay format to analyze students' stereotypes of scientists, Mead & Métraux found both positive images of scientists (brilliant and dedicated, their work advances the nation technologically) and negative images (single purpose, poor family life, infrequent feelings of being rewarded). These results were then used as a basis for creating later measures such as the Draw-A-Scientist Test (DAST) (Chambers, 1983). The DAST was developed with the purpose of measuring children's (aged 5-11) perceptions of science and images of scientists through their drawings of a scientist. Chambers utilized Mead & Métraux's (1957) results when creating a coding system for the drawings (lab coat, eyeglasses, facial hair, etc.); thus, the measure was based on stereotypes from the early 1950s.

The DAST has been used in a variety of populations, countries, and purposes; however, the results still find that the majority of drawings are of white, male scientists (see Fung, 2002; Matthews & Davies, 1999; Newton & Newton, 1998; Rahm & Charbonneau, 1997, Rubin & Cohen, 2003; She, 1995; Steinke, Lapinski, Crocker, et al., 2007; Sumrall, 1995; Thomas, Henley, and Snell, 2006). Although the DAST may decipher whether respondents perceive scientists as men or women (assuming the drawings can be interpreted reliably), the DAST was not designed to explore if men and women respondents differ in their specific image of a scientist. Instead, the DAST sought to understand when children (grades K-5) developed clear images of scientists (Chambers, 1983). The DAST has been criticized on methodological grounds after a second and third drawing of a scientist by the same children yielded different images than the first (Farland-Smith & McComas, 2009; Maoldomhnaigh & Hunt, 1988). Further, drawings may be susceptible to construct validity threats and such issues as gender of the administrator, experimenter bias, experimental situations, social desirability, measure administrator, artistic ability, detail, and consistency of raters' interpretations (Symington & Spurling, 1990; Thomas, Henley, et al., 2006).

The Image of Science and Scientists Scale (ISSS) is another measure that utilized Mead & Métraux's results to create a measure that assesses students' preconceptions about science and scientists. The ISSS was developed originally to measure children's attitudes toward science (Smith & Krajkovich, 1979) and was then used to collect data from high school students, undergraduates, and adults. The items asked students to complete a stem that reads: "When I think of a scientist, I think of a person who:" This stem was followed by statements such as "sits in a laboratory; is courageous; is intelligent; works in a dreary laboratory" (Krajkovich & Smith, 1982). Both its internal reliability (coefficient alpha .86) and construct validity (discriminates between groups who have different attitudes toward science and contributes to predicting science achievement) have been established (Bailer, 1998; Ching, 1992; Erb, 1983; Krajkovich & Smith, 1982).

Like the DAST, the ISSS is not designed to compare gender differences in respondents' specific stereotypes of scientists. The items were generated from the results of Mead & Métraux's (1957) study and included dated items that need to be updated to reflect contemporary science fields. Further, Erb (1983) raises questions about the ISSS's construct validity and asserts the ISSS may have more than one dimension. Advanced scale development procedures, statistics, and computational power now can produce a more psychometrically sound measure. In addition, the full item list of the ISSS was never published and consequently cannot be reproduced or revised for other samples or geographical locations.

The Women in Science Scale (WiSS) (Erb & Smith 1984) has been used in several contemporary studies (e.g. Bailer, 1998; Ching, 1992; Clark, 1986; Giacobbi, 1998; Owen et al., 2007; Ridgill, 1987; Stake & Malkin, 2003, Wyer, 2003a, 2003b; Wyer et al. 2007), and this scale has the virtue of incorporating perceptions of scientists with attitudes toward women. However, the WiSS has significant limitations in both form and scope for capturing stereotypes about scientists, since this strength is also a weakness—some items confound attitudes toward women with stereotypes about scientists. The WiSS, like the DAST and ISSS, was not developed to capture gender differences in respondents' stereotypes of scientists, but instead designed to examine adolescents' attitudes about women working in science occupations (Erb & Smith, 1984).

Research Objective

Stereotypes are often said to be associated with factors used to explain the inequality in science education and employment, vis-à-vis attributions of interests and skills by teacher and parents, negative messages about abilities, evaluations of teaching and research, and hiring and promotion decisions (NAS, 2006). Yet knowledge about the precise character and content of college students' stereotypes about scientists is outdated and incomplete.

The SOS scale, as described in this article, provides a tool for fine-grained analyses that recognize the multidimensionality of individuals' perceptions of scientists as these do (or do not) vary by gender. The objective of the research from which the scale emerged was to develop a psychometrically valid tool for survey research and quantitative, multivariate studies. Conventional methodological approaches in factor analyses can uncover patterns in individuals' responses to multiple items so that when students respond consistently to a series of statements the patterns can be identified. The SOS scale represents the pattern found in our data. However, the project described here was not aimed at capturing whether respondents perceive scientists as males or females; nor is the resulting scale an exhaustive representation of all of students' stereotypes of scientists. In addition, the research was not designed to evaluate students' knowledge about scientists as portrayed through various media channels. (For further discussion of the potential and limitations of the SOS scale, see the limitations and future research sections). To the best of our knowledge, there is no more specific and current scale than the SOS scale for measuring undergraduates' stereotypes about science/scientists in a way that captures multiple dimensions of scientists' images and that allows analyses of these images by respondents' gender.

METHODS

Item Development

Items were developed using multiple sources, including focus groups, earlier published scales aimed at capturing images of scientists (Krajkovich & Smith, 1982; Erb & Smith, 1984; Owen, Toepperwein et al., 2007; Spence, Helmreich, & Stapp, 1973), and scholarship about gender and science (Birke, 1986; Harding, 1991; Keller, 1977; Schiebinger, 1999). Although the objective of the research was to create a quantitative measure of undergraduates' stereotypes of scientists, focus groups were included to inform the wording of questionnaire items (Ulin, Robinson, & Tolley (2005), generate new items (e.g., Wolff, Knodel, & Sittitrai, 1993), improve instruments as a whole (e.g., O'Brien, 1993), and help to adapt items (e.g., Fuller, Edwards, Vorakitphokatorn, & Sermsri, 1993). Furthermore, focus groups offer an efficient method of providing a wide range of information, thoughts, ideas, and experiences to researchers (Krueger, 1994; Vaughn, Schumm, & Singaub, 1996). More specifically, focus groups were conducted with the goal of generating possibilities for new scale items, while also exploring the salience of items from previous studies.

Instructors from three courses at a large, southeastern U.S. university invited their undergraduate students to volunteer to participate in the focus groups. A total of five focus groups were conducted in the fall of the 2005 academic year, with a total of 48 undergraduates (34 men, 14 women) from the three courses participating. Focus Groups 1-3 were conducted with the university’s students enrolled in a chemistry course and the fourth focus group included students from a biomedical engineering course. The fifth focus group was comprised of students enrolled in an Introductory to Psychology course. Observations and data were recorded using the SOAP notes technique - denoting Subjective, Objective, Assessment, and Plan data (SOAP) notes – (Turtle-Song, 2002; Weed, 1968). The SOAP notes technique is commonly employed in the health care industry and for case studies. SOAP notes were used in the focus group portion of this study since these notes are effective at categorizing and interpreting large amounts of qualitative data and helpful for ensuring comments and feedback were captured concisely and meaningfully [see Turtle-Song (2002) & Weed (1968) for more detailed information on SOAP notes]. The notes from the focus group were then tapped for additional information in designing a quantitative scale. There was no incentive or extra credit for the students, though pizza and soda were provided during the focus group meeting.

In all of the focus groups, participants were asked to draw a picture of a scientist (Chambers, 1983). Students were then given the opportunity to talk about their drawing using follow-up questions about science and scientists in relation to: themselves; gender and personal characteristics; their perceptions of scientists; choice of academic career; and, their career intentions. The focus group questions that followed the DAST exercise were designed to explore both gender- and culture-related influences on students’ images of science and scientists. Examples of some of the questions asked include: Are there differences between people that would cause them to pick certain science majors? What country are scientists of different majors from? Would race, gender, or class affect scientists’ interactions with their colleagues? Do you feel that you drew yourself as a scientist? (For more information about the focus groups and their results see Nasser-McMillan, Wyer, Oliver-Hoyo, and Ryder-Burge, accepted paper, *Quarterly Researcher*).

Item Refinement

The DAST exercise focused primarily on providing participants with a visualization of scientists’ characteristics and it proved a useful vehicle for a dialogue within the focus groups about gender and culturally related information as related to the visualizations. Within the lively conversations that resulted, students also discussed the relational and professional components of their images of scientists. Consequently, the DAST drawings *per se* were not as informative or imaginative as the discussions that the drawings generated. Therefore, in addition to the DAST, participants in the focus groups were also asked to complete a draft version of the *Stereotypes of Scientists* (SOS) Scale and then discuss their reactions to the items included in this instrument. Through an iterative process, an initial list of potential scale items was compiled. These items underwent further screening by graduate students and cooperating faculty members in order to analyze the semantics of the items (e.g. reduce ambiguity, refine wording to improve clarity of item, and note duplicate or overlapping items). Then the scale was vetted again in later focus groups. The participants in the last three focus groups were asked to rate their agreement using the six-point Likert scale of agreement (strongly agree to strongly disagree) (Erb & Smith, 1984; Krajkovich & Smith, 1982) and also asked to flag ambiguous or confusing wording in the instrument. The entire item development process took approximately nine months and the scale was modified approximately twelve times before it reached its pilot-stage version. These modifications included such changes as simplifying the language, avoiding redundancy of items, and eliminating terms that were no longer in common usage. This item refinement stage resulted in a pilot instrument consisting of 57 items.

The items were then worded to fit into one of two categories, which were drawn from Erb's 1983 classic study of the psychometric properties of the ISSS scale. Erb's categories distinguished between what 'scientists do' and who 'scientists are'. Of the 57 items in the pilot instrument, the first category, 'scientists do', consisted of 22 items. An example item from this category is: When I think about scientists, I think that they: 'Enjoy their work'. The remaining 35 items comprised the second category, 'scientists are'. An example item from this category is: When I think about scientists, I think that they are: 'family oriented'.

The majority of the items were positively worded; however, nineteen of the items were negatively worded. Of the negatively worded items, four items were paired with a positively worded item as a validity check on responses. For instance, a positively worded item was 'technically competent' and the negatively worded counterpart to that item was stated as 'technically incompetent'. Several items traditionally dichotomized by gender were also included among the 57 items. For example, 'neglect their family life' and 'family oriented'; 'independent' and 'cooperative'; 'self-confident' and 'insecure' were all pairs of items intended to reflect these traditional stereotypes (Bem, 1993; Eagly, 1987; Gilligan, 1982; Tannen, 1990).

Procedures

The *Stereotypes of Scientists* (SOS) Scale was piloted using an undergraduate sample from a wide variety of classes at a large southeastern U.S. university during the 2008-2009 academic year. The scale was piloted as a subsection of a larger *Careers in Science* survey. Participants were asked to rate the extent to which they agreed with the scale's 57 statements about scientists on a six-point Likert scale ranging from strongly agree (6) to strongly disagree (1), with no neutral point.[5] The SOS Scale was developed to function both in web surveys or hard copy surveys.[6] Thus, data collection was conducted using both hard copy and web-survey methods. Respondents were recruited through their course instructors. Faculty members at the university were contacted and asked if they would agree to invite their undergraduate class or classes to be included in the study. Students from those classes were then asked to volunteer to participate in the survey. Participants were told their answers would be anonymous and would be reported only in aggregate. The courses that participated in the hard copy survey (fall 2008 data collection) were surveyed during class time, while students in courses assigned to the web-survey (spring and summer 2009 data collection) were asked to fill out the web survey outside of class time. Hard copy and web data sets were eventually merged for purposes of analyses (n=1,106).

Participants

The sample included college students from a range of courses. The only requirement for study participation was students had to be enrolled in the participating faculty member's undergraduate class. One-third (34%) of respondents were sampled from ecology courses, and 27% of respondents were sampled from psychology courses. Other students were sampled from a zoology course (14%), a biology course (9%), three chemistry courses (9%), a biomedical engineering course (4%), and a women studies course (2%).

The demographic composition of the 1,106 respondents in our study is roughly comparable to racial/ethnic demographics of undergraduates of the primary departments sampled in the study[7] (UPA, 2009). Sixty percent of the participants were women and 40% were men. Seventy-nine percent of participants were European-American, 8% African American, 6% Asian American or Asian, 2% Latino American/Hispanic, and 1% Native American. Four percent of respondents were of other ethnicities. Students were well represented across all academic years (first year to five or more years at their university). Due to the range of courses sampled, academic majors varied widely and no major represented more than approximately one-fifth of the sample (e.g.: Biology = 21.2%, Zoology 17.5%, Psychology 5.9%, Biomedical Engineering 4.6%, Business 3.3%, Chemistry 2.8%).

Data Collection via Hard Copy

The hard copy format of the survey was done via Scantron® response sheets during the fall semester in 2008. Instructors permitted project researchers to administer the survey, which took less than 30 minutes, in the classroom. There was no incentive offered to the student, but students were provided class time to complete the survey. Students were explicitly told that their participation was voluntary. A total of 694 undergraduates were sampled using the hard copy format. Data from 171 undergraduates were excluded from the results due to missing[8] or bad data; thus, data from 523 undergraduates was included from the hard copy format (75% useable response rate).

Data Collection via Web Survey

The second half of the study collected data in the spring and summer of 2008 using an anonymous web survey format. The web survey format took approximately 15-20 minutes to complete and included the same items in the same order as the hard copy format. Instructors who gave their permission to include their classes in the study alerted their classes of the study and provided project researchers email addresses of the class. Since the web survey was conducted outside of class time, most instructors offered their students extra credit to their class grade as an incentive to complete the survey. The survey was voluntary and there was no negative impact on those who opted to not participate. Project researchers contacted students directly via email to provide survey instructions, deadlines, information about an extra credit incentive (if there was one), and the survey link.

Students accessed the survey using unique ids and passwords that kept their answers anonymous. Participants were typically given two weeks to complete the survey with one email reminder at the midpoint and another the day the survey was due. In order for extra credit to be awarded and to keep the survey anonymous, students emailed researchers after they completed the survey (per instructions on the final survey page) to state they had completed the survey. This information was then forwarded to the instructors in order to award extra credit points. These completion notifications were independent of the survey and could not be associated with students' specific responses.

A total of 601 college students were sampled via the web-based survey; 18 of these participants were removed from the study as having provided incomplete or bad data. Thus, a total of 583 college students were included from the web survey format (97% useable response rate).

DATA ANALYSIS

Descriptive Statistics

Descriptive statistics were examined to identify items that did not adequately capture stereotypes. In particular, items that were normally distributed (thus, not capturing a stereotype) were excluded from the study (Bulmer, 1965). Outlier items (those with responses that were extremely skewed or had extremely high kurtosis e.g. virtually all students answered 'mildly agree') were also excluded. In addition, item correlations between positively worded items and their negatively worded counter items were examined (for example, technically competent and technically incompetent). Negatively worded items that were highly correlated (.80 or higher) with their counter positively worded item were excluded (Field, 2005).

Exploratory Factor Analysis

In order to further reduce the number of items and explore the underlying dimensions of the responses, the dataset was analyzed using a principal axis factor analysis with promax rotation[9] (Costello & Osborne, 2005). The scree test, variance explained by the items, and factor loadings (Henson & Roberts, 2006; Tabachnick & Fidell, 2001),[10] were used to determine the factor solution of the scale.

Reliability and Validity

Internal consistency (Cronbach's alpha), was the primary method for assessing the measure's reliability (Carmines & Zeller, 1979; Cronbach, 1951; Field, 2005). The measure's external validity was examined to ensure use for a variety of contexts and diverse populations; thus, the measure was examined for significant differences by gender and format (hard copy vs. web) of the survey.

RESULTS

Descriptive Statistics

Stereotypes are, by definition, widely shared images. As such, responses will not be normally distributed, and therefore analyses set skewness and kurtosis values to identify items with distributions that were asymmetric and peaked with short tails. To evaluate the shape of item-response distributions, skewness and kurtosis criteria were applied following Bulmer's *Principles of Statistics* (1965) guidelines for moderate and high skewness. Seventeen items were removed for having a skewness value below .40 (absolute value). Seven additional items were removed for having a kurtosis value below .30 or above 3.5. For instance, one item was removed, 'scientists are well educated', for having an extremely high kurtosis (5.38), which indicates virtual agreement among respondents in the study.[11]

In addition, correlations were examined for the four item-pairs that were worded both positively and negatively. Two of the four pairs (organized/disorganized and work regular hours/work obsessively) were already removed based on the above skewness/kurtosis criteria. The remaining two pairs were moderately correlated. The negatively worded items (technically incompetent and neglect their family life) were removed while keeping the positively worded companion items (technically competent and family oriented) in the scale.[12] After examining the descriptive statistics and removing a total of 26 items based on the above criteria (see Table 1), the 57-item pilot scale was reduced to 31 items (see Table 2). Next, an exploratory factor analysis was conducted on these 31 items to examine the factor structure of the SOS.

Table 1. Elimination of 26 items based on skewness, kurtosis, and correlations

Negatively worded items that were highly correlated (.40 or higher) to the same item positively worded	**Mean**	**Correlation with Paired Item**
34. Technically incompetent	2.31	0.46
13. Neglect their family life	2.47	0.41
Items with a Kurtosis Higher than 3.5 (absolute value)	**Mean**	**Kurtosis**
36. Well educated	5.41	5.38
2. Design experiments	5.10	5.22
Items with a Kurtosis Lower than .30 (absolute value)	**Mean**	**Kurtosis**
23. Self-sacrificing	3.95	0.23
55. Clueless about popular culture	2.96	0.12
20. Depend on others to use equipment	2.85	-0.01
48. Absent minded	2.83	-0.11
44. Argumentative	4.23	-0.14
Items with a Skewness Lower than .40 (absolute value)	**Mean**	**Skewness**
37. Out of touch with popular culture	3.21	0.39
17. Are the ones who fix equipment that is broken	3.15	0.32
40. Money oriented	3.18	0.26
39. Disorganized	2.96	0.23
5. Work regular hours	3.25	0.10
57. “Hip” or “cool”	3.34	0.08
8. Have lots of money and other resources	3.50	0.07
19. Depend on others to keep the equipment repaired	3.68	-0.01
11. Know a lot about popular culture	3.30	-0.01
30. Emotional	3.48	-0.04
28. Caregivers	3.69	-0.25
4. Work obsessively	4.18	-0.27
24. Good communicators	3.87	-0.32
1. Value recognition/fame	3.79	-0.36
54. Effective leaders	4.01	-0.37
42. Humble	3.83	-0.38
47. Active socially	3.80	-0.39

Table 2. Mean, skewness, and kurtosis of the remaining 31 items

	Mean	Skewness	Kurtosis
6. Have fun with colleagues at work	4.28	-0.85	0.68
7. Maintain friendships with colleagues in other departments	4.50	-0.85	0.89
9. Know a lot about the latest discoveries	4.78	-0.71	1.08
10. Do not have a lot of friends	2.57	0.77	0.44
12. Enjoy their work	5.10	-1.15	3.29
14. Are out of touch with what is happening in the world	2.51	0.86	0.33
15. Act with integrity/have a lot of integrity	4.61	-0.74	1.57
16. Are the ones who know how equipment works	4.49	-0.60	0.52
18. Are careful with expensive instruments	4.95	-0.93	1.37
21. Teach others about the equipment	4.33	-0.71	0.84
22. Have unhappy marriages	2.19	1.17	1.89
25. Competitive	4.65	-0.75	0.97
26. Cooperative	4.46	-0.63	0.78
27. Independent	4.62	-0.78	0.70
29. Rational	4.70	-0.69	0.71
30. Work on a computer	4.71	-0.84	1.19
31. Work oriented	4.86	-0.84	2.16
32. Family oriented	3.98	-0.57	0.45
33. Technically competent	4.84	-0.94	2.34
35. Creative	4.55	-0.67	0.46
38. Organized	4.29	-0.44	0.37
41. Competent	4.89	-0.78	1.61
43. Self-confident	4.55	-0.71	1.50
45. Insecure	2.75	0.58	0.93
46. Collaborative	4.49	-0.50	0.74
49. Highly focused	4.96	-0.63	0.87
50. Effective teachers	3.95	-0.45	0.36
51. Able to learn to use new equipment quickly	4.40	-0.47	0.91
52. Especially intelligent	4.69	-0.53	0.68
53. Logical	4.78	-0.81	1.62
56. Honest	4.45	-0.59	1.22

Exploratory Factor Analysis
An initial principal axis factor analysis with promax rotation with Kaiser normalization did not yield a clear solution. Therefore, based on a scree plot analysis and the results of research conducted previously using the Image of Scientists Scale (ISSS) (Krajkovich & Smith, 1982) and the Women in Science Scale (WiSS) (Erb & Smith, 1984; Owen, Toepperwein et al., 2007), a forced two-factor solution was run. A loading cutoff of .40 or higher was implemented.[13] Nine items that did not load at .40 on either factor were removed (see Table 3).

A second principal axis factor analysis was rerun with the remaining 22 items. All 22 items loaded at .40 or higher; and a two-dimensional solution emerged. The two constructs were interpreted as Interpersonal Competencies and Professional Competencies. These two factors combined explained 37.5% of the variance. The first factor, Professional Competencies, consisted of thirteen items (Cronbach's alpha = .84). Example stereotypes from this factor include: Work oriented, Independent, and Logical. Item loadings ranged from .44 to .68 and explained 23.83% of the variance. The second factor, Interpersonal Competencies, consisted of nine items (Cronbach's alpha = .79). Example stereotypes from this factor include Cooperative, Collaborative, and Family Oriented. The items had loadings that ranged from .40 to .75. This second factor explained 13.2% of the variance (see Table 4).

This factor structure was also analyzed by format (hard copy and web survey) and by gender (men and women). A principal axis factor analysis found the 22 items had the same factor structure for each of the subpopulations (web and hard copy, men and women). When examining the factor structure of the 22 items by format, both the hard copy and web survey had adequate item factor loadings (.35 and higher) and Cronbach's alpha (ranging from .78 to .85). The results of the factor analysis for both genders also showed acceptable item factor loadings (.34 and higher) and Cronbach's alpha (ranging from .77-.85) for both genders. Since the factor structure held by format and by gender, neither variable appears to be a validity threat to the measure.

Overall, the two factors were only slightly correlated (.33), suggesting that each factor made a unique contribution to the scale as a whole. The items in the SOS Scale were originally designed to be consistent with the two-factor solution in the ISSS. However, the factor analyses in this study produced a different two-factor solution. The ISSS (Erb, 1983) distinguished perceptions about the work scientists do from the personal characteristics of a scientist. In contrast, we found a distinction between interpersonal and professional competencies in the patterns of responses in our study.

Table 3. Initial Exploratory Factor Analysis: Stereotypes of Scientists

	Factor Loading	
Item	**Factor 1**	**Factor 2**
52. Especially intelligent	0.69	-0.16
51. Able to learn to use new equipment quickly	0.66	-0.06
49. Highly focused	0.64	-0.01
31. Work oriented	0.60	-0.17
33. Technically competent	0.58	0.03
16. Are the ones who know how equipment works	0.55	-0.13
27. Independent	0.50	-0.16
9. Know a lot about the latest discoveries	0.50	-0.15
53. Logical	0.48	0.16
43. Self-confident	0.47	0.13
25. Competitive	0.46	-0.11
18. Are careful with expensive instruments	0.45	0.10
41. Competent	0.44	0.23
56. Honest	0.39	0.26
15. Act with integrity/have a lot of integrity	0.34	0.32
21. Teach others about the equipment	0.33	0.20
12. Enjoy their work	0.31	0.21
35. Creative	0.27	0.23
30. Work on a computer	0.26	-0.01
38. Organized	0.22	0.21
10. Do not have a lot of friends	-0.25	0.76
6. Have fun with colleagues at work	-0.15	0.63
7. Maintain friendships with colleagues in other departments	-0.08	0.62
22. Have unhappy marriages	-0.12	0.61
32. Family oriented	0.04	0.56
14. Are out of touch with what is happening in the world	-0.16	0.56
26. Cooperative	0.24	0.47
45. Insecure	-0.06	0.44
46. Collaborative	0.19	0.43
50. Effective teachers	0.22	0.30
29. Rational	0.23	0.30

*Note: The items that are shaded and underlined indicate which factor the item loads on, using a conservative factor loading of .40 or above (Tabachnick & Fidell, 2000). An item with no underline indicates the item has too low of a loading for either factor.

Table 4. Exploratory Factor Analysis Results for Stereotypes of Scientists

		Factor Loading	
Item	**Mean**	**Professional Competencies**	**Interpersonal Competencies**
52. Especially intelligent	4.69	.68	-.12
49. Highly focused	4.96	.63	.04
51. Able to learn to use new equipment quickly	4.40	.63	-.03
31. Work oriented	4.86	.58	-.12
33. Technically competent	4.84	.58	.07
16. Are the ones who know how equipment works	4.49	.52	-.11
53. Logical	4.78	.48	.15
27. Independent	4.62	.48	-.12
43. Self-confident	4.55	.47	.14
9. Know a lot about the latest discoveries	4.78	.47	-.11
41. Competent	4.89	.46	.25
25. Competitive	4.65	.46	-.07
18. Are careful with expensive instruments	4.95	.44	.12
10. Do not have a lot of friends	2.57	-.17	.75
6. Have fun with colleagues at work	4.28	-.10	.61
7. Maintain friendships with colleagues in other departments	4.50	-.03	.61
22. Have unhappy marriages	2.19	-.06	.60
14. Are out of touch with what is happening in the world	2.51	-.10	.55
32. Family oriented	3.98	.08	.53
26. Cooperative	4.46	.27	.43
45. Insecure	2.75	-.030	.42
46. Collaborative	4.49	.21	.40
Factor Mean Score		4.73 (*SD*=.50	4.41** (*SD*=.60)
Variance explained (Total = %)	37.05	23.83	13.22
Cronbach's Alpha		0.84	0.79
Number of items (Total = 22 items)		13	9

*Note: N = 1063[14]; The items that are shaded and underlined indicate which factor the item loads on, using a conservative factor loading of .40 or above (Tabachnick & Fidell, 2000). An item with no underline indicates the item has too low of a loading for either factor.
**Items 10, 22, 14, & 45 were reverse coded before calculating the Interpersonal Competencies mean score.

DISCUSSION

The *Stereotypes of Scientists* (SOS) scale was developed to capture college students' images of scientists. The SOS scale measures groups of items that comprise dimensions of stereotypes of scientists. Exploratory factor analyses revealed a two-dimensional measure. The 57-item pilot SOS scale was reduced to 22 items over two dimensions: Scientists' Professional Competencies (13 items) and Scientists' Interpersonal Competencies (9 items). Psychometric properties of the 22-item SOS scale are robust, with strong Cronbach's alphas, item-distributions that meet the tests for normality even while capturing widely shared responses[15], and good internal reliability and construct validity.

The factor structure that emerged in our analyses was unanticipated. Given that the wording of the original items drew from Erb's (1983) insights that the ISSS had two embedded factors, one associated to what scientists 'do' and another associated with who scientists 'are', we expected this distinction to survive the analysis, albeit with additional and/or new items to update the scale. Instead, the 22 items clustered to reveal two major constructs within students' stereotypes of scientists: professional and interpersonal competencies. This division suggests that students distinguish scientists' skills and characteristics specific to their jobs from those skills and characteristics related to social interactions, personal life, or working with others.

Although the scale is meant to be used as a whole, individual items were examined for internal reliability and to explore if responses were in general positive or negative. Mean scores on negative items that remained in the scale were low, indicating that most respondents disagreed with the negatively worded statement; for instance, the stereotypes that scientists do not have a lot of friends, are insecure, and have unhappy marriages. These responses suggest that, at least for respondents in our study, stereotypes about scientists are more positive than not. In other cases, the item means and loadings supported the reliability of the scale; for instance, 'self confident' had a relatively high mean score while 'insecure' had a relatively low mean score. Similarly, 'independent' and 'self-confident' loaded on one factor while 'cooperative' and 'collaborative' loaded together on the other.

In overview, among students in our sample, there was consensus about some longstanding characteristics, while other familiar items fell away. On the one hand, the items independent, logical, and especially intelligent are traditional stereotypes that all loaded together on the professional competencies factor (Mead & Métraux, 1957). On the other hand, other traditional stereotypes, such as scientists are clueless about popular culture, work obsessively, or are absent-minded (Barbercheck, 2001; Mead & Métraux, 1957), had low loadings and were removed. Given the multidimensionality of the scale, the remaining list of 22 items included characteristics with potentially contradictory meanings. This suggests a portrait of scientists who could be competitive but also cooperative and collaborative; and that scientists could be family oriented but also have fun with colleagues at work.

It is important to reiterate that stereotypes are not necessarily accurate and that they exist regardless of facts. Thus, our study does not advance knowledge about the *actual* professional and interpersonal competencies of scientists. To the degree our results are generalizable, this study does advance knowledge about college students' widely shared images of scientists. The relationship of those stereotypes to students' experiences with scientists or scientific projects, or students' abilities and interests in science, remains an open question.

Limitations

These results provide a valuable foundation for understanding the relationship between stereotypes of scientists and a host of other variables. However, this study did have notable limitations. First, there were limitations related to the sample. The SOS Scale development process was informed principally by U.S. undergraduates' images of scientists and the sample was based on a convenience sample from one U.S. university. Although the SOS Scale has a larger sample size (n = 1,106) than its older cousins the ISSS and WiSS, the SOS Scale nonetheless would be strengthened by national and international studies to confirm its generalizability. The results may be specific to the views of college students in the southeastern region of the U.S. and may or may not extend to other geographical locations, cultures, or age groups. In particular, since most participants in our study were European American (79%), it would be beneficial to examine the results with a more diverse sample. A diverse sample would also be beneficial for examining if the scale is appropriate, or how it differs, for various populations such as for K-12 students, students in other countries, or in other regions in the U.S.

Further, the scale analyses did not test whether the scale constructs varied by STEM majors and non-STEM majors, since the majority of students in our sample were STEM majors. Though the study included an item to indicate participant's major, a significant number of respondents chose 'other' or 'undecided' when asked to specify their major (n = 139 'other' major, 55 = 'undecided' major). Further, certain academic majors were overrepresented, while other majors were under-represented. Almost half of the sample is comprised of college students majoring in the agricultural and life sciences, while the sample included less than 10% of students majoring in physical sciences & mathematics. The lack of distribution of majors, particularly majors traditionally segregated by gender such as biology and physics (NSB, 2010), may be impacting the scale construction and further research could reveal if stereotypes of scientists vary by academic major. Testing the applicability of the scale, and assessing scale differences cross-culturally and across a variety of populations and education levels would add to the research base and help inform research about how stereotypes of scientists may be related to gender segregation in STEM fields.

The sample may also be subject to a response bias. The instructors who agreed to participate in a research project with a gender and science emphasis may be instructors sensitive to women in science in their own classrooms. Further, the results may be impacted by over representing undergraduate students with high academic ambition since some respondents received extra credit for their participation and may have been driven to participate to improve their class grades. In addition, the study could have benefited by the inclusion of a performance measure, such as the average of students' grades or class marks. This would have provided control for any effect that high or low performers were having on the results and help control for any response bias for those who took the survey because of extra credit.

Other limitations unrelated to the sample include the constructs themselves. Again, future research would lend more credibility to the constructs in other populations and cultures. In particular, this study was not designed to assess whether students make a distinction between scientists and professionals in general. This study was designed to parallel the same general terms of earlier scales (Chambers, 1983; Erb & Smith, 1984; Krajkovich & Smith, 1982; Owen et al., 2007), referring to 'science' and 'scientist' without providing respondents with a specified definition. As a consequence, participants' interpretation of 'scientist' and 'science' was subjective. A respondent's idiosyncratic definition of scientist or science may vary major-to-major or be influenced by extraneous variables such as personal experiences, encounters with science, scientists, and laboratory environments. As a result, the findings may reflect multiple interpretations of science as a construct. These discrepancies could impact responses on the measures, potentially altering the stereotypes being assessed and threatening construct validity.

Although this research could be strengthened by addressing these limits in future research studies, these results provide a strong foundation for understanding undergraduates' stereotypes of scientists. The results for the original 57 items did not reveal gender differences in the factors, but by making the items (and the analyses) available we hope to spark further research, review, and extensions to better understand the conditions under which gender differences may emerge.

Implications and Future Research

In research on persistence and attrition in STEM fields, it is common wisdom that students who have the talent and ability to succeed as scientists choose other fields because they understand a science career as all-consuming, cut-throat competitive, and removed from social life (Bennett & Yabroff, 2008; Newman, 2008; Stross, 2008). This trope has been especially powerful in discussions about how gender norms for women may preclude women from seeking a career in science. Women, so goes this line of reasoning, value interdependence over independence, emotion over reason, cooperation over competition, and family over work. Our research did not find these presumed gender differences in relation to college students' stereotypes about scientists. However, our findings did reveal stereotypes that fall into two distinct categories – interpersonal and professional competencies. This distinction between competencies was made by women and men alike, suggesting that stereotypes about scientists-as-men are neither as homogeneous nor as singularly masculinist as widely assumed. While stereotypes about scientists may be influential in students' commitments to science education and careers, their influence is perhaps more complicated than the equation of 'scientist' with 'man' would predict. Indeed, these stereotypes may now include positive qualities long associated with women.

This study takes a methodologically detailed approach to reporting empirical evidence of current stereotypes of scientists, and the findings provide a strong foundation for future research studies. The results provide a fresh look at undergraduates' stereotypes of scientists, which, until now, have been assumed to be stable since the 1950s (Beardslee & O'Dowd, 1961; Chambers, 1983; Mead & Métraux, 1957). Our findings suggest that college students distinguish between scientists' professional skills (professional competencies) and social skills (interpersonal competencies). However, more research is needed to confirm these dimensions and in other populations, cultures, educational systems and levels, age groups, and specific academic majors. Further refinements of the scale would promote a finer grained analysis of changes over time in images of scientists. In its present form, the scale is an important starting point for examining if, and how, stereotypes can explain why women remain disproportionately under-represented within some STEM fields while well represented in others.

This article has included all 57 of the original items tested, with their means and factor loadings, to ground refinements of the scale and comparative research utilizing it.[16] For instance, the survey items can be altered to change the stem from 'when I think about a scientist I think of someone who…' to 'when I think about an engineer I think of someone who…', or 'when I think about an intelligent person I think of someone who…' to test the convergent validity of the scale and to explore distinctions between images of scientists and engineers. The SOS scale is an easy and short instrument that can be used in multiple environments (web or hard copy surveys, classrooms, non-profit or government groups), with a variety of populations (K-12, undergraduate students, ethnic and/or cross-cultural comparisons, country-specific studies, diverse demographic or socioeconomic groups), and for a range of purposes (as a pre/post test to evaluate an intervention, longitudinal evaluations, educational counselling, as a variable in empirical studies of self-image as scientist, educational persistence, career commitment, to name but a few).

In addition, the theoretical literature on STEM stereotypes is based primarily on the history and philosophy of Western science. Science, as a broadly defined system of human inquiry about the natural world, has a long and distinguished international history (Harding, 1998; Harding, 1993; Stanley, 1993). The SOS Scale offers researchers the opportunity to explore cross-cultural differences and similarities in the meanings and perceptions associated with being and becoming a scientist. The groundbreaking work of our predecessors, including Mead & Métraux (1957) and Chambers (1983), clearly sparked decades of educational research and teaching innovations that arguably influenced the concrete expansion of opportunities for women to apply their talents and abilities in STEM fields – at least in some countries, and in some fields. Given the promise and possibilities of cross-cultural analyses, we trust our work can be a similar catalyst for international applications and perspectives. It is through the generative processes of research, refinement, and revision, that new directions and paradigms can emerge. The SOS scale is a hopeful offering for that future.

ENDNOTES

[1] This research was supported by National Science Foundation, NSF HRD-0522860.

[2] See UKRC (http://www.theukrc.org/resources/ukrc-reports) for more information related to scientists in the media.

[3] Source: National Science Board (2010). *Science & Engineering Indicators-2010.* Vol. I NSB-10-01. Arlington, VA: National Science Foundation. Available from http://www.nsf.gov/statistics/seind10/

[4] Source: National Science Foundation, Division of Science Resources Statistics (2008). Science and Engineering Degrees: 1966-2006. Detailed Statistical Tables NSF 08-321. Arlington, VA. Available from http://www.nsf.gov/statistics/nsf08321/

[5] See Schaeffer & Presser (2003) for discussion of including a neutral point.

[6] See Dillman (1999) and Kaplowitz, Hadlock, & Levine (2000) for a review of the pros and cons of these data collection methods.

[7] The demographics of undergraduates enrolled (during the fall semester 2009) in the departments of biological science, psychology, and zoology were compared to the sample's demographic composition.

[8] Respondents with more than 15% of their data missing were excluded from the sample.

[9] See Costello & Osbourne (2005) for a discussion of why principal axis factor analysis is preferred to principal component analysis.

[10] The traditional examination of determining the factor structure from eigenvalues being greater than one is widely disputed (Costello & Osborne, 2005; Henson & Roberts, 2006).

[11] For discussion of the importance of reporting these measures in research, see: Hopkins, K. D., and Weeks, D. (1990). Tests for normality and measures of skewness and kurtosis: Their place in research reporting. *Educational and Psychological Measurement, 50,* 717-729; Chissom, B.S. (1970). Interpretation of the kurtosis statistic. *The American Statistician, 24,* 19-22; and DeCarlo, L.T. (1997). On the meaning and use of kurtosis. *Psychological Methods, 2,* 292-307.

[12] Negatively worded items may produce an artifactual factor during analysis and so the usefulness of negative items is unclear (Peterson, Speer, & Hughey, 2006; Spector, Van Katwyk, Brannick, & Chen, 1997).

[13] This cutoff was based on an evident gap in loadings and the factor loading guidelines from Comrey (1973) and Field (2005). Comrey asserts .45 as a "fair" loading and Field sets .30 as a minimum loading.

[14] The SPSS default of listwise deletion was used.

[15] In an analysis of the scale for goodness-of-fit, RMSEA (root mean square error of approximation) estimate was .08; SRMR (standardized root mean square residual) was .06. Both were within recommended values for acceptable model fit (Drewes, 2009). For more information on the factor analyses of the scale, see Schneider, J.S. (2010). *Impact of Undergraduates' Stereotypes of Scientists on their Intentions to Pursue a Career in Science.* (Doctoral dissertation, North Carolina State University, 2010).

[16] All 57 items used in the pilot instrument are provided in Table 1 and Table 2 for replication purposes. Further, the EFA provided displays the factor structure of the 22 item SOS Scale. In addition, the item stems and response scale are provided in the methods section.

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