Proficient in Pink? Exploring the Perceived Impact of Gender-Stereotyped Personal Protective Equipment on Women in Makerspaces

ISAM 2022 Paper No.: 55

6th International Symposium on Academic Makerspaces

Anastasia M. Schauer[1], Zoe Klesmith[2], and Katherine Fu[3]

[1]Anastasia M. Schauer; School of Mechanical Eng., Georgia Institute of Technology; e-mail: aschauer7@gatech.edu
[2]Zoe Klesmith; School of Computational Science and Eng., Georgia Institute of Technology; e-mail: zklesmith3@gatech.edu
[3]Katherine Fu; Dept. of Mechanical Eng., University of Wisconsin-Madison; e-mail: kate.fu@wisc.edu

Motivation & Background

In an academic context, makerspaces provide an extracurricular opportunity for students to develop skills and engage in hands-on projects [1]. Despite their growing popularity, makerspaces struggle to attract and retain a diverse user base [2]. This paper will focus on efforts to attract women to makerspaces, an environment that they have historically been excluded from [3], [4]. Because makerspaces are often characterized by collaboration and teamwork [5], the lack of a major demographic group, such as women, prevents the makerspace from enjoying the benefits of diverse teamwork, which include an expanded pool of talent, better complex problem-solving, and increased long-term growth [6], [7].

Many of the barriers discouraging women from using makerspaces are invisible. Much of the equipment traditionally found in a makerspace, such as hand tools, laser cutters, and 3D printers, are associated with a masculine stereotype [8]. Because women have been found to be less interested in joining and more likely to leave masculine-stereotyped spaces [9], this presents a problem for attracting and retaining women in makerspaces. While simply existing as a woman in a men-dominated space can trigger stereotype threat and reduced test performance in women [10], these particular types of biased situational cues increase identity threat and reduce women's sense of belonging in STEM environments [11].

A critical way to increase women's sense of belonging in makerspaces is by increasing their self-efficacy, or belief in their own ability for success [12]. Compared to men, women display lower levels of self-efficacy, even when their actual abilities are similar [13]. This bias is not only internalized by women, but also applied to them by STEM faculty members [14] and even their own parents [15]. Because self-efficacy is correlated with both entering and becoming successful in STEM fields [16], [17], boosting women's self-efficacy should be a key strategy in addressing the STEM gender gap.

Women who work in career fields dominated by men also face the jeopardization of their physical safety by ill-fitting personal protective equipment (PPE) [18] provided by companies who mistakenly assume that one size fits all. In addition to the physical safety aspect, wearing too-large PPE can affect women's sense of belonging, with some women comparing themselves to a "child" and receiving similarly negative comments from men at work whose identical PPE fit their bodies properly [19]. While PPE designed specifically for women does exist, it is a prime example of the "pink tax" [20], often available only in pink, at a higher price, and even with lower durability [21] than men's PPE.

Not only is there a lack of evidence to support women actually preferring pink PPE, but forcing women into pink PPE may reinforce their status as an "other" in a space dominated by men [22]. Women have also reported a desire to hide their "female body characteristics" in order to fit in at the workplace [21]. While some women may genuinely prefer the color pink or find it empowering to embrace their femininity, pink PPE may also serve as a constant visual reminder of being in the minority, potentially triggering the harmful effects of stereotype threat [11] and reducing women's self-efficacy. This paper aims to answer two research questions:

RQ1) How does wearing gender-stereotyped PPE impact the way that women in makerspaces are perceived by their peers?

RQ2) How does wearing gender-stereotyped PPE impact the way that women perceive themselves as part of the makerspace community?

Methodology

In order to answer the research questions stated previously, a Qualtrics survey was distributed online using Reddit [23] and Prolific [24]. Participants were limited to undergraduate and graduate engineering students from various institutions across the U.S. The survey was comprised of two parts. Part 1 answers RQ1 by presenting an image of a makerspace student employee and asking for the participants' perceptions of the person in the image. Images were accompanied by the following caption:

The woman/man in the photo is an undergraduate engineering student. She/he has a job in the on-campus makerspace, where she/he maintains the space and helps other users make projects. While working in the space, she/he has to wear the personal protective equipment (PPE) shown in the photo.

Participants were randomly assigned to one of four experimental conditions by varying whether they saw a man or woman, and whether the person was wearing pink or neutral (grey) PPE, and the pronouns in the caption above

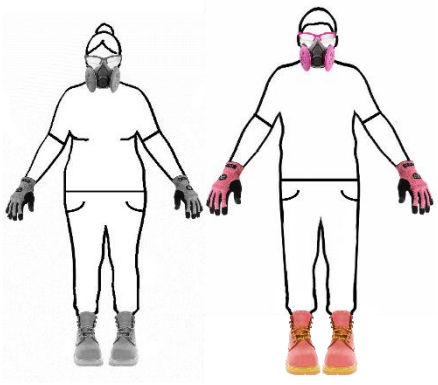

Fig. 1 Sample images from Part 1 of the study – woman in grey (left) and man in pink (right)

were displayed accordingly. Out of 73 total participants, 17 were in the "pink woman" group, 19 were in the "grey woman" group, 17 were in the "pink man" group, and 20 were in the "grey man" group.

The PPE shown in this study was steel-toed boots, safety gloves, a dust mask, and safety glasses. Two of the example images are shown in Fig. 1. In order to avoid biases resulting from physical appearance, PPE was modeled on line drawings based on the average body size of American men and women [25]. After viewing the image and reading the caption, participants answered a series of questions using an anchored 5-point Likert scale. Specific questions will be discussed in-depth in the Results & Discussion section of this paper.

Part 2 of the study answers RQ2 by putting participants in a situation where they are starting a job in a makerspace and have been given a set of PPE, as shown in Fig. 2, that they will need to wear during work. Participants were shown a caption along with two images: one of the set of PPE they were given, and one of the set that the rest of their coworkers wear. The caption was as follows:

Imagine you are an undergraduate engineering student. Today is the first day of your job in the on-campus makerspace, where you will maintain the space and help users make projects. When you get to your desk, you find a welcome package containing the personal protective equipment (PPE) shown in the photo.

After this, a photo was displayed of either a pink or grey set of PPE. The 34 participants who had seen a figure wearing pink PPE in Part 1 of the survey were assigned pink PPE for Part 2. The 39 participants who saw grey in Part 1 were assigned grey again in Part 2. The next part of the caption read:

You notice that your coworkers use this PPE:

Below was an image of the set of grey PPE. All participants were told that their coworkers wear grey PPE in order to replicate the common scenario that occurs in makerspaces, where the people who are given gender-stereotyped PPE in a makerspace also make up a minority of makerspace users. Participants were then instructed to imagine themselves in the scenario they read about in Part 2 and answer self-efficacy questions. Self-efficacy questions were developed based on previous work [14], [26]. These questions were adapted to two more scenarios in which participants were asked to

Fig. 2 PPE set images from Part 2 of the study –grey (left) and pink (right)

evaluate how they would be viewed by their coworkers in the makerspace, as well as the users of the makerspace. Finally, participants were shown the two sets of PPE side-by-side and asked to select which one they would prefer to use in the hypothetical scenario.

73 participants were recruited, although some participants declined to provide all demographic information. Of the participants who provided this information, 30 were women and 43 were men. The median age of the participants was 22, and 41 participants were white, 18 were Asian, Native Hawaiian, or other Pacific Islander, 5 were Hispanic or Latino, 3 were black or African American, 1 was American Indian or Alaska Native, and 4 identified with more than one race or other. When asked to categorize their level of experience in makerspaces as novice, beginner, proficient, advanced, or expert, the median participant categorized themselves as a beginner.

Results & Discussion

To analyze Likert scale data, the Wilcoxon signed-rank test was used as the nonparametric alternative to a t-test due to the non-normal distribution of data. The chi-square test was used to perform the analysis of the categorical data collected when participants indicated their preference of PPE. The metric developed by Moss-Racusin et al. [14] to evaluate the competence of a STEM student worker was modified for this paper. The "competency metric" was calculated by averaging together the evaluations of whether a person was "competent" and "qualified."

Part 1, in which participants were asked to make a judgement of a person, showed a surprising lack of significant results. Although the researchers intended for participants to make quick decisions and answer based on their first instinct, participants struggled to make decisions based on the limited information provided. Some participants commented on their lack of ability to make a judgement about the person due to the lack of context and information given about the makerspace.

As a result, no significant differences were found between experimental cases of participants' willingness to ask the person for help and to trust them with helping them in the makerspace. Additionally, gender and PPE color had no influence on participants' evaluations of the person's independence, success, professionalism, approachability, level of intimidation, competency metric, how unsure they were, or their level of fitting in at the makerspace.

Table 1 Results of Wilcoxon signed-rank tests comparing Likert scale responses between pink PPE and grey PPE cases from Part 2 of the study (a significance level of α = 0.05 was used and denoted by *)

	Gender	Test Statistic	Significance
At this job, I feel…			
Like I fit in	Women	195.0	< 0.001*
	Men	310.5	< 0.001*
Confident	Women	176.5	0.002*
	Men	281.5	0.007*
Creative	Women	143.0	0.086
	Men	212.0	0.492
Independent	Women	153.0	0.029*
	Men	211.5	0.498
Successful	Women	160.5	0.011*
	Men	245.0	0.093
Singled-out	Women	4.5	< 0.001*
	Men	40.0	< 0.001*
Unwelcome	Women	17.5	< 0.001*
	Men	69.0	< 0.001*
Empowered	Women	178.5	< 0.001*
	Men	271.0	0.017*
Professional	Women	160.0	0.014*
	Men	267.0	0.019*
Approachable	Women	129.0	0.286
	Men	217.5	0.397
Uncomfortable	Women	79.0	0.263
	Men	75.5	0.001*
Unsure of myself	Women	72.0	0.154
	Men	72.0	0.010*
Intimidated	Women	107.5	0.911
	Men	99.5	0.011*
My coworkers will think I…			
Am approachable	Women	161.0	0.012*
	Men	252.5	0.064
Fit in	Women	179.5	0.001*
	Men	295.5	0.002*
Users of the makerspace will…			
Think I am approachable	Women	104.0	1.000
	Men	172.5	0.632
Think I fit in	Women	181.0	< 0.001*
	Men	320.0	< 0.001*
Want to ask me for help	Women	112.5	0.736
	Men	187.0	0.964
Find me intimidating	Women	138.5	0.131
	Men	232.5	0.219
Trust me	Women	160.0	0.014*
	Men	260.0	0.033*

Interestingly, participants assessed people wearing pink PPE as more confident than people wearing grey PPE (z = 493.5, p = 0.045), although gender had no effect on this correlation.

Additionally, participants assessed the women makerspace workers as more creative than men (z = 440.0, p = 0.006), regardless of PPE color; this is supported by associations between women and more stereotypically "creative" makerspace usage, compared to more "technical" usage associated with men [27].

Considerably more significant results, as shown in Table 1, were found during data analysis of Part 2 of the study. Because this part of the study was built on perceptions of the self, rather than perceptions of others, participants had more context and personal connection to the scenario, leading to participants applying their related makerspace experiences, which were potentially negative, when evaluating the scenario. Although participants refrained from making negative judgements of others based on stereotypes in Part 1 of the study, participants appeared to apply those negative stereotypes to themselves and expect that others would also view them in a similar way. Additionally, the reminder that they were the only person in the environment dressed in pink PPE may have reinforced the effects of stereotype threat [11].

As shown by the analysis in Table 1, being in a scenario in which they were the only makerspace employee wearing pink PPE caused both men and women to have a more negative perception of how confident, fitting in, singled-out, unwelcome, empowered, and professional they felt. In particular, the lower feelings of empowerment while wearing pink PPE were unexpected; these results indicate that women in makerspaces derive more empowerment from fitting in rather than from standing out. Women felt that wearing pink PPE would cause them to feel less independent and successful in their roles, while men did not share these perceptions.

While men felt that wearing pink PPE instead of grey PPE would make them feel uncomfortable, again, likely because it was violating a gender stereotype, PPE color did not affect women's comfort level. However, women reported generally higher levels of discomfort than men (z = 418.0, p = 0.009), so PPE color did not impact their already high discomfort. This same trend existed for the feeling of being unsure of oneself (z = 437.0, p = 0.016), which is indicative of the low levels of self-efficacy women were earlier hypothesized to have in makerspaces. Men additionally reported that wearing pink PPE would make them feel intimidated, but women's level of intimidation was not affected by the color of their PPE. Regardless of PPE color, women felt that users of the makerspace would view them as less intimidating than men did, although whether participants viewed "intimidating" as a negative trait or as a positive indication of authority is unclear.

Being in the pink PPE scenario caused women to have a lower perception of their own computed competency metric (z = 160.0, p = 0.016), while men's competency metric was not significantly affected by their PPE color (z = 254.5, p = 0.067). Both men and women expected coworkers (z = 1008.0, p < 0.001) and users of the makerspace (z = 1029.5, p < 0.001) to view them with a lower competency metric if they wore pink PPE. This result supports the prediction that adherence to gender stereotypes in men-dominated spaces has a negative impact on self-efficacy, potentially as a result of stereotype threat.

Following the same trend as above, reading about the scenario in which they wore pink PPE caused women to feel that they would be viewed as more feminine by themselves (z = 160.5, p = 0.014), coworkers (z = 166.5, p = 0.006), and users of the makerspace (z = 166.5, p = 0.006). While the color of their PPE did not impact men's self-evaluated gender expression (z

= 231.0, $p = 0.219$), men felt that they would be viewed as less masculine by coworkers ($z = 302.0$, $p = 0.001$) and makerspace users ($z = 287.0$, $p = 0.005$) if they wore pink PPE. These trends could be due to the social backlash men receive from deviating from gender stereotypes [28], while this deviation did not affect the men's perception of themselves, perhaps because they knew the pink PPE was assigned to them, not a choice they made themselves.

Although women were not given information on the gender breakdown of the makerspace, they felt that their coworkers ($z = 840.0$, $p = 0.024$) and users ($z = 844.5$, $p = 0.020$) of the makerspace would not view them as fitting in as well as men do, regardless of PPE color: a trend which is again indicative of the greater diversity problem within makerspace environments [2]. Women felt that they could appear more approachable to their coworkers by wearing grey PPE to fit in with them.

Although, when given the choice, participants overall preferred the grey PPE to the pink PPE ($\chi^2 = 14.918$, $p < 0.001$), women did not exhibit a significant preference between the grey and pink PPE ($\chi^2 = 2.133$, $p = 0.144$). It did not appear that participants' choice of PPE was primed by their experimental group, as being shown either pink or grey PPE throughout Parts 1 and 2 of the experiment did not impact their PPE choice ($\chi^2 = 0.912$, $p = 0.340$).

Multiple women were careful to distinguish between being given the choice of wearing pink PPE, as in the final survey question, compared to being assigned pink PPE based on their gender, which is how they perceived the scenario in Part 2. Another described feeling conflicted when choosing between the PPE due to the feeling that "powerful" and "feminine" were difficult for her to reconcile. A few participants, both men and women, described not having a preference between the pink and grey PPE, as long as the pink worked as effectively as the grey.

Limitations & Future Work

One limitation in the design of this study was the existence of a benchmark in Part 2 that did not exist in Part 1. Participants appeared to struggle with forming judgements about the person they were asked to evaluate in Part 1, possibly because they were given very little context. In Part 2, participants evaluated themselves in a scenario where they knew what PPE the other employees of the hypothetical makerspace were wearing, giving them a point of comparison. This, in addition to the increased scrutiny with which participants evaluated themselves, likely contributed to the disparity in significant results between Part 1 and Part 2. Interesting future work would be to include an additional experimental case in Part 2 where some participants were assigned grey PPE and told that their coworkers all wore pink, in order to confirm whether the negative reactions were more related to gender stereotypes or to being singled out by PPE color.

Ideally, the two parts of this survey would be conducted on two separate pools of participants in order to reduce bias from Part 1 influencing responses to Part 2, but the two parts were combined in order to increase recruitment. For women taking the study, any sense of being a minority or not fitting in during Part 2 of the study may have been softened if they were in the case that saw another woman working in the makerspace in Part 1, where the representative demographic could trigger an increase in self-efficacy [13]. Similarly, seeing a person dressed in pink PPE during Part 1 may lessen the effect of being the only person in the makerspace dressed in pink PPE in Part 2.

Another limitation of this study is that it measures participants' evaluation of a purely hypothetical situation, although there is neural research to support the effectiveness of imagined scenarios compared to real ones [29]. It is likely that participants would have different perceptions of themselves or another person in real life, compared to viewing a photo and imagining a scenario. Future work could include outfitting participants with PPE and observing their experiences working in an actual makerspace.

Comments from the participants revealed that the purpose of the study was apparent to some participants, particularly ones in the pink PPE experimental group. This may have led to the good-subject effect influencing the results [30], or a conscious effort by participants to not exhibit gender bias or stereotypes while answering the survey questions. Some participants also noted that the amount and type of PPE utilized in this study was excessive for most makerspace environments, which some participants interpreted as an indicator of a lack of skill or confidence in the makerspace.

Conclusions

This paper contributes to the existing body of work on diversity, self-efficacy, and gender stereotypes in makerspaces. Ensuring that women feel comfortable in academic makerspaces is critical for retention throughout college and their careers, which results in positive outcomes for diverse teams of engineers. Part of maintaining a safe and comfortable makerspace is not only providing the proper safety and accessibility accommodations to everyone, but also ensuring that these accommodations are equitable and do not contribute to the discomfort of its users in any other way. This study found that wearing pink PPE, and particularly being isolated as one of the only people in an environment wearing pink PPE, is harmful for people's perceptions of themselves and the way they feel others perceive them.

In the hypothetical scenario in this study, no evidence was found to support women's preference for pink PPE over "standard" colored PPE, which begs the question of why companies are marketing PPE to women using stereotypes that women do not necessarily want to follow. In addition to this preference, wearing PPE that reinforces gender stereotypes causes women to experience lower self-efficacy and question their abilities in their workspace; not only do they view themselves as less competent, but they also feel that others are also viewing them as less competent. Perhaps one of the simplest ways to increase women's self-efficacy, and by extension their retention in STEM fields, is to provide them with PPE that will keep them safe without forcing them to stand out from the rest of their team. In addition to surmounting the first hurdle of providing PPE designed for women's bodies, academic makerspaces must also remain aware of the large impact that something as simple as buying

pink PPE can have on their makerspace culture.

References

[1] T. Barrett *et al.*, "A Review of University Maker Spaces," in *2015 ASEE Annual Conference and Exposition Proceedings*, Seattle, Washington, 2015, p. 26.101.1-26.101.17.

[2] A. C. Barton, E. Tan, and D. Greenberg, "The Makerspace Movement: Sites of Possibilities for Equitable Opportunities to Engage Underrepresented Youth in STEM," *Teach. Coll. Rec. Voice Scholarsh. Educ.*, vol. 119, no. 6, pp. 1–44, 2017.

[3] T. Capel, B. Ploderer, and M. Brereton, "The Wooden Quilt: Carving Out Personal Narratives in a Women-Only Makerspace," in *Proceedings of the 2020 ACM Designing Interactive Systems Conference*, 2020, pp. 1059–1071.

[4] S. Fox, "Feminist Hackerspaces as Sites for Feminist Design," in *Proceedings of the 2015 ACM SIGCHI Conference on Creativity and Cognition*, 2015, pp. 341–342.

[5] M. Galaleldin, F. Bouchard, H. Anis, and C. Lague, "The Impact of Makerspaces on Engineering Education," *Proc. Can. Eng. Educ. Assoc. CEEA*, 2016.

[6] K. Intemann, "Why Diversity Matters: Understanding and Applying the Diversity Component of the National Science Foundation's Broader Impacts Criterion," *Soc. Epistemol.*, vol. 23, no. 3–4, pp. 249–266, 2009.

[7] R. Strachan, A. Peixoto, I. Emembolu, and M. T. Restivo, "Women in engineering: Addressing the gender gap, exploring trust and our unconscious bias," in *2018 IEEE Global Engineering Education Conference (EDUCON)*, 2018, pp. 2088–2093.

[8] M. Melo, "How Do Makerspaces Communicate Who Belongs? Examining Gender Inclusion through the Analysis of User Journey Maps in a Makerspace," *J. Learn. Spaces*, vol. 9, no. 1, 2020.

[9] S. Cheryan, V. C. Plaut, P. G. Davies, and C. M. Steele, "Ambient belonging: How stereotypical cues impact gender participation in computer science.," *J. Pers. Soc. Psychol.*, vol. 97, no. 6, pp. 1045–1060, 2009.

[10] M. S. McGlone and J. Aronson, "Stereotype threat, identity salience, and spatial reasoning," *J. Appl. Dev. Psychol.*, vol. 27, no. 5, pp. 486–493, 2006.

[11] M. C. Murphy, C. M. Steele, and J. J. Gross, "Signaling Threat: How Situational Cues Affect Women in Math, Science, and Engineering Settings," *Psychol. Sci.*, vol. 18, no. 10, pp. 879–885, 2007.

[12] A. Bandura, "Self-efficacy: Toward a unifying theory of behavioral change," *Psychol. Rev.*, vol. 84, no. 2, pp. 191–215, 1977.

[13] M. A. Hutchison, D. K. Follman, M. Sumpter, and G. M. Bodner, "Factors Influencing the Self-Efficacy Beliefs of First-Year Engineering Students," *J. Eng. Educ.*, vol. 95, no. 1, pp. 39–47, 2006.

[14] C. A. Moss-Racusin, J. F. Dovidio, V. L. Brescoll, M. J. Graham, and J. Handelsman, "Science faculty's subtle gender biases favor male students," *Proc. Natl. Acad. Sci.*, vol. 109, no. 41, pp. 16474–16479, 2012.

[15] K. Muenks, E. G. Peterson, A. E. Green, R. A. Kolvoord, and D. H. Uttal, "Parents' Beliefs about High School Students' Spatial Abilities: Gender Differences and Associations with Parent Encouragement to Pursue a STEM Career and Students' STEM Career Intentions," *Sex Roles*, vol. 82, no. 9, pp. 570–583, 2020.

[16] R. W. Lent, H.-B. Sheu, D. Singley, J. A. Schmidt, L. C. Schmidt, and C. S. Gloster, "Longitudinal relations of self-efficacy to outcome expectations, interests, and major choice goals in engineering students," *J. Vocat. Behav.*, vol. 73, no. 2, pp. 328–335, 2008.

[17] J. S. Eccles, "Understanding Women's Educational And Occupational Choices: Applying the Eccles et al. Model of Achievement-Related Choices," *Psychol. Women Q.*, vol. 18, no. 4, pp. 585–609, 1994.

[18] Occupational Safety and Health Administration, "Women in Construction - Personal Protective Equipment." https://www.osha.gov/women-in-construction/ppe

[19] L. Galvez Puentes, "Fitting In: Analyzing the Fit of Safety Vests in the Construction Industry," California Polytechnic State University, 2020. https://digitalcommons.calpoly.edu/cmsp/481

[20] B. de Blasio and J. Menin, "From Cradle to Cane: The Cost of Being a Female Consumer," New York City Department of Consumer Affairs, 2015.

[21] H. Wagner, A. J. Kim, and L. Gordon, "Relationship between Personal Protective Equipment, Self-Efficacy, and Job Satisfaction of Women in the Building Trades," *J. Constr. Eng. Manag.*, vol. 139, no. 10, p. 04013005, 2013.

[22] S. Min, "Gendered role communication in marketing blue-collar occupational gear and clothing in the United States," *Fash. Text.*, vol. 2, no. 1, p. 24, 2015.

[23] I. Shatz, "Fast, Free, and Targeted: Reddit as a Source for Recruiting Participants Online," *Soc. Sci. Comput. Rev.*, vol. 35, no. 4, pp. 537–549, 2017.

[24] S. Palan and C. Schitter, "Prolific.ac—A subject pool for online experiments," *J. Behav. Exp. Finance*, vol. 17, pp. 22–27, 2018.

[25] National Center for Health Statistics, "FastStats - Body Measurements," 2021. https://www.cdc.gov/nchs/fastats/body-measurements.htm

[26] N. Betz and G. Hackett, "The relationship of career-related self-efficacy expectation to perceived career options in college women and men," *J. Couns. Psychol.*, vol. 28, pp. 399–410, 1981.

[27] R. Wittemyer, B. McAllister, S. Faulkner, A. McClard, and K. Gill, "MakeHers: Engaging Girls and Women in Technology through Making, Creating and Inventing," Intel, 2014.

[28] C. A. Moss-Racusin, "Male backlash: penalties for men who violate gender stereotypes," in *Gender in Organizations*, Edward Elgar Publishing, 2014, pp. 247–269.

[29] M. C. Reddan, T. D. Wager, and D. Schiller, "Attenuating Neural Threat Expression with Imagination," *Neuron*, vol. 100, no. 4, pp. 994-1005, 2018.

[30] A. L. Nichols and J. K. Maner, "The Good-Subject Effect: Investigating Participant Demand Characteristics," *J. Gen. Psychol.*, vol. 135, no. 2, pp. 151–166, 2008.