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Empathy or Science? Empathy Explains Physical Science Enrollment for Men and
Women

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Abstract

Those in the physical sciences work to understand relationships among non-social entities and this may come at a cost to their understanding of social relationships. Alternatively, it could be that those in the physical sciences differ in how comfortable they feel in social situations. Prior research had been confined to looking at differences between particular subject majors (e.g., humanities) and physical sciences, leaving open the possibility that people choosing subjects like psychology or biology might differ on empathy. University students (N=404) majoring in humanities, social science, life science, or physical science completed the Empathy Quotient (EQ). Confirmatory factor analysis showed three-factors of the EQ, and these were used in multinomial logistic regression. Empathy differences made a unique contribution to explaining subject major choice. We found that greater levels of empathy predicted membership in social and life sciences, while lower levels of empathy predicted physical sciences enrollment.

Keywords: Empathy; College Students; Gender; Subject Major; Empathy Quotient.

1. Introduction

People who study science have been described as lacking in empathy when compared to people who study humanities, possibly explaining the disparity between men and women's choices in science-related majors at university (Billington, Baron-Cohen, & Wheelwright, 2007; Lai et al., 2012; Wakabayashi, 2013). Early findings suggested that these gender differences were explained by women's academic performance (Cole, 1997; Rossi, 1965). However, more recent evidence from a sample of 127,000 undergraduate students has found that, regardless of performance, women majoring in science have a higher rate of switching their subject major within the first year when compared to men (Dickson, 2010; Seymour & Hewitt, 1997). Thus, we propose that the explanation is incomplete, such that prior research has failed to examine individual difference factors accounting for choice in subject major. For example, those in the physical sciences seek to understand relationships among non-social entities (Feist, 2013) and this may come at a cost to their empathic understanding of social relationships, suggesting an important role of empathy in subject major selection regardless of gender (Manson & Winterbottom, 2012). This begs the question as to whether individual difference factors, which typically differ between men and women (Moriguchi, Touroutoglou, Dickerson, & Barrett, 2014; Rubinstein, 2005; Thakkar et al., 2014; Thomson, 2014), could explain why women are underrepresented in specifically physical science majors? Further, research is lacking in specifying the generalizability to all fields of science (Feist, 2013).

1.1. Gender and science

There is a lack of college enrollment into the sciences by females when compared to males (Beede et al., 2011; Chen & Weko, 2009; Le, Robbins, & Westrick, 2014; Miller, Slawinski Blessing, & Schwartz, 2006; O'Brien, Blodorn, Adams, Garcia, &

Hammer, 2014). Gender associated variance in science achievement is what was primarily thought to prevent women from pursuing advanced degrees in the sciences (Katz, Allbritton, Aronis, Wilson, & Soffa, 2006). These differences may be seen as early as 8-9 years of age, subsequently increasing through middle and into high school (Beller & Gafni, 1996; Lindberg, Hyde, Petersen, Linn, 2010). However, examining college grade point average in science between females and males revealed that performance was equal at the undergraduate level (Dickson, 2010; Glynn, Taasobshirazi, & Brickman, 2007), which further supports evidence against the notion that women are as less competent than men in science (see Brainard & Carlin, 1998; Bridgeman & Lewis, 1996; Gallagher & Kaufman, 2005; Hyde, Lindberg, Linn, Ellis, & Williams, 2008; Stewart, 1998). Arguably, there could be a mismatch between the learning environment women and men prefer and the learning environment associated with particular subject fields (Murphy, Steele, & Gross, 2007); women could then be pushed out of, or feel unwelcome in, the science classroom (Cheryan, Plaut, Davies, & Steele, 2009). Teachers may teach science in the traditional manner of approaching education from a logical perspective that is devoid of considering the importance of the socio-emotional climate in the classroom (Arghode, Yalvac, & Liew, 2013). Therefore, less empathic teaching environments may push away females from science subjects (Demetriou, Wilson, & Winterbottom, 2009) yet may facilitate male enrollment. Indeed, men make up the majority of those in the science and engineering profession (National Science Foundation [NSF], 2015).

However, gender may not be as important as considering individual differences in empathy, such that those with higher empathy may gravitate toward particular subjects that, in the short-term of a university career, nurture cooperative learning and social

interactions in the classroom. In the long-term of career-choice, achievement in particular subjects may rely on high levels of empathic responding (e.g., clinical application of science).

1.2. Empathy and science

Empathizing involves an ability to understand other people's mental states and emotions, and be interested in the social connection with others (Kim & Lee, 2010). The ability to empathize is of particular importance for those successfully pursuing medical and clinical careers (Barak, 1990; Lambert & Barley, 2001; Hojat et al., 2002; Rosenfield & Jones, 2004). Further, empathy has been shown to be associated with altruistic ethical decision-making (Brown, Suatter, Littvay, Sautter, & Bearnes, 2010; Schwarz, 2000), which may indeed influence an individual's career choice. Whilst women have been reported to have higher levels of empathy than men (Manson & Winterbottom, 2012; Willer, Wimer, & Owens, 2015), research by Billington and colleagues (2007) provides strong evidence for a "brain type" (p.263) in explaining choice in academic career. By classifying 415 undergraduate students by their empathizing and systemizing abilities, Billington et al. (2007) found that those enrolled in physical sciences exhibited low empathizing and high systemizing abilities, whilst the converse was true for those in humanities. These "brain types" were a stronger predictor than the individual's biological sex as a determinant of subject major enrollment. This may be explained by those majoring in humanities having a "people orientation" due to their higher levels of empathy (Feist, 2013). This "people orientation" stands in contrast to a "thing orientation" (Feist, 2006; Graziano, Habashi, & Woodcock, 2011; Prediger, 1982) characterizing those who study physical sciences (Feist, 2013). That is, those in the

physical sciences reclusively work to understand relationships among non-social entities (Feist, 2013). Further, as those studying physical sciences are shown to favor a systemizing thinking style over empathizing (Billington et al., 2007;), this may impact the social environment for learners and educators in the physical sciences (Osborne & Dillon, 2008; Vedder-Weiss & Fortus, 2011). Science may be a solitary environment where investigations and writing are done alone and teaching styles are less person-centered (Vedder-Weiss & Fortus, 2011). Scientists have been found to prefer to be left alone (Feist, 2013; Wilson & Jackson, 1994). In fact, people in science related fields were more prone towards introversion rather than extraversion and being generally outgoing (Feist, 1998; Lounsbury et al., 2012). Thus, this focus toward solitary activities may stifle an interest in other people, possibly explaining empathy differences between physical science and other subjects; however, this may generalize to all science-related fields, which encourage similar types of activities.

1.3. Multidimensional structure of empathy

Present methods focusing on dispositional empathy tend to view it as a multidimensional concept made up of both cognition and emotion (Dadds et al., 2009; Davis, 1980). Recent research has shown it to be comprised of three distinct and equally important factors, cognitive, emotional reactivity (affective), and social skills (Allison, Baron-Cohen, Wheelwright, Muncer, 2011; Berthoz, Wessa, Kedia, Wicker, & Grezes, 2008; Gronholm, Flynn, Edmonds, & Gardner, 2012; Lawrence, Shaw, Baker, Baron-Cohen, & David, 2004). The cognitive element of empathy has been described as the ability to which a person can identify with and understand another person's point of view (Baron-Cohen, 1995). The affective element has been described as the ability to which a

person experiences feelings such as sympathy or concern. Dadds and colleagues (2009) refer to cognitive empathy as the difference between knowing the ‘how’ and ‘why’ of other people’s feelings and affective empathy as ‘feeling’ the emotions of another person. In addition to these elements of understanding others mental states, social skills relate to an individuals’ behavior, in particular, their ability to interact within social situations. Further to the discussion on empathy and science, it could be that those in the physical sciences differ in how comfortable they feel in social situations, implicating the importance of measuring perception of social skills in addition to empathy. Indeed, a focus on solitary activities may limit exposure to social situations in which people learn to engage flexibly with others (see Feist, 2013). Thus, it could be that those in the physical sciences differ in how comfortable they feel in social situations. Yet research is lacking in examining the multidimensional structure of empathy with regard to humanities and the three main branches of science; social sciences, life sciences, and physical sciences (Feist, 2013).

2. Aims

Prior research has been confined to looking at differences between a particular subject area (e.g., humanities) and physical sciences. Thus, prior research neglects the possibility that people choosing subjects like psychology or biology might differ on empathy. For example, many of the social sciences and life sciences (e.g., psychology and biology) draw from a broad range of skills that integrate social studies and math/statistical enquiry, which may be related to a lack of empathy or social skills (Furnham & Crump, 2013). The aim of this study was to determine if empathy was a stronger predictor for subject major (physical science, life sciences, social sciences, and

humanities) enrollment when compared to gender. Thus, it may be that women are less represented in the physical sciences, which may be due to their higher levels of empathy. Only by looking at the unique contribution of these factors, can possible explanations emerge. Further, we examined the multidimensional structure of empathy using the Empathy Quotient (Baron-Cohen & Wheelwright, 2004), and used the resulting factors to statistically predict subject major.

3. Method

3.1. Participants

Students ($N=404$, 51% male) were recruited from undergraduate prerequisite courses in philosophy, physics, and anthropology. The racial-ethnic identification of the participants were, 28.4% Caucasian, 25.2% Asian American, 22.5% Asian, 10% Pacific Islander/Native Hawaiian, 2.2% European, 2.9% Hispanic-American, 2% African-American, 1.2% Mexican/Central and South American, 0.7%, Middle Eastern, 0.5% Native American/Alaskan, 3.9% indicated more than two ethnicities and 0.5% failed to report. The average age was 22.09 ($SD = 6.14$). Students' year of study ranged from first year to fourth year.

3.2. Instrument

The Empathy Quotient (EQ) provides a total score from 40 items, which captures cognitive and affective empathy (Baron-Cohen & Wheelwright, 2004). The EQ has been established as the most comprehensible, reliable, and valid empathy scale to date. With a test-retest reliability of $r = .97$, and a Cronbach's alpha measured validity of .92, it scores well, and is ranked highly by other researchers in the field (Baron-Cohen & Wheelwright, 2004). Furthermore, the use of the Rasch model for analysis provides an excellent level

of construct, with an item reliability of .99, and person reliability of .92 (Allison et al., 2011). The convergent validity has also been assessed and confirmed in correlation to the 'Reading the Mind in the Eyes' Test (Baron-Cohen, Wheelwright, Hill, Raste, & Plumb, 2001). In this study, the EQ had a Cronbach's alpha coefficient of .85, which suggests it is a reasonably reliable self-assessment measurement, and matches other non-US sampled studies (see, Muncer & Ling, 2006). Recently, research has provided evidence towards a three-factor model on the EQ providing a more accurate measure of empathy subtypes (Muncer & Ling, 2006; Allison et al., 2011). These three factors are, cognitive empathy, emotional reactivity, and social skills.

3.3. Procedure

Participants were administered the EQ within classrooms. Classes ranged in size with no less than eight students and no more than 150 participants in an administration. Each participant was instructed to complete the EQ without the influence of their peers, and after 15 minutes the questionnaires were collected. For those who chose not to participate they were asked to leave the EQ blank. Participants who failed to complete the entire EQ ($n=37$), had not decided on a major ($n=4$), or selected a double-major across two different categories ($n=5$) were omitted from the study. Each participant was asked what subject major they were majoring in for their degree and these were then categorized into four main disciplines: Social Sciences consisted of, psychology, sociology, anthropology, economics, political sciences, education, social work, Asian studies, and child development; Humanities consisted of languages, arts, theology, and philosophy; Life Science consisted of, medical and health related fields, and biology; Physical Sciences included, engineering, computer sciences, earth sciences, mathematics,

and sciences. Gender enrollment varied, with men having a dominant presence in Physical Science (82.5%) and Humanities (57.4%), whilst women were more prevalent in Social Science (57%) and Life Science (69.6%).

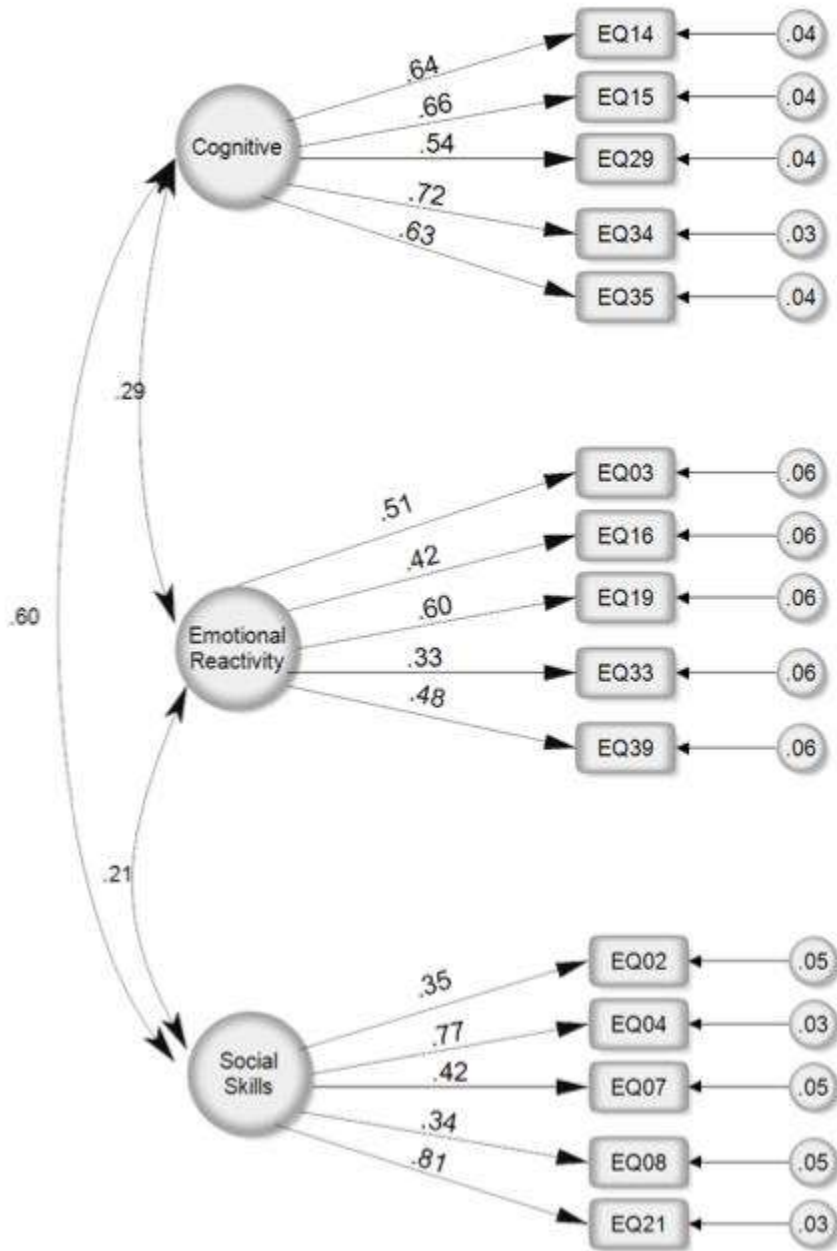
4. Results

4.1. Confirmatory Factor Analysis on the Empathy Quotient

We used Mplus 7.2 (Muthen & Muthen, 2008-2012) with maximum-likelihood estimation to perform a confirmatory factor analysis – the aim was to confirm that a three factor model fit the data. Confirmatory methods are preferable over exploratory methods, particularly when prior research directs a specific structure with specific items being associated with each factor. Thus, we tested the fit of the model identified by Muncer and Ling (2004) which included 15 items. There was no missing data in the present study, so we analyzed the full data set. To examine whether the model fit (or explained) the data well, we used chi-square: a nonsignificant chi-square indicates good fit. Yet, chi-square with sample sizes as large as that used in the present study ($N=404$) is often significant with even trivial deviations from a perfect model. Hence, we used to three indices of practical fit as suggested by prior research (TLI, Tucker & Lewis, 1973; CFI, Bentler, 1990; and RMSEA, Browne & Cudeck, 1993). A comparative fit index (CFI) and $TLI > .90$ suggests an acceptable model fit (Bentler & Bonett, 1980) and $> .95$ suggests a good model fit (Hu & Bentler, 1999). A root mean square error of approximation (RMSEA) $< .08$, suggests an acceptable fit; an RMSEA $< .06$ suggests a good fit (Browne & Cudeck, 1993). Although chi-square was significant, the indices of practical fit suggest that the model tested had an acceptable fit, $\chi^2(df=87)=163.59$, $p < .05$; $TLI = .92$, $CFI = .93$, $RMSEA = .047$, 90% CI=.036 - .058.

The standardized parameter estimates and standard errors are shown in Figure 1 provide an index of the association of each item with its factor with parameter estimates of one indicating a perfect relationship. The strongest indicators for the cognitive factor were items 34 and 15. For emotional reactivity, the strongest item was 19, and for social skills, the strongest items were 4 and 21. Examining the standard errors, they were similar across the factors, indicating similarly adequate fit across all factors. However, the emotional reactivity factor had only moderate factor loadings (only one $> .60$) and higher standard errors than the other two factors, indicating this factor had higher residual error not accounted for by the items. The factors were correlated with each other, since they all indicate different facets of empathy. The strongest factor correlations were between cognitive empathy and social skills ($r = .60$), while the correlations between the other factors were weaker, possibly due to the larger error variance for emotional reactivity in relation to the other factors (see Figure 1).

Figure 1. Three factor model of the Empathy Quotient.



Females were higher in emotional reactivity ($M=6.20$, $SD=2.08$), social skills ($M=5.77$, $SD=2.50$), and cognitive empathy ($M=5.86$, $SD=2.38$) compared to men ($M=4.98$, $SD=2.25$; $M=5.16$, $SD=2.37$; $M=5.40$, $SD=2.42$; respectively). These gender differences were significant for emotional reactivity ($t(402)=5.68$, $p<.001$, $d=.56$), and

social skills ($t(402)=2.53, p<.05, d=.25$), but not cognitive empathy ($t(402)=1.95, p=.05, d=.19$). Age was unrelated to the empathy factors.

4.2. Prediction of Subject Major by Demographic Variables and Empathy

Multinomial logistic regression was used to predict subject major, testing the idea that those in the physical sciences were lower in cognitive empathy, emotional reactivity, and social skills than the other subject major classifications (humanities, social sciences, and life sciences). A two-step multinomial logistic regression was conducted to compare physical sciences against each of the other subject majors. On the first step gender and age were included, and this was significant, $\chi^2(6, N=391) = 82.07, p<.001$. Adding the three empathy factors to the model at step two resulted in a significant overall model fit. The overall model was significant, $\chi^2(15, N=391) = 138.92, p<.001$. The improvement in fit at step two, including the empathy factors, was also significant, $\Delta\chi^2(9, N=391) = 56.86, p<.001$. Table 1 notes odds ratios and confidence intervals to compare the other classifications against physical science. Odds ratios greater than one reflect the odds of people being classified in one group over the other (i.e., the comparison group with respect to being in physical sciences) based on the level of the independent variable. Confidence intervals including one were non-significant. Confidence intervals may also be used to estimate effect sizes, with intervals further away from one indicating greater effect sizes.

Table 1. Multinomial logistic regression analysis for physical sciences

	Odds Ratios (95% CI)			
	Social			
	Sciences vs. Physical	Humanities vs. Physical	Life Sciences vs. Physical	Chi-square (df=3)
Gender				
(female)	4.99*** (2.44-10.18)	3.15** (1.47-6.75)	8.10*** (4.02-16.32)	41.14***
Age	1.01 (.93-1.09)	1.01 (.94-1.10)	.86** (.78-.95)	17.00**
Emotional				
Reactivity	1.25** (1.08-1.45)	1.17 (1.00-1.36)	1.16* (1.01-1.34)	9.39*
Cognitive				
Empathy	1.25** (1.08-1.45)	1.20* (1.03-1.41)	1.20* (1.03-1.38)	9.93*
Social Skills	1.27** (1.09-1.47)	1.24** (1.06-1.45)	1.23** (1.06-1.42)	12.09**

Note: * $p < .05$; ** $p < .01$; *** $p < .001$

Females were more likely to be in the non-physical science majors, and younger people were more likely to be in life sciences than physical sciences. Females were 76-89% more likely to be in any other subject major than physical sciences. People higher in social skills and cognitive empathy were more likely to be any other subject major than physical sciences. For every unit increase in social skills there was a 23-27% increase in the odds of being in subject majors other than physical sciences. For every unit increase in cognitive empathy there was a 20-25% increase in the odds of being in subject majors

other than physical sciences. However, people in humanities did not differ significantly in emotional reactivity from people in physical sciences. The largest effect for emotional reactivity was for social sciences versus physical sciences with every unit increase in emotional reactivity translating to a 25% increase in the odds of being in social sciences over physical sciences. People higher in emotional reactivity were more likely to be enrolled in life sciences or social sciences than in physical sciences.

5. Discussion

This study confirms that factor scores on the empathy quotient provided unique predictive power to explain enrollment in physical science college majors, even when taking into account one of the largest predictors (i.e., gender) of college major choice. The present findings dovetail with prior research (see Billington et al., 2007) and show that the difference between physical science and humanities majors was generalizable to other subject majors, including social sciences and life sciences. To the authors' knowledge, this is the first study to date to test the three-factor model identified in prior research (see Muncer & Ling, 2006; Allison et al., 2011) using a demographically diverse population. The three-factor model was shown to be a good fit. Expanding on prior research by Billington and colleagues (2007), including the three factors revealed that levels in social skills and cognitive empathy explained enrollment in physical science majors. However, emotional reactivity was less consistent in predicting differences across the subject majors.

For the first time, we were able to show that people choosing physical sciences are different from those choosing humanities, social sciences, and life sciences as they reported lower empathy and social skills. Prior research had been limited to looking at

differences between humanities and physical sciences, leaving open the possibility that people choosing subjects that require broader and more integrative skills, such as statistical enquiry and social studies (e.g., psychology and biology) may have different empathic profiles. It could be argued that those in social sciences and life science choose careers that are more service orientated, which rely on empathic concern. Performance in these disciplines requires high levels of empathy in order to be successful (Wright, McKendree, Morgan, Allgar, & Brown, 2014). We replicated prior findings that people with higher empathy were more likely to be in humanities than physical sciences (Billington et al., 2007). Further, this was most evident for social skills and cognitive empathy within the empathy facets, which previous research had neglected to unpack. In addition, the present study found that empathy differences predicted membership in social sciences and life sciences as compared to physical sciences. The fact that humanities and physical sciences did not differ significantly in emotional reactivity may be seen as consistent with prior research, such that engineering students have been found to score lower on cognitive empathy, but did not significantly differ on affective empathy (Rasoal, Danielsson, & Jungert, 2012).

Prior research has broken down facets that look at empathizing and systemizing in relation to students majoring in physical sciences and humanities (Billington et al., 2007). Those in humanities show greater empathizing cognitive styles, representing a “people orientation”. This stands in contrast to a “thing orientation” characterized by those studying physical sciences who work to understand relationships among non-social entities (Feist, 2013). This focus on non-social entities may come at a cost to their understanding of social relationships. Our findings suggest those in physical sciences

differ in how comfortable they feel in social situations. Scientists have been found to prefer solitary activities (Feist, 2006; Feist, 2013; Wilson & Jackson, 1994), which may stem from their non-affiliative behavior and inclination toward introversion (Lounsbury et al., 2012). This lack of social interest and gravitation away from social activities may explain our largest findings with social skills and cognitive empathy. Further, these doubly-affecting deficits may explain a choice to engage with subjects that match their self-perception, given that science-related fields may support a learning environment devoid of feelings and emotions (Arghode et al., 2013).

Our findings highlight the importance of the affective and cognitive empathy distinction, and support previous work showing gender differences in empathy (Manson & Winterbottom, 2012; Muñoz, Qualter, & Padgett, 2011). Also, gender disparities in subject majors matched that of the current data, finding that men are largely more representative in physical sciences than women; whilst women were substantially more represented in life sciences. Given the unique effects of empathy in our models and the findings regarding gender, this could be due to learning environments in science classrooms (Vedder-Weiss & Fortus, 2011). Indeed, if female students do not feel welcome or comfortable in a logical and emotionally-absent learning context (see e.g., Arghode et al., 2013), they may opt-out of these major subject areas. However, our findings suggest these gender differences are not as important as empathy differences. Therefore, both men and women would be expected to choose physical science majors when their empathy levels are lower. Conversely, men and women with higher levels of empathy are more likely to be drawn to people-orientation subject majors (e.g., nursing

[Penprase, Oakley, Ternes, & Driscoll, 2014]). Further research is needed to unpack these effects over time to determine directions of effects, however.

Whilst women are well represented in life science and social science majors there remains large gender disparities in the physical sciences with men outnumbering women (NSF, 2015). Prior research has shown that a supportive academic environment is integral for students' positive perception of their subject major (Ramsey, Betz, & Sekaquaptewa, 2013). However, women majoring in science, technology, engineering, and mathematics (STEM) have been shown to face less socially supportive environments (Cohn, 2000; Lyness & Heilman 2006; Murphy, Steel, & Gross, 2007). Our results compliment this prior research, showing that students in physical science majors, regardless of gender, have lower levels of social skills and cognitive empathy, which may impact the social learning environment. This, in conjunction with women having reportedly higher levels of empathy (Billington et al., 2007), may be an explanation as to why women select other scientific fields of study other than the physical sciences.

5.1. Limitations

As with any study, the present study has some limitations. We were unable to determine whether people with lower social skills and empathy choose physical sciences versus other subject majors. Selection effects may account for differences observed given that people strive for person-environment fit. For example, differences were observed in high-school students intending to study certain majors, matching their counterparts at university in particular personality traits (Balsamo et al., 2013). However, longitudinal studies document change over time in empathy levels based on subject major choice (Hojat et al., 2004; Konrath et al., 2011; Newton, Barber, Clardy, Cleveland, O'Sullivan,

2008). In addition, these findings are based on self-report measures and shared method variance may explain the relationships found. Future research should consider using peer reports of empathy, for example.

6. Conclusions

The strengths of this study include that it was based on a large sample of students from a demographically diverse population. In addition, this sample accommodated a wide distribution of subject majors allowing for comparisons across four major subject areas. We also used the three factors of empathy to explore the source of differences in empathizing. The present study showed that empathy deficits in those who study physical sciences differ meaningfully from those in other science majors including social sciences and life sciences. Although males and females differed in subject major and empathy, empathy differences made a unique contribution to explaining subject major choice. This study is important in that it provides strong evidence that biological gender is not the best determinant of college major choice. We were able to show that the low empathic profile seen in prior research is not generalizable to all scientific subject majors. Rather, those in the social and life sciences, who require multidisciplinary and integrative skills, were highest in social skills, and cognitive and affective empathy. Further, we provide evidence that the empathy-deficiency link in predicting physical science enrollment from any other subject major is largely explained by empathic social skills and understanding others' mental states than for feeling an emotional connection with other people.

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