Commentary

Psychological Science
2023, Vol. 34(12) 1404–1410

DOI: 10.1177/09567976231202450
www.psychologicalscience.org/PS

The Gender-Equality Paradox in Chess Holds Among Young Players: A Commentary on the Vishkin (2022) Study

Clotilde Napp[1,2] and Thomas Breda[2,3]
[1]Université Paris Dauphine, DRM; [2]CNRS; and [3]Paris School of Economics

Abstract

Vishkin (2022) shows that female participation in chess is lower in more gender equal countries (the "gender-equality paradox") but that this relation is driven by the mean age of the players in a country, which makes it more of an epiphenomenon than a real paradox. Relying on the same data on competitive chess players (N = 768,480 from 91 countries) as well as on data on 15-year-old students (N = 312,571 from 64 countries), we show that the gender-equality paradox for chess holds among young players. The paradox also remains on the whole population of chess players when controlling for the age of the players at the individual rather than at the country level or when controlling for age differences across countries. Therefore, there is a gender-equality paradox in chess that is not entirely driven by a generational shift mechanism as argued by Vishkin (2022), and previous explanations for the paradox cannot be dismissed.

Received 2/15/22; Revision accepted 7/8/22

The gender-equality paradox refers to the fact that more gender-egalitarian, wealthy, developed countries exhibit larger gender differences than less economically developed countries, although we would expect those countries to reduce such differences. This paradox has already been shown in a number of domains such as gender differences in choices of occupations (Charles & Bradley, 2009; Stoet & Geary, 2018), personality traits (Costa et al., 2001; Mac Giolla & Kajonius, 2019), values (Schwartz & Rubel-Lifschitz, 2009), and preferences (Falk & Hermle, 2018).

In a recent study, Vishkin (2022) analyzed the gender-equality paradox for chess participation. Relying on exhaustive data on participation in chess tournaments from the World Chess Federation[1] (Fédération Internationale des Échecs, or FIDE; N = 803,485 across 160 countries; age range = 3–100 years), Vishkin first provided empirical evidence that participation of female players is indeed higher in less gender-egalitarian countries (according to two widely used measures). However, Vishkin showed that the mean age of the players in a country fully accounts for this relationship and concluded that it is then not paradoxical but, rather, is an "epiphenomenon of gender equality," driven by the age structure of the players. On the basis of this result, the author suggested that a generational shift mechanism explains the gender-equality paradox—individuals in more gender-egalitarian countries being older and older individuals holding less egalitarian values—in particular toward chess. Moreover, the author argued that explanations previously considered in the literature for the gender-equality paradox (Breda et al., 2020; Charles & Bradley, 2009; Lippa et al., 2010; Stoet & Geary, 2018) cannot be valid for chess.

In this commentary, we argue (a) that the gender-equality paradox in chess is not an epiphenomenon entirely driven by the age structure of the players, (b) that the generational shift mechanism does not account for the gender-equality paradox, and (c) that previous explanations remain plausible for chess. Our main point is the first and we prove it through two different approaches. First, we show that the gender-equality paradox remains valid on the whole sample of competitive chess players considered in the study by Vishkin

Corresponding Author:
Clotilde Napp, Université Paris Dauphine, DRM
Email: clotilde.napp@dauphine.psl.eu

(2022), when the age structure of players is controlled for in alternative and finer ways than in the latter work. To do so, we either control for players' age at the individual level or average out the effect of players' age on their gender in country-level analyses. Second, we show that the gender-equality paradox holds among young chess players of the same age, which would not be possible if the gender-equality paradox in chess were fully explained by the age structure of the players.

In Study 1, we relied on the same data set as in the Vishkin (2022) study, considering the whole sample for some analyses and restricting our attention to specific age ranges for others. In Study 2, we relied on the Programme for International Student Assessment (PISA2012), with more than 300,000 observations about chess playing at 15 years old in more than 60 countries. This data set usefully complements Study 1 because it targets a given young age and because it focuses on recreational chess playing versus competitive chess in Study 1.

Statement of Relevance

More gender-equal and developed countries are expected to have lower gender differences in all domains. The gender-equality paradox is the fact that the opposite has been shown to hold true in some domains. A better understanding of this paradox is important for the understanding of gender differences and their origin. Vishkin (2022) shows that there is a gender-equality paradox in chess participation but that it appears to be an epiphenomenon since it is driven by the age structure of the players. He concludes from this result that a generational shift mechanism likely explains the cross-country pattern in chess. We show that there is a *paradoxical* cross-country relationship between female participation in chess and countries' level of gender equality and development cannot be simply explained by the age structure of the players and requires other explanations.

Open Practices Statement

Databases and codes allowing the replication of the results have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/3kj6u.

Study 1: FIDE Data

Method

Data set. Because Vishkin's (2022) data could not be accessed, data on chess participation were retrieved on January 15, 2022, from the FIDE website (https://ratings.fide.com/download.phtml). FIDE receives reports on games and tournaments played in national chess federations and international competitions and compiles a list of players on the basis of this information. The list contains information about active or inactive players and their federation (i.e., country), gender, and birth year. We essentially considered the same exclusion criteria as in the Vishkin study. We excluded participants with missing information for country or birth year. We also excluded inactive players as well as participants with improbable birth years (before 1921 or after 2018). In our analysis and to ease the discussion, we kept the same 91 countries as in the Vishkin study (i.e., countries with at least 1,000 players). The final sample of all players (all ages) comprised 768,480 players originating from 91 countries (16.1% female). We also considered various age ranges: younger than 13, 13 to 16, 17 to 20, 20 to 25, 25 to 35, 35 to 50, and older than 50 years. The number of players in these age ranges varied between 100,000 and 150,000; female participation decreased sharply with age, from 23.4% for players younger than 13 years to 14.5% for 25- to 35-year-olds and 4.7% for players older than 50 years (see the Supplemental Material available online).

Measures. To measure female participation in chess by country, we considered the share of female players among all chess tournaments. For measures of gender equality and development, we first used the two measures of country-level gender equality adopted by Vishkin (2022): the Global Gender Gap Index (GGGI 2019) from the World Economic Forum and the Gender Inequality Index (GII 2020) from the United Nations Development Programme. These two composite measures quantify gender-based disparities across the four areas of health, educational attainment, economic participation, and political empowerment. These measures capture vertical rather than horizontal gender segregation (with which they do not necessarily covary; for discussions on the multifaceted nature of gender equality, see Charles, 2017; Knight & Brinton, 2017; Richardson et al., 2020). We considered the opposite of the GII, denoted by M-GII, so that higher values of our measure correspond to higher levels of equality.

To these measures of gender equality in practice, we added a measure of gender equality in some specific values from the World Value Survey (Wave 7, 2017–2020) because, as recalled by Vishkin (2022), the gender-egalitarian ideology can play a role in the gender-equality paradox. The index of equality in values relies on the agreement with items about gender equality in

education, in the labor force, and in politics. We also used country-level measures of economic wealth and development commonly used in the literature on the gender-equality paradox (Charles & Bradley, 2009; Falk & Hermle, 2018; Lippa et al., 2010). We considered the most common measure of economic wealth, the (per capita) gross domestic product (GDP) taken from the World Bank data, and averaged over the years 2005, 2010, 2015, and 2020. We also considered the Human Development Index (HDI) from the Human Development report, which incorporates measures of education and life expectancy on top of economic wealth. We also averaged it over the years 2000, 2010, 2015, and 2019 to get a more stable picture of development from the 2000s onward. To these two measures, we added an indicator of economic, social, and cultural status provided by PISA, which captures inequalities across students in parental education, parental occupation, and home possessions.

We refer to these six measures of gender equality, wealth, and development as GED measures. We recall that Vishkin (2022) considered only the first two. We finally considered the measure of median age in the countries as well as the percentage of the population younger than 20 years from the Central Intelligence Agency's Factbook.

Country-level and individual-level analyses. Most of our analyses were conducted at the country level using regression models of the following type:

$$Fem\_Part_c = \alpha_1 GED_c + \beta_1 D_c + \varepsilon_c, \quad (1)$$

where Fem_Part_c is the share of female chess players in country c, GED_c is one of the GED measures of country c, and D_c is a given control, such as the median age of country c. These models permit analyzing how female representation in chess is related with countries' GED level. Before conducting any regression, we standardized the GED variable on the regression sample. This allowed us to compare the magnitude of the coefficients across specifications as they were expressed in a similar metric. More specifically, α_1 measured by how many percentage points Fem_Part_c varied when the GED_c measure varied by 1 standard deviation.

To control for individual-level heterogeneity, we also used individual-level regressions. The micro-level counterpart to our cross-country regression Model 1 is as follows:

$$Girl_{ic} = \alpha_2 GED_c + \mu X_{ic} + \varepsilon_{ic}, \quad (2)$$

where $Girl_{ic}$ is a dummy variable equal to 1 if individual i in country c is a girl, and X_{ic} is a vector of control variables whose content varies according to the different specifications (including age). In Model 2, the coefficient α_2 captured how female participation (the probability of being a woman among chess players) varies with countries' development or equality. Equation 2 was estimated by weighted least squares using weights normalized to sum to 1 in each country. Such "senate" weights ensured that each country had the same weight in the analysis. Standard errors were clustered at the country level because it was the relevant level of analysis.

Results

We first observed a large variation across countries in the share of female chess players participating in official tournaments (herein, "female participation") on the whole sample as well as in the various age ranges. For instance, among players younger than 13 years, mean female participation in chess was equal to 24% but varied from 6% (Ireland) to 43% (Mongolia) with a standard deviation of 0.08.

Whole sample. We started by considering the whole sample, including all players of all ages as in the study by Vishkin (2022). We show in Table 1, Row A1 and Table S1 in the Supplemental Material that there is a significant cross-country negative relationship between female participation and our six GED measures. An increase of 1 standard deviation in one of the GED measures is associated with a decrease in female participation in chess, from 2.2 (GGGI; $N = 87$) to 3.6 (GDP; $N = 91$) percentage points. These are large variations compared with the average female participation in chess (16.1%). The associated correlations between female participation and GED measures varied between 0.28 (with GGGI) and 0.46 (with GDP). The relations seem stronger for measures of development than for gender equality.

We first verified Vishkin's (2022) result about players' mean age: If we control by the mean age of the players in a country, the relation between GED measures and female participation in chess fully disappears (see Table S2a in the Supplemental Material and Table 1, Row A2). However, it is not clear what the mean age of the players captures. Vishkin (2022, pp. 2, 8) suggested that the mean age *of the population* in less gender-equal countries may actually contribute to explaining the gender-equality paradox in chess. We show that this is not the case: Controlling for the age structure of a country barely affects the relationship between GED measures and female participation in chess (see Table 1, Row A3, where the median age of the population is controlled for, and Table S2b, where the share of the population younger than 20 years is also controlled for). This shows that it is really the mean age *of chess players* in

Table 1. Relationship Between Countries' Gender Equality or Development and Female Participation in Chess

	Marginal effect of variable on female participation in chess (country level)					
Measure	M-GII	GGGI	Equality values	GDP	HDI	ESCS
A. Keeping all chess players						
1. No controls	–0.0244**	–0.0221**	–0.0293**	–0.0359**	–0.0277**	–0.0299**
2. Controlling for mean age of players in the country	0.00347	0.0049	0.00127	–0.0007	0.0010	–0.0059
3. Controlling for age structure in the country	–0.0291*	–0.0158†	–0.0282**	–0.0358**	–0.0334**	–0.0288**
4. Controlling for age of the players at the individual level	–0.0147*	–0.0111*	–0.0150**	–0.0206**	–0.0166**	–0.0201**
B. Looking at the relationship by age group (years)						
1. Younger than 13	–0.0351**	–0.0191*	–0.0228**	–0.0358**	–0.0368**	–0.0301**
2. 13–16	–0.0289**	–0.0201**	–0.0244**	–0.0320**	–0.0303**	–0.0321**
3. 15–16[a]	–0.0249**	–0.0156*	–0.0175**	–0.0184**	–0.0299**	–0.0234**
4. 17–20	–0.0268**	–0.0197**	–0.0244**	–0.0339**	–0.0341**	–0.0286**
5. 20–25	–0.0246**	–0.0221**	–0.0252**	–0.0381**	–0.0310**	–0.0353**
6. 25–35	–0.0148†	–0.0149†	–0.0244**	–0.0320**	–0.0176*	–0.0283**
7. 35–50	–0.00797	–0.0178*	–0.0212*	–0.00921	0.000583	–0.00795
8. Older than 50	–0.00733	–0.0111	–0.0149	–0.00603	0.00457	0.00327

Note: The table presents estimates of the effect of measures of gender equality (Global Gender Gap Index, or GGGI; Gender Inequality Index, or GII; equality values), wealth (gross domestic product, or GDP), or development (Human Development Index, or HDI; economic, social, and cultural status, or ESCS) on female participation in chess, standardized on the whole sample. The variable M-GII denotes the opposite of GII. See the main text for the description of these measures. Panel A considers the whole sample of chess players, and panel B considers specific age ranges.
[a]Programme for International Student Assessment (PISA) data are on playing chess and not only tournaments.
†$p < .10$. *$p < .05$. **$p < .01$.

each country that affects the gender-equality paradox in chess and not the age profile of the general population.

To account for the age of chess players and its possible link with the gender-equality paradox, Vishkin (2022) simply added a control for the mean age of the players in a country. Although this might be valid to show that players' age matters, it is not the optimal way to fully correct for differences in the age structure of the players across countries. To overcome these limits, we propose two approaches. First, we studied the link between GED measures and female participation in chess at the individual level, controlling directly for players' age (see Equation 2 and Table S2d). This allowed us to control for variations across countries in the whole distribution of players' age. Second, we considered a country-level measure of *residual* female participation in chess after the effect of the age of the players on their gender had already been taken out (see details in the Supplemental Material and Table S2c). For both approaches, results were of the same magnitude and showed that the paradoxical relationship was strongly reduced with respect to the setting without controlling for age (by about 40%) but remained both quantitatively meaningful and statistically significant (see Table 1, Row A4 and Table S2d). For instance, an increase of 1 standard deviation in GDP (resp. M-GII) is associated with a decrease of 2.1 (resp. 1.5) percentage points of female participation in chess after age is controlled for.[2] Together, these results show the robustness of the paradoxical relationship for the six GED measures considered when accounting more finely for differences across countries in the age structure of the players than does a single control for their mean age.

Age ranges. We then considered specific age ranges. If we restrict our attention to young generations, then the relationship between female participation and the six GED measures is negative and significant (see Table S3 in the Supplemental Material and Table 1, panel B). This strong relationship was valid for the following age ranges: younger than 13, 13 to 16, 17 to 20, and 20 to 25 years. For instance, for the age range younger than 13 years, an increase in GDP of 1 standard deviation (resp. M-GII) was associated with a decrease of 3.6% (resp. 3.5%) of female participation, and for the age range of 20 to 25

years, an increase in GDP of 1 standard deviation (resp. M-GII) was associated with a decrease of 3.8% (resp. 2.5%) of female participation.

We also analyzed how the relation between female participation in chess and our GED measures evolves with age. We observed in Table S3 and Table 1 that the relation was strong among young generations but that it decreased with age. In particular, it was less systematically significant in the age ranges of 25 to 35 years and 35 to 50 years and became not significant for players older than 50 years. We confirmed this decrease of the strength of the relation with age by analyzing the coefficient of the interaction of age with our GED measures, in a regression of female participation on age, GED measures, and their interaction (see Table S4 in the Supplemental Material). The coefficient of age interaction with the GED measure was significant and positive for the six GED measures we considered, which means that for older players, the negative relation between female participation and GED measures was weaker, consistent with the results obtained for different age brackets considered separately.

In Table S4, we show the confirmation of Vishkin's (2022) result that female participation strongly increases from older to younger ages. However, this increase is higher in lower GED countries, as shown by the positive regression coefficient obtained for the effect of the interaction between players' age and GED measures. To confirm this point more directly, we computed for each country the increase of female participation from older to younger ages as in the Vishkin study and then showed in a country-level regression that this increase was higher in lower GED countries (see Table S5 in the Supplemental Material).

Study 2: PISA2012 Data

Method

Data set. Data are from the PISA2012, an every-3-year international assessment of the knowledge and skills of about half a million 15-year-old students among more than 60 countries in mathematics, reading, and science. The sample of students is representative of the population they cover. PISA2012 includes a question about chess. Item st49q05 asked students whether they play chess (a) always or almost always, (b) often, (c) sometimes, or (d) never or rarely. The final sample with available information about chess consists of 312,571 observations (50.8% female) in 64 countries. PISA provides weights to make surveyed students representative of the 15-year-old students of the participating countries. We used these weights in all of our analyses so that the results we provide are not subject to sample selection and are representative statistics. See the Supplemental Material for more details on the PISA survey.

We considered a (regular or occasional) chess player to be a student who answered with (a), (b), or (c). With this definition, 43% of students were chess players; among them, 34% were female, on average, which is a larger percentage than in Study 1 (16.1%).

Measures and statistical analyses. We considered the same GED measures as in Study 1. We measured female representation in chess by the share of female players among regular or occasional chess players. We used country-level models as in Equation 1 to analyze the relation between GED measures and female representation in recreational chess playing.

Results

As in Study 1, but less so, we observed variation in female representation across countries, from 17% (Japan) to 49% (Albania), with a mean of 35% and a standard deviation of 0.05. Female representation in chess playing at 15 years old based on PISA data was also correlated with female participation in chess tournaments among young generations based on FIDE data. However, the correlation is not perfect ($r = .46$), showing that our alternative measure of female participation in "recreative chess playing" does not capture exactly the same aspects of chess playing as the one based on participation in tournaments. This alternative measure based on PISA is arguably less related to individuals' competitiveness, which may directly influence the gender-equality paradox in chess. Indeed, it is well known to vary by gender (e.g., Niederle & Vesterlund, 2011) and also exhibits a gender-equality paradox (Napp & Breda, 2022).

Table 1, Row B3 as well as Table S6 in the Supplemental Material show that the gender-equality paradox held for recreative chess playing at 15 years old. There was a significant and negative relationship between our six GED measures and female representation among chess players. The magnitude of the relation is very similar to that obtained on the FIDE data set. An increase of 1 standard deviation in one of the GED measures is associated with a decrease of female representation in chess, from 1.6 (GGGI; $N = 59$) to 3 (HDI; $N = 61$) percentage points. The associated correlations varied between 0.29 (with GGGI) and 0.56 (with HDI).

Discussion

On the whole sample of competitive chess players, we obtained, as did Vishkin (2022), a negative cross-country relationship between female participation in

competitive chess and countries' gender equality—captured by composite measures either of equality in practice, such as the GGGI or the GII, or of gender equality in values—and showed its extension to countries' economic wealth and development. As in the study by Vishkin, the relationship fully disappeared when we controlled for the mean age of the players in each country. However, it was reduced but no longer disappeared when we controlled more finely for players' age, and it was valid and strong when we restricted the analysis to young players of the same age—which we show both for competitive players as in the Vishkin study and for recreative players using an alternative data set. This difference likely resulted from the fact that the mean age of the players captured other country characteristics that affect the gender-equality paradox, beyond the direct effect of players' age. This could be because aggregating information at a higher level than the one at which it is observed can lead to erroneous estimations of the relations (ecological fallacy; e.g., Freedman, 1999; Piantadosi et al., 1988; Robinson, 1950).

In addition, we show that the gender-equality paradox remains almost unchanged when we control for the age profile of the *population* (rather than chess players). This implies that the generational shift mechanism suggested by Vishkin (2022; individuals in lower GGGI countries being younger and younger individuals holding more egalitarian values) cannot directly explain the paradox.

The strength of the paradoxical relation between GED measures and the share of female chess players decreases with age and disappears for older generations. This might be because these generations likely made the decision to play chess and participate in tournaments decades ago, when the socioeconomic environment was very different, and the gender gap among these players is less likely to be related to today's countries' level of development and gender equality. The gender gap in competitive chess among older generations can also involve other factors that may or may not be related to gender equality. For instance, female representation can be lower among older generations if women, more than men, give up competitive chess throughout their lifetime (e.g., because they have less spare time), and these gender differences in spare time can depend on countries' level of gender equality. In all cases, young generations (on which the paradox holds) arguably give a better picture of contemporary behaviors than older ones do.

Finally, Vishkin (2022) observed that for almost all countries, female participation in chess increases from older to younger ages, and he interpreted this observation as inconsistent with previous explanations of the gender-equality paradox, such as innate preferences or gender stereotypes: Younger generations should be more gender equal than older generations, hence innate preferences for instance should be more easily expressed, which should lead to a decrease (and not an increase) of female participation. However, several unobserved factors may contribute to the higher female participation in the young generation (e.g., most countries had policies explicitly encouraging women to play, women increased their participation in sports and hobbies in all domains, and women tend to stop playing when they get older), and readers are invited to be cautious with the above reasoning. To our opinion, the key point is that even if all countries saw female participation increasing in the young generation, this was less the case for the more gender-equal or more developed ones (see Tables S4 and S5). This result is actually fully consistent with previous explanations of the gender-equality paradox: In countries that are more gender equal, an easier expression of women's innate lack of interest in chess (or higher gender stereotypes) may have prevented women from increasing their participation in chess over time at the same rate as in less gender equal countries.

To sum up, we showed that Vishkin's (2022) conclusions can be misleading because there is still a *paradoxical* cross-country relationship in chess, one that requires explanations other than just a correction for the structure of the population or than the generational shift mechanism. In particular, explanations involving innate preferences that can be better expressed, or new forms of gender stereotypes in more gender-equal countries, cannot be dismissed and should be further analyzed by future research.

Transparency

Action Editor: Patricia J. Bauer
Editor: Patricia J. Bauer
Author Contribution(s)

Clotilde Napp: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing – original draft.

Thomas Breda: Conceptualization; Data curation; Formal analysis; Investigation; Methodology; Writing – original draft.

Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

Funding

This work was supported by the Women and Science Chair (a Dauphine Foundation Chair in partnership with Fondation L'Oréal, Generali France, La Poste, Safran, and Talan). Thomas Breda also acknowledge the support of the EUR grant ANR-17-EURE-0001.

Open Practices

This article has received the badge for Open Data. More information about the Open Practices badges can be found at http://www.psychologicalscience.org/publications/badges.

ORCID iD

Clotilde Napp https://orcid.org/0000-0002-7008-5949

Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/09567976231202450

Notes

1. Note that Dilmaghani (2021) used the same data set to analyze the gender gap in competitive chess across countries but focused on top levels of attainment and on the role of a legacy of state socialism.
2. Note that we also controlled in the individual-level regressions by a fifth order polynomial in age to capture nonlinearity, with no additional effect on the results.

References

Breda, T., Jouini, E., Napp, C., & Thebault, G. (2020). Gender stereotypes can explain the gender-equality paradox. *Proceedings of the National Academy of Sciences, USA*, *117*, 31063–31069.

Charles, M. (2017). Venus, Mars, and math: Gender, societal affluence, and eighth graders' aspirations for STEM. *Socius: Sociological Research for a Dynamic World*, *3*. https://doi.org/10.1177/2378023117697179

Charles, M., & Bradley, K. (2009). Indulging our gendered selves? Sex segregation by field of study in 44 countries. *American Journal of Sociology*, *114*, 924–976.

Costa, P. T., Jr., Terracciano, A., & McCrae, R. R. (2001). Gender differences in personality traits across cultures: Robust and surprising findings. *Journal of Personality and Social Psychology*, *81*(2), 322–331.

Dilmaghani, M. (2021). The gender gap in competitive chess across countries: Commanding queens in command economies. *Journal of Comparative Economics*, *49*, 425–441.

Falk, A., & Hermle, J. (2018). Relationship of gender differences in preferences to economic development and gender equality. *Science*, *362*(6412). https://doi.org/10.1126/science.aas9899

Freedman, D. A. (1999). Ecological inference and the ecological fallacy. *International Encyclopedia of the Social & Behavioral Sciences*, (6), 4027–4030.

Knight, C. R., & Brinton, M. C. (2017). One egalitarianism or several? Two decades of gender-role attitude change in Europe. *American Journal of Sociology*, *122*(5), 1485–1532.

Lippa, A., Collaer, M. L., & Peters, M. (2010). Sex differences in mental rotation and line angle judgments are positively associated with gender equality and economic development across 53 nations. *Archives of Sexual Behavior*, *39*, 990–997.

Mac Giolla, E., & Kajonius, P. J. (2019). Sex differences in personality are larger in gender equal countries: Replicating and extending a surprising finding. *International Journal of Psychology*, *54*, 705–711.

Napp, C., & Breda, T. (2022). The stereotype that girls lack talent: A worldwide investigation. *Science Advances*, *8*(10), Article eabm3689. https://doi.org/10.1126/sciadv.abm3689

Niederle, M., & Vesterlund, L. (2011). Gender and competition. *Annual Review of Economics*, *3*(1), 601–630.

Piantadosi, S., Byas, D. P., & Green, S. B. (1988). The ecological fallacy. *American Journal of Epidemiology*, *127*(5), 893–904.

Richardson, S. S., Reiches, M. W., Bruch, J., Boulicault, M., Noll, N. E., & Shattuck-Heidorn, H. (2020). Is there a gender-equality paradox in science, technology, engineering, and math (STEM)? Commentary on the study by Stoet and Geary (2018). *Psychological Science*, *31*(3), 338–341.

Robinson, W. S. (1950). Ecological correlations and the behavior of individuals. *American Sociological Review*, *15*(3), 351–357.

Schwartz, S. H., & Rubel-Lifschitz, T. (2009). Cross-national variation in the size of sex differences in values: Effects of gender equality. *Journal of Personality and Social Psychology*, *97*, 171–185.

Stoet, G., & Geary, D. C. (2018). The gender-equality paradox in science, technology, engineering, and mathematics education. *Psychological Science*, *29*(4), 581–593.

Vishkin, A. (2022). Queen's gambit declined: The gender-equality paradox in chess participation across 160 countries. *Psychological Science*, *33*(2), 276–284.