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No Evidence for a Relationship between Intelligence and Ejaculate Quality

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Abstract

Genetic quality may be expressed through many traits simultaneously, and this would suggest a phenotype-wide fitness factor. In humans, intelligence has been positively associated with several potential indicators of genetic quality, including ejaculate quality. We conducted a conceptual replication of one such study (Arden, Gottfredson, Miller, & Pierce, 2009) by investigating the relationship between intelligence (assessed by the Raven Advanced Progressive Matrices Test – Short Form) and ejaculate quality (indexed by sperm count, sperm concentration, and sperm motility) in a sample of 41 men (ages ranging 18 to 33 years; $M = 23.33$; $SD = 3.60$). By self-report, participants had not had a vasectomy, and had never sought infertility treatment. We controlled for several covariates known to affect ejaculate quality (e.g., abstinence duration before providing an ejaculate) and found no statistically significant relationship between intelligence and ejaculate quality; our findings, therefore, do not match those of Arden, Gottfredson, Miller, and Pierce (2009) or those of previous studies. We discuss limitations of this study and the general research area and highlight the need for future research in this area, especially the need for larger data sets to address questions around phenotypic quality and ejaculate quality.

No Evidence for a Relationship between Intelligence and Ejaculate Quality

The nature of the relationship between ejaculate quality and phenotypic traits has been the subject of debate among researchers. Some research suggests a phenotype-wide fitness factor, such that many phenotypic features simultaneously indicate genetic quality (Houle, 2000; Møller & Thornhill, 1997; Pomiankowski & Møller, 1995), which is more broadly the foundation of the phenotype-linked fertility hypothesis. This hypothesis predicts that ejaculate characteristics correlate positively with male phenotype and that females should be able to assess male phenotypic quality as an honest cue of ejaculate quality to ensure high fertilization success (Sheldon, 1994). Thus, phenotypic traits and ejaculate quality should correlate positively, as both indicate genetic quality (Arden, Gottfredson, Miller, & Pierce, 2009). The phenotype-wide fitness factor may reflect mutation load, as mutations have pleiotropic effects on many traits (McGuigan, Petfield, & Blows, 2011). If an individual has a low mutation load, then there would be fewer detrimental effects of that load across a variety of phenotypic traits (Houle, 2000; Miller, 2000).

In some non-human animals, there is evidence that supports the hypothesis of a phenotype-wide fitness factor. For example, in wild Trinidadian guppies (*Poecilia reticulata*), females prefer males with bright orange spots (Houde, 1987) which may reflect good immune function and thus indirect benefits to females who choose brightly colored males (Grether, Kasahara, Kolluru, & Cooper, 2003). Furthermore, ejaculate quality correlates positively with body size and swimming strength during mating displays in male guppies (Matthews, Evans, & Magurran, 1997). In pied flycatchers (*Ficedula hypoleuca*), individuals with more intensely black feathers (thought to reflect overall genetic quality; Slavsgold & Lifjeld, 1992) have longer, more fertile sperm (Calhim, Lampe, Slagsvold, & Birkhead, 2009).

Studies in humans have also documented positive correlations between phenotypic traits and ejaculate quality, suggesting a phenotype-wide fitness factor. Previous research has examined ejaculate quality and its relationship to phenotypic traits such as facial attractiveness, body symmetry, and intelligence (see for a review Jeffrey, Pham, Shackelford, & Fink, 2016). For instance, women's assessments of men's facial attractiveness correlate positively with sperm motility and morphology in a sample of Spanish men (Soler et al., 2003). A later study found a positive correlation between an index of ejaculate quality and facial attractiveness ratings (of the same Spanish men) provided by a different sample of men and women (Soler et al., 2014). Other research reports positive associations of intelligence with ejaculate quality (Arden, Gottfredson, Miller, & Pierce, 2009), male fertility (Kolk & Barclay, 2020), overall physical health (Arden, Gottfredson, & Miller, 2009), and height (Silventoinen, Posthuma, van Beijsterveldt, Bartels, & Boomsma, 2006; Sundet, Tambs, Harris, Magnus, & Torjussen, 2005), suggesting that intelligence correlates with an overall fitness factor. However, not all research shows these positive correlations between phenotype quality and ejaculate quality. Simmons and colleagues (2011), for example, found that having a low-pitched voice (an indicator of masculinity) correlated negatively with ejaculate quality. Similarly, Peters and colleagues (2007) found no association between men's physical attractiveness (as rated by women from photographs) and ejaculate quality.

In their study of ejaculate quality and intelligence, Arden, Gottfredson, Miller, and Pierce (2009) operationalized intelligence as a factor score from five intelligence tests: the (1) Verbal and (2) Arithmetic subtests of the Army Classification Battery (Montague, Williams, Gieseking, & Lubin, 1957), the (3) Information and (4) Block Design subtests of the Wechsler Adult Intelligence Scale – Revised (Wechsler, 1981), and the (5) Reading subtest of the Wide Range Achievement Test (Jastak, Bijou, & Jastak, 1965). These tests were used because the authors reported that they were the most psychometrically sound of a broad battery of intelligence measures. Ejaculate quality was operationalized as sperm count, sperm concentration, and sperm motility measured from a single ejaculate produced by masturbation. The researchers controlled for age, abstinence duration (time since most recent ejaculation), body mass index (BMI; calculated as weight in kg/height in m^2), and self-reported tobacco use, alcohol use, and marijuana use. Because the sample consisted of Vietnam War veterans (n = 425), Arden, Gottfredson, Miller, and Pierce (2009) also controlled for exposure to toxins. The results revealed positive zero-order correlations between the calculated general (or "*g*") factor score of intelligence and all three measures of ejaculate quality. Additionally, the *g* factor score positively predicted all three ejaculate quality measures in regression models that included the relevant covariates.

Arden, Gottfredson, Miller, and Pierce (2009) concede that a limitation of their study is the use of only one ejaculate per participant, given that ejaculates can vary considerably within individuals due to several factors beyond the assessed covariates (e.g., level of arousal, as higher arousal produces better quality samples; Gerris, 1999; Mallidis, Howard, & Baker, 1991; Schwartz, Laplanche, Jouannet, & David, 1979). The current study is a conceptual replication of Arden, Gottfredson, Miller, and Pierce that addresses this limitation by securing two ejaculates per participant and calculating average values for each ejaculate parameter and each participant. Replications are especially important in light of the recent replication crisis in psychology (Open Science Collaboration, 2015). We used the same measures of ejaculate quality reported by Arden, Gottfredson, Miller, and Pierce (sperm count, sperm concentration, and sperm motility) and measured intelligence with the Raven Advanced Progressive Matrices Test – Short Form (Arthur & Day, 1994). Additionally, we controlled for the relevant ejaculate quality covariates of age, abstinence duration, and BMI.

Method

Participants

The current study reports novel analyses of a subset of data from a larger project (Pham et al., 2018). The original dataset included responses from 66 men, with ages ranging 18 to 34 years ($M = 22.77$; $SD = 3.83$). The original sample consisted of 69.7% Caucasian men, 9.1% African American men, 4.5% Asian men, with the remainder identifying with the ethnic categories of Indian, Hispanic, or other. Only data from men who provided two ejaculate samples (see Procedures) and completed the intelligence measure were included in the current analyses. Thus, the final sample included 41 men attending a Midwestern university in the United States, with ages ranging 18 to 33 years ($M = 23.33$; $SD = 3.60$; 78.0% of the sample was Caucasian, with Asian representing the second-most commonly reported ethnicity at 7.3%; see Pham et al., 2018). By self-report, participants had not had a vasectomy, had never sought infertility treatment, and were currently in a committed, heterosexual, sexually active relationship for at least six months (range 6 to 123 months; $M = 33.54$; $SD = 25.57$). Thus, exclusion criteria included fertility issues, being single, and identifying as non-heterosexual.

Measures

Intelligence. Intelligence was measured with the Raven Advanced Progressive Matrices Test – Short Form (Raven-SF; Arthur & Day, 1994). Since the original study consisted of a battery of other questionnaires unrelated to intelligence (see procedures), the Raven-SF was used because it is easy to administer in a timely manner. Under these circumstances, the short form reduces fatigue from completing multiple surveys in one sitting. The Raven-SF test consists of 12 matrix or design problems and individual scores are summed to calculate a final score. Every correct problem counts as one point, for a maximum of 12 points. Previous research using the Raven-SF reported Cronbach's alpha reliabilities between .58 and .66 (Arthur, Tubre, Paul, & Sanchez-Ku, 1999) and the full version has an internal consistency of .90 (Raven, Court, & Raven, 1994). In the current study, alpha was .59.

Ejaculate quality. Ejaculate quality was assessed using the Semen Quality Analyzer (SQA-V; Medical Electronic Systems, Los Angeles, California, US), a fully automated machine that analyzes ejaculates along with several clinical parameters (see Pham et al., 2018, for details). Sperm count is the number of motile sperm in the ejaculate (in millions); sperm concentration is the number of sperm (in M/ml of ejaculate); and sperm motility is the percentage of progressively motile sperm. Upon receipt of the participant's masturbatory ejaculate, the ejaculate was syringed into a proprietary measurement capillary, which was inserted into a chamber in the SQA-V for automatic analysis. After completion of the automated analysis, all materials that directly contacted the ejaculate were discarded in a biohazard waste container. In a previous study, the two ejaculate samples from each participant were examined for differences using a Wilcoxon signed-rank test, which revealed no significant differences (see Pham et al., 2018). We also correlated each parameter across the two ejaculates provided by each participant. Each parameter was moderately correlated across the two ejaculates (average Spearman's $\rho = 0.44$; $p < 0.05$). For parsimony and reportorial efficiency, we averaged parameters estimated from the two ejaculates for each participant. We verified that those ejaculate parameters were within the reference values for fertile ejaculate characteristics provided by the World Health Organization (see Pham et al., 2018, for details).

Covariates. We assessed several covariates known to affect ejaculate quality: age, body mass index (BMI), and abstinence duration. Some ejaculate parameters vary over the lifespan—for example, the number of sperm in an ejaculate decreases with age (Cooper et al., 2010; Ng et al., 2004). Additionally, obesity is associated with infertility in men; BMI, for example, is negatively associated with sperm count (Eisenberg et al., 2013). Moreover, some ejaculate parameters are affected by abstinence duration prior to ejaculation; for example, rapid and repeated ejaculation reduces sperm number in subsequent ejaculates (Hopkins, Sepil, & Wigby, 2017).

Procedures

All procedures were approved by the institutional review board of the university where data were collected. Participants were recruited via advertisements posted on bulletin boards on the local university campus. They contacted the laboratory to schedule three in-person sessions. In Session 1, participants were escorted to a private room and completed a survey containing several self-report questionnaires unrelated to the current report (measures of personality, relationship investment and satisfaction, mate retention tactics, developmental and life history, risk of infidelity, and sociosexual orientation). Then, the researchers collected several anthropometric measurements (body height and weight, testes size and weight [self-measured at home], head circumference, biceps circumference, waist-to-hip ratio, shoulder-to-hip ratio, and handgrip strength; see also DeLecce et al., 2020; Pham, et al., 2018). During Session 1, participants received materials required to collect and transport two masturbatory ejaculates in two scheduled sessions (i.e., Sessions 2 and 3). The materials included a non-latex, non-spermicidal condom, a plastic twist-tie, a screw-top specimen container, a biohazard Ziploc bag, and aluminum foil.

Participants were instructed to abstain from ejaculating for at least 48 hours prior to each masturbatory session, following World Health Organization (2010) guidelines. Participants were asked to masturbate without the help of their partner and to not use any materials that we did not provide (e.g., pornography, lubricant). Participants masturbated to ejaculation in a private location of their choosing while wearing the provided condom. After ejaculation, participants sealed the condom and delivered it (within one hour of ejaculation) to the laboratory. Participants provided written consent, were informed about the purpose of the study at Session 1, and received US$25 after each session.

Data analysis

We generated descriptive statistics and evaluated skew and kurtosis of dependent and independent variables. Due to non-normality in some variables, we calculated Spearman's zero-order correlations between all target variables: sperm count, sperm concentration, sperm motility, intelligence, abstinence period, age, and BMI. To control for the possible effects of the covariates known to affect ejaculate quality (abstinence period, age, and BMI), we calculated Spearman's partial correlations between the three ejaculate parameters and intelligence. Lastly, we calculated exploratory Spearman's zero-order and partial correlations between the same variables for the data provided by the 61 men that produced at least one ejaculate sample.

Results

Table 1 presents descriptive statistics for the target variables. Because the ejaculate parameters deviated from normal distributions (as indicated by a Shapiro-Wilk's test; see DeLecce, et al, 2020), we calculated Spearman correlations for zero-order correlations (Fowler, 1987). There were no statistically significant correlations between intelligence and sperm count, sperm concentration, or sperm motility. Considering the covariates of age, abstinence duration, and BMI in partial correlations between intelligence and sperm count, sperm concentration, and sperm motility also revealed no statistically significant associations. Table 2 reports zero-order and partial correlations between ejaculate quality measures, intelligence, and covariates (The same pattern of results obtained with a linear mixed model analysis, the results of which are available from the first author on request).

For exploratory purposes, we also calculated correlations between ejaculate parameters and intelligence for the sample of 61 men who provided at least one ejaculate sample. There were no significant zero-order Spearman's correlations between intelligence and sperm count, sperm concentration, or sperm motility (see Table 3). After conducting partial correlations controlling for the same covariates of age, BMI, and abstinence period, there were still no significant correlations between intelligence and sperm count, sperm concentration, or sperm motility (see Table 3).

Discussion

As a test of the hypothesis of a phenotype-wide fitness factor (Arden, Gottfredson, & Miller, 2009), we investigated whether intelligence correlates positively with ejaculate quality. Arden, Gottfredson, Miller, and Pierce (2009) reported that intelligence (a composite measure of five intelligence tests) positively correlated with sperm count, sperm concentration, and sperm motility. The results of our conceptual replication do not match those reported by Arden, Gottfredson, Miller, and Pierce as we did not detect significant associations between intelligence and any of the ejaculate quality measures (i.e., sperm count, sperm concentration, and sperm motility).

There are several possible reasons why the current research failed to replicate the results reported by Arden, Gottfredson, Miller, and Pierce (2009), given the differences in the design of the two studies. Arden, Gottfredson, Miller, and Pierce secured a single ejaculate from each participant, whereas we secured two ejaculates from each participant. We then calculated the average for each parameter across the two ejaculates and used the average values in tests of relationships with intelligence. Because ejaculate parameters are known to exhibit within-individual variability (Mallidis, Howard, & Baker, 1991; Schwartz, Laplanche, Jouannet, & David, 1979), the null relationships we identified may be attributable to the use of averaged and, therefore, more representative ejaculate parameters.

Arden, Gottfredson, Miller, and Pierce (2009) investigated a sample of veterans, whereas in the current study we investigated a sample of college students. These are different populations, and the relationships of interest may not manifest in the same way in these different groups. One reason there could be a problem with generalizability across these populations is the difference in age ranges despite using age as a covariate in both cases. Arden, Gottfredson, Miller, and Pierce reported an age range of 31-44 years, whereas the current study included participants with an age range of 18-33 years. Some ejaculate parameters vary over the lifespan—for example, the number of sperm in an ejaculate decreases with age (Cooper et al., 2010; Ng et al., 2004).

Perhaps if genetic quality correlates with both intelligence and ejaculate quality via mutation load, those of higher phenotypic quality can better withstand the detriments associated with senescence. In this case, the relationship between ejaculate quality and intelligence provides a more reliable signal of genetic quality with increasing age. Evidence in mute swans (*Cygnus olor)* indicates that a decline in reproductive performance due to senescence is moderated by individual differences (McCleery, Perrins, Sheldon, & Charmantier, 2008). Perhaps a similar mechanism applies to humans. Thus, future research should use similar age ranges rather than two different ranges to control for this possibility. The latter study design may complicate the ability to draw definitive conclusions on the relationship between ejaculate quality and intelligence.

An important limitation of the current research is the small sample of 41 men, as small sample sizes increase the risk of both Type I and Type II errors. Our analyses, therefore, may have lacked sufficient power to detect the small effect sizes, r = .14 to .19, reported by Arden, Gottfredson, Miller, and Pierce (2009). Small sample sizes are a recurrent limitation of psychological research investigating ejaculate quality (e.g., Baker & Bellis, 1989; Pook et al., 2005), perhaps due to difficulties recruiting participants outside a clinical setting. Arden, Gottfredson, Miller, and Pierce analyzed data from a sample of 425 men, which afforded the analyses over 80% power to detect small effects. However, it is important to note that the correlation coefficients we obtained were similar in magnitude to those reported by Arden, Gottfredson, Miller, and Pierce, ranging from -.18 to .30, and the repeated-measures nature of our study gave it greater power despite the small sample size. Nevertheless, future research should investigate the relationship between intelligence and ejaculate quality using sufficiently large samples, as such small effect sizes for the relationship between ejaculate quality and intelligence may be negligible in terms of significance after multiple tests of this relationship.

In conclusion, we investigated the relationship between intelligence and ejaculate quality to replicate conceptually research reported by Arden, Gottfredson, Miller, and Pierce (2009). We did not find evidence consistent with a phenotype-wide fitness factor; instead, we identified no significant associations between intelligence and ejaculate quality. This is an under-investigated area that requires additional research, thus we hesitate to advance any firm conclusions about the phenotype-wide fitness factor in humans and whether and how it might relate to ejaculate quality. An ideal study might include a composite measure of intelligence, perhaps including both the Wechsler (as it is the most frequently used intelligence test across cultures; Weschler, 1981) and Raven (Arthur & Day, 1994) measures, as well as the incorporation of more than one ejaculate per participant using a sufficiently large sample to detect small effects with 80% power. An estimate of the sample size required to reach this level of power suggests at least 153 participants.

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Table 1. Descriptive statistics for target variables.

Target variable	Mean	*SD*	Skewness	Kurtosis
Intelligence	7.02	1.98	0.84	-0.49
Sperm count (M/Ejaculate)	60.05	55.16	4.08	3.35
Sperm concentration (M/ml)	56.50	33.45	0.78	-0.89
Sperm motility (%)	44.41	16.59	-0.59	-0.94
Age	23.33	3.60	2.41	0.32
Abstinence days	3.28	5.37	14.91	44.77
Body Mass Index	27.18	5.12	3.57	5.02

Note: See text for definition of each variable; $n = 41$.

Table 2. Spearman's zero-order and partial correlations (i.e. controlling for age, abstinence period, and body mass index) between measures of the target variables and measures of ejaculate quality.

Zero-order Spearman's correlations

	Target variables							
Ejaculate quality	Intelligence		Abstinence		Age		Body mass index	
	ρ	*p*	*ρ*	*p*	*ρ*	*p*	*ρ*	*p*
Sperm count	.21	.195	.33	.029	-.23	.154	-.15	.349
Sperm concentration	-.13	.424	.25	.102	-.04	.817	-.12	.439
Sperm motility	.19	.226	.22	.156	-.23	.151	-.17	.302

Partial Spearman's correlations

	Target variable	
Ejaculate quality	Intelligence	
	ρ	*p*
Sperm count	.12	.473
Sperm concentration	-.18	.301
Sperm motility	.10	.571

Note: See text for variable definitions; *n* = 41.

Table 3. Spearman's zero-order and partial correlations (i. e. controlling for age, abstinence period, and body mass index) between measures of the target variables and measures of ejaculate quality for the sample of men ($n = 61$) who only provided one ejaculate.

Zero-order Spearman's correlations

	Target variables							
Ejaculate quality	Intelligence		Abstinence		Age		Body mass index	
	ρ	p	ρ	p	ρ	p	ρ	p
Sperm count	.03	.846	.08	.523	-.19	.193	-.18	.174
Sperm concentration	-.18	.185	.15	.257	.05	.749	-.23	.085
Sperm motility	.23	.079	-.07	.581	-.34	.018	.02	.863

Partial Spearman's correlations

	Target variable	
Ejaculate quality	Intelligence	
	ρ	p
Sperm count	.14	.388
Sperm concentration	-.06	.719
Sperm motility	.30	.052

Note: See text for variable definitions.