

# Do Men Produce Higher Quality Ejaculates When Primed With Thoughts of Partner Infidelity?

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## Abstract

Sperm competition theory can be used to generate the hypothesis that men alter the quality of their ejaculates as a function of sperm competition risk. Using a repeated measures experimental design, we investigated whether men produce a higher quality ejaculate when primed with cues to sperm competition (i.e., imagined partner infidelity) relative to a control prime. Men ( $n = 45$ ) submitted two masturbatory ejaculates—one ejaculate sample for each condition (i.e., sperm competition and control conditions). Ejaculates were assessed on 17 clinical parameters. The results did not support the hypothesis: Men did not produce higher quality ejaculates in the sperm competition condition relative to the control condition. Despite the null results of the current research, there is evidence for psychological and physiological adaptations to sperm competition in humans. We discuss methodological limitations that may have produced the null results and present methodological suggestions for research on human sperm competition.

## Keywords

sperm competition, humans, ejaculate quality, evolutionary psychology

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Sperm competition occurs when a female copulates with two or more males within a sufficiently brief time period, resulting in sperm of the different males competing to fertilize ova (Parker, 1970). Among humans, a common context for sperm competition is female infidelity (Shackelford, 2003; Smith, 1984). A paternally investing man whose regular partner pursues extra-pair copulations is at risk of cuckoldry (i.e., unwitting investment of resources into offspring to whom he is not genetically related). The costs of cuckoldry may have driven the evolution of male sperm competition tactics—strategic adjustments in psychology, behavior, and physiology that increase the likelihood of sperm competition success. Because men have finite resources for survival and reproduction (e.g., sperm production), men judiciously deploy sperm competition tactics: Men attend to specific sperm competition cues and adjust their sperm competition tactics accordingly (Baker & Bellis, 1993; Goetz et al., 2005; Shackelford, 2003).

A widely documented sperm competition tactic across taxa is ejaculate adjustment (Smith, 1984). Males of various species

alter the quality of their ejaculates across several parameters, including number of sperm and percentage of motile sperm, as a function of sperm competition risk (Simmons & Fitzpatrick, 2012). Males at greater sperm competition risk produce larger volume ejaculates to increase the probability that their sperm—and not the sperm of rival males—fertilize ova (Wedell, Gage, & Parker, 2002). Among many avian species, for example, males at greater sperm competition risk produce ejaculates with a greater number of sperm at the next copulation (Nicholls, Burke, & Birkhead, 2001; Pizzari, Cornwallis, Løvlie, Jakobsen, & Birkhead, 2003).

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Cuckoldry is likely to have been a recurrent adaptive problem for ancestral men over human evolutionary history (Baker & Shackelford, 2017). Estimates indicate approximately 3.1% of children are genetically unrelated to their social father (Voracek, Haubner, & Fisher, 2008), with estimates as high as 29.8% for men with low paternity confidence (Anderson, 2006). Given the substantial costs imposed on men as a result of cuckoldry, it is reasonable to suggest that men may have evolved solutions to address problems of sperm competition including cognitive, behavioral, and physiological adaptations responsive to sperm competition risk (see Baker & Bellis, 1993; Kilgallon & Simmons, 2005; Pham & Shackelford, 2014).

Psychological and behavioral adaptations to sperm competition in humans include adjustments of mate retention behaviors and copulatory behaviors (Pham & Shackelford, 2014; Shackelford & Goetz, 2007). More physically attractive females present greater sperm competition risk than less attractive females, and therefore, men partnered to women who present a greater risk of sperm competition (i.e., they are more attractive) copulate more frequently with them (Pham et al., 2014) and perform more semen displacing behaviors during copulation (Goetz et al., 2005). Men partnered to women who spend more time around potential male rivals also report greater interest in copulating with their partner (Pham & Shackelford, 2013). These findings suggest that men are attentive to cues of sperm competition and show corresponding cognitive and behavioral changes.

Additional research with humans suggests that men can adjust their ejaculate as a function of sperm competition risk (Baker & Bellis, 1995). Men who spend a greater proportion of time apart from their regular partner since the couple's last copulation (i.e., indexing greater sperm competition risk) ejaculate a greater number of sperm at the couple's next copulation (Baker & Bellis, 1993). Men produce masturbatory ejaculates containing a greater percentage of motile sperm when viewing pornography depicting two men and one woman (i.e., a cue to sperm competition) than when viewing pornography depicting three women (i.e., absence of sperm competition; Kilgallon & Simmons, 2005). Men viewing images of more attractive women produce higher quality masturbatory ejaculates than when viewing images of less attractive women (Leivers, Rhodes, & Simmons, 2014). Joseph, Sharma, Agarwal, and Sirot (2015) found that men produce lower quality masturbatory ejaculates when viewing images of a woman to whom they have previously masturbated than when viewing images of a novel woman. These findings from Joseph et al. are consistent with the "topping off" model proposed by Baker and Bellis (1993), which posits that men adjust their ejaculates to maintain an optimal population of viable sperm in their partner's reproductive tract across time. Men therefore appear capable of adjusting the quality of their ejaculates in response to sperm competition risk.

Results from Joseph et al. (2015), Kilgallon and Simmons (2005), and Leivers, Rhodes, and Simmons (2014) demonstrate the effect of visual stimuli on human ejaculate adjustment.

Although visual stimuli often elicit the most intense sexual responses for men (e.g., Julien & Over, 1988; Leivers et al., 2014; Rupp & Wallen, 2008), written depictions of sexual stimuli have been shown to be psychologically and behaviorally arousing for both men and women (Schmidt, Sigusch, & Schäfer, 1973) and may also elicit genital arousal in men (Julien & Over, 1988). Contemporary research by Starratt, McKibbin, and Shackelford (2013) demonstrates the potential utility of written stimuli for assessing sperm competition outcomes. Starratt et al. found that men experimentally primed with thoughts of their long-term partner's infidelity report greater interest in copulating with their partner—a sperm competition tactic that reflects men's motivation to urgently place their sperm into competition with rival sperm that may be in their partner's reproductive tract (Pham & Shackelford, 2013; Shackelford, Goetz, McKibbin, & Starratt, 2007; Shackelford et al., 2002). Given that previous research has demonstrated experimental effects of infidelity priming manipulations (Starratt, McKibbin, & Shackelford, 2013), it is reasonable to expect that when primed with thoughts of partner infidelity (and possible cuckoldry) men may adjust their ejaculates to increase their chances of success in sperm competition with rival sperm. We therefore hypothesized that men will produce a higher quality ejaculate when primed with thoughts of partner infidelity than when primed with a control stimulus.

## Method

### Participants

Participants were recruited via advertisements posted on bulletin boards on the campus of a Midwestern University in the United States and throughout the surrounding community. The advertisements included contact information (i.e., laboratory phone number and e-mail address) and participation inclusion criteria. Men were eligible to participate if they (1) had not had a vasectomy, (2) had never sought treatment for infertility, (3) were aged 18–35 years, and (4) were currently in a committed, sexually active relationship lasting at least 3 months with a woman aged 18–35 years.

Potential participants contacted the laboratory to schedule three in-person sessions—one intake session, followed by two masturbatory sessions. The original data set included responses from 66 men, with ages varying from 18 to 34 years ( $M = 22.77$ ; standard deviation [ $SD$ ] = 3.83), mostly not married (90.9%), and with relationship length varying from 6 to 123 months ( $M = 33.15$ ;  $SD = 26.62$ ;  $Mdn = 27$  months). Only data from men who provided ejaculate samples for both conditions were included in analyses. The final sample included 45 men, with ages ranging from 18 to 33 years ( $M = 23.3$ ;  $SD = 3.6$ ), mostly unmarried (86.7%), and with relationship length ranging from 6 to 123 months ( $M = 35.5$ ;  $SD = 26.8$ ;  $Mdn = 27$  months). Given the moderate effect sizes found in previous related research (Joseph et al., 2015; Kilgallon & Simmons, 2005; Leivers et al., 2014), our design and sample size were adequate to detect a moderate effect.

## Materials and Procedure

All procedures were approved by the institutional review board of the university where data were collected. Data collection occurred between April 2013 and May 2016. Participants arrived to the laboratory at a scheduled time to complete Session 1 (intake session) and were escorted to a private room by a researcher. Participants were given a written consent form and were shown a video describing the procedures of the study. Consenting participants were randomly assigned to receive either the experimental condition or the control condition first. The researcher then provided the participant with detailed instructions and the necessary materials to produce and transport masturbatory ejaculates.

Participants received a sealed envelope containing written scenarios unique to their assigned condition for the next masturbatory session. Participants were instructed not to open the envelope until immediately before they began to masturbate. In the experimental, sperm competition (hereafter “infidelity”) condition, participants were instructed to masturbate while imagining the following scenario:

Imagine that your romantic partner confessed to you earlier today that she cheated on you 2 days ago by having sex with a man that she recently met. She assured you that it was only a one-night stand and that it will not happen again. Despite being upset about her infidelity, you decide to give her another chance. Now, you and your romantic partner are going to have sex for the first time since she admitted that she cheated on you. Focus on what you think that first sexual experience would be like after her confession. Your task is to think only about this sexual experience while you masturbate. Do not allow other thoughts or fantasies to distract you during your masturbation. Focus only on what it would be like to have sex with your romantic partner after learning that she had recently cheated on you.

In the control, non-sperm-competition (hereafter “gambling”) condition, participants were instructed to masturbate while imagining the following scenario:

Imagine that your romantic partner confessed to you earlier today that she lost a considerable amount of money when she went gambling 2 days ago. She assured you that it was only a one-time mistake and that it will not happen again. Despite being upset about her gambling; you decide to give her another chance. Now, you and your romantic partner are going to have sex for the first time since she admitted that she recently lost a lot of money gambling. Focus on what you think that first sexual experience would be like after her confession. Your task is to think only about this sexual experience while you masturbate. Do not allow other thoughts or fantasies to distract you during your masturbation. Focus only on what it would be like to have sex with your romantic partner after learning that she had recently lost a lot of money gambling.

The gambling condition depicts a scenario in which the participant has been betrayed by their partner (similar to the

infidelity condition) but in a nonsexual context. Participants received materials needed to produce and transport the masturbatory ejaculate: nonlatex, nonspermicidal condom, plastic twist tie, screw top specimen container, biohazard Ziploc bag, and aluminum foil. Following the guidelines provided by the World Health Organization (2010), participants were instructed to abstain from sexual activity for 48 hr (but not longer than 7 days) prior to each of their scheduled masturbatory sessions. Participants were able to reschedule their subsequent sessions or to request replacement materials (e.g., if the condom broke) without penalty. Participants were compensated US\$25 at the conclusion of Session 1. We also secured several measures unrelated to the current research during Session 1. A list of these measures is available upon request.

Prior to arriving to the laboratory for Session 2 (the first masturbatory session), participants chose a private location in which to masturbate. Participants opened the sealed envelope and read the written instructions and then masturbated while thinking about the provided scenario. Participants were asked to not use any materials that we did not provide (e.g., pornography, lubricant). Participants were also instructed to masturbate without the help of their partner. Prior to ejaculation, participants placed a condom on their penis and then ejaculated into the condom. Participants then removed the condom, ensuring no spillage. The opening of the condom was sealed with a plastic twist tie, placed in the specimen container, which was then placed in the biohazard Ziploc bag, and wrapped in aluminum foil. Participants transported the packaged ejaculate under their armpit to retain the warmth and thus the viability of the ejaculate and arrived to the laboratory within 1 hr of ejaculation.

Upon arriving to the laboratory, participants gave their packaged ejaculate to a researcher who immediately analyzed the semen (see below). The researcher then provided the participant with another set of materials—identical to the materials provided at Session 1—to produce and transport their ejaculate for Session 3. Participants were given a sealed envelope that included the instructions for the condition that they did *not* receive for Session 2. Participants received US\$25 at the conclusion of Session 2. The procedures for Session 3 (the second masturbatory session) were identical to the procedures for Session 2 except that participants did not receive additional materials. Participants received US\$25 at the conclusion of Session 3. Time between Session 2 and Session 3 ranged from 2 to 28 days, with an average of time of 7 days between masturbatory sessions.

Ejaculate quality was assessed using the Semen Quality Analyzer (SQA-V; Medical Electronic Systems, Los Angeles, California, USA)—a fully automated machine that analyzes semen along 17 clinical parameters (see Table 1) using electro-optical technology, signal conversion, and the application of proprietary algorithms. Upon receipt of the participant’s masturbatory ejaculate at Sessions 2 and 3, a researcher pipetted the entire ejaculate from the condom and measured the volume of the ejaculate (in milliliter) using the volumetric markings on the pipette. The ejaculate was then pipetted into a

**Table 1.** Definitions, Means and SDs, Ranks, Main Effects, and  $p$  Values for Parameters Between Conditions.

Parameter	Definition	Wilcoxon Signed-Rank Test ( $I - G$ )									
		Infidelity			Gambling			Ranks			
		<i>M</i>	<i>SD</i>	<i>n</i>	<i>M</i>	<i>SD</i>	<i>n</i>	Pos.	Neg.	<i>Z</i>	<i>p</i>
01	Concentration of progressive sperm that are shaped normally <sup>a</sup>	11.0	14.0	42	10.3	9.7	39	17	20	-0.69	0.488
02	Quantity of progressive sperm that are shaped normally	18.2	20.8	38	25.1	28.8	39	16	17	-0.05	0.957
03	Percentage of progressive sperm that are shaped normally	29.9	13.6	42	29.3	9.1	38	18	18	-0.13	0.900
04	Concentration of rapid progressive motile sperm (a) <sup>b</sup>	6.7	10.5	40	7.5	10.1	41	15	16	-0.34	0.732
05	Percentage of rapid progressive motile sperm (a)	14.7	18.7	42	15.0	16.7	41	23	14	-0.83	0.407
06	Concentration of slow progressive motile sperm (b)	9.1	7.8	42	9.9	10.7	41	15	24	-0.83	0.406
07	Percentage of slow progressive motile sperm (b)	15.6	10.9	42	16.8	10.9	41	23	16	-0.59	0.553
08	Quantity of progressive motile sperm (a + b)	36.4	40.0	39	41.9	45.4	41	15	21	-0.79	0.428
09	Percentage of nonprogressive motile sperm (c)	13.5	7.5	42	15.1	8.6	41	20	18	-0.57	0.572
10	Concentration of motile sperm (a + b + c)	24.0	20.4	43	24.1	19.7	42	15	25	-0.87	0.382
11	Quantity of motile sperm (a + b + c)	54.0	52.7	39	60.0	59.4	41	15	21	-0.79	0.432
12	Percentage of motile sperm (a + b + c)	42.8	23.5	43	43.7	23.8	44	21	21	-0.29	0.769
13	Percentage of not moving or dead sperm (d)	56.2	22.8	42	53.1	21.3	41	19	20	-0.47	0.635
14	SMI <sup>c</sup>	78.6	85.9	42	89.6	105.4	45	18	22	-0.07	0.941
15	Sperm concentration within the sample	56.9	36.7	43	57.2	47.3	42	16	25	-0.73	0.468
16	Velocity of the fastest moving cells (microns/sec)	8.6	4.2	41	9.1	3.3	38	15	16	-0.28	0.782
17	Volume of the semen sample	2.6	1.4	45	2.4	1.1	44	17	24	-1.17	0.240

Note:  $n$  = number of cases per analysis. a = rapid progressive motility (forward), b = slow progressive motility (curved), c = nonprogressive motility (circles), and d = dead or not moving. SMI = sperm motility index; SD = standard deviation.

<sup>a</sup>Millions/ml. <sup>b</sup>Motility is subdivided into four categories. <sup>c</sup>SMI is an index such that higher scores reflect higher overall quality of sperm motility.

sterile specimen container. A test strip (Medical Electronic Systems) was dipped momentarily into the ejaculate to assess pH and white blood cell count. The ejaculate was syringed into a proprietary measurement capillary, which was inserted into a chamber in the SQA-V (Medical Electronic Systems) for automatic analysis. After completion of the automated semen analysis, all materials that directly contacted the ejaculate were discarded in a biohazard waste container.

## Results

The semen analysis generated 4 dichotomous parameters (e.g., pH, viscosity) and 17 continuous parameters (e.g., concentration of sperm with rapid progressive motility, percentage of morphologically normal progressive sperm; see Table 1). Outliers (i.e., any data greater than 3.0 SDs from the mean of that variable) were identified and removed using casewise deletion. A Shapiro–Wilk’s test was conducted, which tests the null hypothesis that a sample distribution was drawn from a normally distributed population (Shapiro & Wilk, 1965). Skewness and kurtosis for each continuous parameter were assessed. For small samples ( $n < 50$ ; see Table 1),  $z$ -scores greater than 1.96 for either skewness or kurtosis suggest a nonnormal distribution (George & Mallery, 2010). The Shapiro–Wilk’s test indicated a normal distribution for seven and four parameters of the infidelity and gambling conditions, respectively. The sample was nonnormally distributed for all other parameters, and therefore nonparametric tests were conducted.

Wilcoxon signed-rank tests were conducted to identify differences in each ejaculate parameter between the infidelity and

gambling conditions. The Wilcoxon (1945) signed-rank test assesses rank differences in scores between samples and is adequate for both normally and nonnormally distributed samples. Because each ejaculate parameter had a nonnormal distribution in at least one condition, we conducted Wilcoxon signed-rank tests for tests of all ejaculate parameters. The results indicated that the pairwise difference between the infidelity and gambling conditions was not significant for any of the tested ejaculate parameters (see Table 1). We also conducted Wilcoxon signed-rank tests controlling for number of abstinence days. We considered the unstandardized residuals of each parameter for each condition. The results indicated that the pairwise difference between the infidelity and gambling conditions was marginally significant ( $p < .10$ , gambling condition showed higher scores) for quantity of morphologically normal progressive sperm (Parameter 2) and sperm motility index (Parameter 14).

## Discussion

The current study examined whether men adjust their ejaculate quality as a function of sperm competition risk. We hypothesized that men would produce a higher quality ejaculate when primed with thoughts of partner infidelity (infidelity condition) than when primed with a control stimulus (gambling condition). The results did not indicate differences in ejaculate quality across any of the 17 clinical parameters tested, and therefore, the study hypothesis was not supported. Men in the current study did not produce a higher quality ejaculate when

primed with thoughts of partner infidelity than when primed with a control stimulus.

There are several possible explanations for the null results in the current study. Condom use during masturbation may have prevented proper tests of the hypothesis. The World Health Organization (2010) recommends that men ejaculate directly into nonlatex, nonspermicidal condoms to collect copulatory samples but directly into wide mouth nontoxic containers (usually glass or plastic) to collect masturbatory samples. Men in the current research were instructed to ejaculate with the condom on their penis to collect masturbatory samples. This method ensures less spillage compared to ejaculating into a container. The use of condoms, however, may be less sexually arousing to men due to decreased physical sensitivity. The null results therefore may be attributable to a “floor effect” across both conditions in which men may have been aroused *just enough* to ejaculate but not aroused enough to reveal differences between conditions. Future research should require men to ejaculate directly into a wide mouth container to decrease the potential negative effects of condom use on men’s sexual arousal.

The use of written stimuli in the current study presented unique costs and benefits. Although it allowed for greater control of variables by limiting variance that could be introduced by audiovisual stimuli, the use of written stimuli may also have constrained ecological validity and may not have constituted a salient manipulation. Using written stimuli assuaged some of the ethical concerns with priming partner infidelity in a romantic relationship. Because written stimuli have demonstrated the capability of eliciting sexual arousal (e.g., Schmidt et al., 1973) and because written erotica has been widely consumed throughout human history (Black, 2009), we anticipated that the written stimuli would be an effective manipulation that would also not constitute a long-term threat to participants’ relationships. Men frequently report sexual arousal to fantasies that have no basis in reality nor any possibility of coming true (e.g., extradyadic fantasies; Hicks & Leitenberg, 2001), so the present manipulation was an attempt to minimize relationship disturbances from imagining fictitious partner infidelity, while still activating psychological mechanisms sensitive to sperm competition in men. However, men are the primary consumers of visual pornography (Malamuth, 1996) and may require visual stimuli (rather than written stimuli) to achieve significant changes in arousal and consequent adjustment of ejaculate quality. Prior research documenting ejaculate adjustment in humans has used experimental manipulations of visual stimuli (e.g., Kilgallon & Simmons, 2005; Leivers et al., 2014), rather than written stimuli, as in the current study. Given research suggesting sex differences in mental processing (e.g., Hamann, Herman, Nolan, & Wallen, 2004) and attending to sexual and erotic stimuli of varying modalities (e.g., Dekker, Everaerd, & Verhelst, 1985; Lykins, Meana, & Straus, 2008), subsequent studies may make use of visual or audiovisual stimuli to shed further light on the present results. Future researchers are encouraged to use visual stimuli (e.g., pornography) to

manipulate psychological mechanisms that may have evolved to solve adaptive problems of sperm competition.

The stimuli may also have lacked efficacy due to the presentation environment. Having participants read the vignettes and produce ejaculates outside of the laboratory introduced additional variance that could not be controlled (e.g., the use of unauthorized stimuli, the comfort of the surroundings). Environments could have differed (both within and between participants) along a number of factors (e.g., temperature) known to impact semen parameters (see World Health Organization, 2010, for environmental factors that may affect ejaculate sample quality). Whether participants diligently read the scenarios (and thus properly introduced the appropriate stimuli) cannot be stated with the level of certainty as in a laboratory procedure. Further, because ejaculates were produced outside of the laboratory, samples may have been degraded by the time they were analyzed. Participants did verify that ejaculates were produced and delivered to the laboratory within 1 hr; however, it is possible that participants’ responses did not accurately reflect actual time of ejaculation. Although it would have been preferred to have participants produce samples in the laboratory using a specimen container or seminal retention device (Schoenfeld, Amelar, Dubin, & Skwerers, 1978), the protocols detailed in the present research were implemented as ethical and biosafety controls at the university level.

Finally, our sample consisted primarily of nonmarried, young men in relationships of relatively short duration. The risk of cuckoldry—and, thus, the infidelity manipulation—may therefore not be as salient as it might have been for married men or men in more committed relationships of longer duration. For some of these men, conception might even constitute a reason for termination of the relationship, and thus paternity uncertainty may not be a relevant consideration. Future researchers are encouraged to test the ejaculate adjustment hypothesis in a sample of married men or men in longer term, more committed relationships.

Alternatively, the results of the current research may indicate the absence of mechanisms in men that evolved to solve adaptive problems of sperm competition. The results may also indicate that men may not be attentive to the particular sperm competition cue (i.e., partner infidelity) that was assessed in the current study. Despite the null results of the current research, however, there is evidence for psychological and physiological adaptations to sperm competition in humans (Pham & Shackelford, 2014) and a substantial body of research addressing nonhuman sperm competition (reviewed in Simmons & Fitzpatrick, 2012). Many sperm competition studies in nonhumans, however, involve procedures that cannot be replicated using human participants (e.g., manipulating the number of males with whom a female copulates and then measuring which sperm of the different males fertilize ova; Price, Dyer, & Coyne, 1999). Logistical and ethical constraints have resulted in a relative lack of experimental sperm competition research on humans compared to sperm competition research on nonhumans. A parsimonious interpretation of the null results is therefore that they are a consequence of one or more

methodological artifacts. The current research nevertheless contributes important methodological information to the sperm competition literature more generally and highlights methodological considerations for researchers investigating adaptations to human sperm competition.

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### References

- Anderson, K. (2006). How well does paternity confidence match actual paternity? *Current Anthropology*, *47*, 513–520.
- Baker, R. R., & Bellis, M. A. (1993). Human sperm competition: Ejaculate adjustment by males and the function of masturbation. *Animal Behaviour*, *46*, 861–885.
- Baker, R. R., & Bellis, M. A. (1995). *Human sperm competition: Copulation, competition and infidelity*. London, England: Chapman & Hall.
- Baker, R. R., & Shackelford, T. K. (2017). A comparison of paternity data and relative testes size as measures of level of sperm competition in the Hominoidea. *American Journal of Physical Anthropology*.
- Black, R. W. (2009). Online fan fiction, global entities, and imagination. *Research in the Teaching of English*, *43*, 397–425.
- Dekker, J., Everaerd, W., & Verhelst, N. (1985). Attending to stimuli or to images of sexual feelings: Effects on sexual arousal. *Behaviour Research and Therapy*, *23*, 139–149.
- George, D., & Mallery, M. (2010). *SPSS for Windows step by step: A simple guide and reference, 17.0 update* (10th ed.). Boston, MA: Pearson.
- Goetz, A. T., Shackelford, T. K., Weekes-Shackelford, V. A., Euler, H. A., Hoier, S., Schmitt, D. P., & LaMunyon, C. W. (2005). Mate retention, semen displacement, and human sperm competition: A preliminary investigation of tactics to prevent and correct female infidelity. *Personality and Individual Differences*, *38*, 749–763.
- Hamann, S., Herman, R. A., Nolan, C. L., & Wallen, K. (2004). Men and women differ in amygdala response to visual sexual stimuli. *Nature Neuroscience*, *7*, 411–416.
- Hicks, T. V., & Leitenberg, H. (2001). Sexual fantasies about one's partner versus someone else: Gender differences in incidence and frequency. *Journal of Sex Research*, *38*, 43–50.
- Joseph, P. N., Sharma, R. K., Agarwal, A., & Sirot, L. K. (2015). Men ejaculate larger volumes of semen, more motile sperm, and more quickly when exposed to images of novel women. *Evolutionary Psychological Science*, *1*, 195–200.
- Julien, E., & Over, R. (1988). Male sexual arousal across five modes of erotic stimulation. *Archives of Sexual Behavior*, *17*, 131–143.
- Kilgallon, S. J., & Simmons, L. W. (2005). Image content influences men's semen quality. *Biology Letters*, *1*, 253–255.
- Leivers, S., Rhodes, G., & Simmons, L. W. (2014). Context-dependent relationship between a composite measure of men's mate value and ejaculate quality. *Behavioral Ecology*, *25*, 1115–1122.
- Lykins, A. D., Meana, M., & Strauss, G. P. (2008). Sex differences in visual attention to erotic and non-erotic stimuli. *Archives of Sexual Behavior*, *37*, 219–228.
- Malamuth, N. (1996). Sexually explicit media, gender differences and evolutionary theory. *Journal of Communication*, *46*, 8–31.
- Nicholls, E. H., Burke, T., & Birkhead, T. R. (2001). Ejaculate allocation by male sand martins, *Riparia riparia*. *Proceedings of the Royal Society of London Series B: Biological Sciences*, *268*, 1265–1270.
- Parker, G. G. (1970). Sperm competition and its evolutionary consequences in the insects. *Biological Reviews*, *45*, 525–567.
- Pham, M. N., & Shackelford, T. K. (2013). The relationship between objective sperm competition risk and men's copulatory interest is moderated by partner's time spent with other men. *Human Nature*, *24*, 476–485.
- Pham, M. N., & Shackelford, T. K. (2014). Human sperm competition: A comparative evolutionary analysis. *Animal Behavior and Cognition*, *1*, 410–422.
- Pham, M. N., Shackelford, T. K., Holden, C. J., Zeigler-Hill, V., Hummel, A., & Memering, S. L. (2014). Partner attractiveness moderates the relationship between number of sexual rivals and in-pair copulation frequency in humans (*Homo sapiens*). *Journal of Comparative Psychology*, *128*, 328–331.
- Pizzari, T., Cornwallis, C. K., Løvlie, H., Jakobsson, S., & Birkhead, T. R. (2003). Sophisticated sperm allocation in male fowl. *Nature*, *426*, 70–74.
- Price, C. S., Dyer, K. A., & Coyne, J. A. (1999). Sperm competition between *Drosophila* males involves both displacement and incapacitation. *Nature*, *400*, 449–452.
- Rupp, H. A., & Wallen, K. (2008). Sex differences in response to sexual stimuli: A review. *Archives of Sexual Behavior*, *37*, 206–218.
- Schmidt, G., Sigusch, V., & Schäfer, S. (1973). Responses to reading erotic stories: Male-female difference. *Archives of Sexual Behavior*, *3*, 181–199.
- Schoenfeld, C., Amelar, R. D., Dubin, L., & Skwerers, R. G. (1978). Evaluation of a new silastic seminal fluid collection device. *Fertility and Sterility*, *30*, 319–321.
- Shackelford, T. K. (2003). Preventing, correcting, and anticipating female infidelity: Three adaptive problems of sperm competition. *Evolution and Cognition*, *9*, 90–96.
- Shackelford, T. K., & Goetz, A. T. (2007). Adaptation to sperm competition in humans. *Current Directions in Psychological Science*, *16*, 47–50.
- Shackelford, T. K., Goetz, A. T., McKibbin, W. F., & Starratt, V. G. (2007). Absence makes the adaptations grow fonder: Proportion of time apart from partner, male sexual psychology, and sperm competition in humans (*Homo sapiens*). *Journal of Comparative Psychology*, *121*, 214–220.
- Shackelford, T. K., LeBlanc, G. J., Weekes-Shackelford, V. A., Bleske-Rechek, A. L., Euler, H. A., & Hoier, S. (2002). Psychological adaptation to human sperm competition. *Evolution and Human Behavior*, *23*, 123–138.

- Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, *52*, 591–611.
- Simmons, L. W., & Fitzpatrick, J. L. (2012). Sperm wars and the evolution of male fertility. *Reproduction*, *144*, 519–534.
- Smith, R. L. (1984). Human sperm competition. In R. L. Smith (Ed.), *Sperm competition and the evolution of animal mating systems* (pp. 601–659). New York, NY: Academic Press.
- Starratt, V. G., McKibbin, W. F., & Shackelford, T. K. (2013). Experimental manipulation of psychological mechanisms responsive to female infidelity. *Personality and Individual Differences*, *55*, 59–62.
- Voracek, M., Haubner, T., & Fisher, M. L. (2008). Recent decline in nonpaternity rates: A cross-temporal meta-analysis. *Psychological Reports*, *103*, 799–811.
- Wedell, N., Gage, M. J., & Parker, G. A. (2002). Sperm competition, male prudence and sperm-limited females. *Trends in Ecology and Evolution*, *17*, 313–320.
- Wilcoxon, F. (1945). Individual comparisons by ranking methods. *Biometrics Bulletin*, *1*, 80–83.
- World Health Organization. (2010). *WHO laboratory manual for the examination and processing of human semen* (5th ed.). Geneva, Switzerland: WHO Press.