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Image content influences men's semen quality

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There is increasing evidence from non-human animals that males adjust their ejaculate expenditure according to the risk of sperm competition. In this study we show that, after controlling for lifestyle factors known to influence semen quality, human males viewing images depicting sperm competition had a higher percentage of motile sperm in their ejaculates. Many lifestyle variables were confirmed to influence semen quality, including the recent suggestion that storage of mobile phones close to the testes can decrease semen quality.

Keywords: sperm competition; sperm motility; humans

1. INTRODUCTION

Studies of non-human animals are revealing a remarkable ability in males for facultative adjustments of the ejaculate. These adjustments conform to the expectations of game theoretical models that male fitness will be maximized when subject to the competition that arises between sperm when females mate with more than one male (Parker *et al.* 1997; Wedell *et al.* 2002). Thus, males ejaculate more sperm, or sperm of better quality, when the risk of sperm competition (the probability that a female will mate with more than one male) is high (Burness *et al.* 2004; DelBarco-Trillo & Ferkin 2004; Pound & Gage 2004) but reduce the number of sperm ejaculated when the intensity of sperm competition (the number of males competing for a given set of ova) increases beyond two (Pilastro *et al.* 2002; Pizzari *et al.* 2003).

The artificial insemination industry has repeatedly reported that increased sperm counts can be obtained from males allowed to view conspecific mating activity prior to ejaculate delivery (Hemsworth & Galloway 1979; Mader & Price 1984). Likewise, in the human fertility industry, viewing sexually explicit images or videos prior to ejaculation has been reported to increase the total number of sperm and the percentage of motile sperm in an ejaculate (Yamamoto *et al.* 2000). A survey of adult literature content and preferences has revealed that men prefer images depicting scenarios that would promote sperm competition (two males and a female) to images depicting situations that would not (two females and a male; Pound 2002). It was suggested that the appeal of images depicting sperm competition could be explained if heightened sexual arousal resulting from viewing such images arose due to an evolutionary history of sperm competition. If true, men viewing images depicting sperm competition are predicted to have higher semen quality than men viewing images of females alone.

2. METHODS

This work was carried out under the approval of the University of Western Australia Human Research Ethics Committee. We recruited 52 heterosexual men between the ages of 18 and 35 years from the campus of the University of Western Australia. Height and weight were determined and subjects completed a questionnaire that sought information on lifestyle factors thought to influence semen quality (see Electronic Appendix). Subjects were asked to abstain from all sexual activity for at least 48 h, but no longer than 6 days (World Health Organization 1999), before obtaining a semen sample while viewing one of two randomly allocated sets of four sexually explicit images. One image set depicted images of two males and a female (sperm competition images) while the alternative set depicted three females. Images were provided in sealed envelopes with instructions that they were not to be viewed until semen collection. Subjects were asked to collect their semen after 07.00 in a 70 ml container covered in aluminium foil and deliver it to the laboratory, ensuring that samples were kept warm in a pocket or under their arm, no later than 09.00. The time restriction was imposed to minimize the risk of semen deterioration prior to analysis. Subjects were provided with a vernier calliper and asked to return a measure of the width and length of their left and right testis, an indication of the time taken to obtain the sample, the time of day that the semen was collected and the time since last ejaculation. When subjects returned their sample, they were asked if they would participate a second time. Of the 52 men, 25 agreed. These men returned one to two weeks later and were allocated the alternative image set to that used for their first contribution.

Semen quality was assessed using World Health Organization (1999) protocols. Whether the sample had liquefied was noted, and the percentage of motile sperm and the number of sperm per ml of ejaculate were determined. Prior to analysis, one of us (S.J.K.) was trained by a qualified seminologist at a local fertility clinic and assessed using the Fertility Society of Australia's External Quality Assurance Scheme for Reproductive Medicine. S.J.K.'s results fell within the range of results obtained by fertility clinics in the Australasian region. We classified sperm samples based on the percentage of A and the percentage of B motility, where A is the percentage with rapid progressive motility and B is the percentage with slow or sluggish progressive motility. Measures of the same semen samples were highly repeatable (sperm per ml: $F_{51,52}=60.8$, $p<0.0001$, $R=0.968$; motility $F_{51,52}=21.9$, $p<0.0001$, $R=0.913$). For those men that participated twice, measures of testis volume, calculated as the volume of an ovoid, were highly repeatable (left testis $F_{24,25}=9.7$, $p<0.0001$, $R=0.897$; right testis $F_{24,25}=10.12$, $p<0.0001$, $R=0.901$).

All data were screened for normality and homoscedasticity of variances and transformed where necessary. Data were analysed using general linear modelling. Owing to the large number of potentially important variables, we first entered all possible independent variables into a model and then performed a stepwise backward deletion of insignificant terms. To reduce the risk of committing a type I error, we re-ran the final model including all terms with $p \leq 0.1$. All reported means are presented $\pm$1s.e. and are raw means, and are therefore unadjusted for other factors and covariates in the model.

3. RESULTS

We were able to explain almost 90% of the variance in the percentage of motile sperm contained within an ejaculate ($r^2=0.899$, $F_{28,23}=7.34$, $p<0.0001$). After controlling for lifestyle factors, image content had a significant influence on sperm motility. Subjects viewing images of sperm competition had a greater proportion of motile sperm in their ejaculates than those viewing images of females ($52.1\pm7.3\%$ versus $49.3\pm8.0\%$; $F_{1,23}=5.08$, $p=0.034$). Moreover, men that rated the images as being more explicit than they had viewed before had higher motility ($58.7\pm7.7\%$) than men who rated the images as being less explicit ($38.0\pm8.4\%$; $F_{3,23}=3.95$, $p=0.021$). Several

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physical and lifestyle factors also influenced sperm motility. Samples that failed to liquefy had fewer motile sperm, men raised in urban environments had more motile sperm than men raised in rural environments and the proportion of motile sperm increased with age, testis size and the time of day the sample was collected, but decreased with the time taken to deliver the sample to the laboratory for testing and the time taken to obtain the sample (see table A1 in the Electronic Appendix). Men with partners and those who had higher levels of sexual activity also had more motile sperm. Smoking and alcohol consumption both affected sperm motility. These factors have been shown elsewhere to influence sperm motility (Künzle *et al.* 2002; Sharpe & Franks 2002) and their effects here provide internal validity to our analysis. Interestingly, men who carried their mobile phone in their hip pocket or on their belt had lower sperm motility ($49.3 \pm 8.2\%$) than men who did not carry a mobile phone or who carried their mobile phone elsewhere on the body ($55.4 \pm 7.4\%$; $F_{1,23} = 33.28$, $p < 0.0001$).

We were able to account for 62% of the variance in the number of sperm per ml of ejaculate ($r^2 = 0.617$, $F_{15,36} = 3.86$, $p < 0.001$). Again, after controlling for lifestyle factors, image content had a significant effect on sperm numbers. Men viewing images depicting sperm competition had fewer sperm in their ejaculate than those viewing images of females (61.35 ± 1.27 versus $76.64 \pm 1.26 \times 10^6$ sperm ml^{-1}; $F_{1,36} = 8.48$, $p = 0.0061$). Moreover, men who rated images as being more explicit than they had viewed before had a higher concentration of sperm ($72.84 \pm 1.30 \times 10^6$ sperm ml^{-1}) than men who rated the images as being less explicit ($47.39 \pm 1.37 \times 10^6$ sperm ml^{-1}; $F_{3,36} = 5.35$, $p = 0.004$). As with sperm motility, the effects of physical and lifestyle factors lend internal validity to our results. Men who spent more time seated per day had lower sperm counts (see also Figa-Talamanca *et al.* 1996) and sperm concentration increased with increasing testes size (see table A2 in the Electronic Appendix). Interestingly, moderate consumption of caffeine was associated with higher sperm concentration and, again, men who carried a mobile phone in their hip pocket or on their belt had a lower sperm concentration ($65.60 \pm 1.26 \times 10^6$ sperm ml^{-1}) than men who either did not carry a mobile phone or who stored it elsewhere on the body ($75.67 \pm 1.30 \times 10^6$ sperm ml^{-1}; $F_{1,36} = 12.09$, $p = 0.0013$). There was a moderate correlation between sperm concentration and the percentage of motile sperm ($r = 0.410$, $n = 52$, $p = 0.003$).

Previous studies of ejaculate adjustment by males have used between-subject designs, which are likely to yield conservative results due to potentially confounding factors that could influence semen quality between the subjects involved. In our between-subject analysis we have attempted to control for as many potentially confounding factors as possible, but an arguably better approach is to adopt a within-subject design (Pound & Gage 2004). Of our subjects, 25 agreed to participate a second time so that we were able to provide them with the opposite image type to that used on their first trial. Each subject thus acted as his own control for many of the variables that influence semen quality, including individual variation between men that might be genetic in origin. However, the order in which images were presented to the men did differ. Our between-subject analysis suggested that men may become habituated to images; men who found the images less explicit than they had viewed previously had a lower percentage of motile sperm and a lower sperm concentration. A habituation effect in our within-subject test would be expected to enhance the effect of image content when sperm competition images were viewed first, and to mitigate the effect of image content when sperm competition images were viewed second. We therefore conducted two separate analyses, one for each order of image presentation. When men viewed the sperm competition image in their first trial, they had higher sperm motility when viewing the sperm competition images ($57.9 \pm 1.4\%$) than when viewing the images of females ($52.7 \pm 1.4\%$; $r^2 = 0.88$, between-subject $F_{11,11} = 6.68$, $p = 0.002$; image type $F_{1,11} = 7.29$, $p = 0.021$). As expected, the effect size of image content was greater than that found in our between-subject analysis (Cohen's d: between-subject 0.313, within-subject 0.551). For men viewing images of females in their first trial, the effect of image type was not significant ($r^2 = 0.82$; between-subject $F_{12,12} = 4.38$, $p = 0.008$; image type $F_{1,12} = 0.32$, $p = 0.584$; percentage of motile sperm with the sperm competition image $46.6 \pm 3.2\%$, percentage of motile sperm with females alone image $49.5 \pm 3.2\%$). There were significant differences between subjects in sperm motility for both orders of presentation.

Within-subject analysis of sperm concentration showed that although men differed significantly in the numbers of sperm per ml of ejaculate, image content had no effect on sperm concentration, either when sperm competition images were viewed first ($r^2 = 0.79$, between-subject $F_{11,11} = 3.82$, $p = 0.018$; image type $F_{1,11} = 0.001$, $p = 0.982$) or second ($r^2 = 0.88$, between-subject $F_{12,12} = 7.27$, $p = 0.001$; image type $F_{1,12} = 0.04$, $p = 0.842$). Men produced ejaculates with $73.98 \pm 1.13 \times 10^6$ sperm ml^{-1} when viewing the sperm competition images compared with $72.97 \pm 1.14 \times 10^6$ sperm ml^{-1} when viewing images of females alone.

4. DISCUSSION

Our data show that image content can have an impact on men's semen quality. The use of images in manipulating social context is becoming widespread in animal behaviour research and a recent study of sticklebacks showed that males ejaculate more sperm after viewing videos of a conspecific male courting a female than a male tending eggs at his nest (Zbinden *et al.* 2004). The between-subject patterns for sperm motility in men could be viewed as consistent with theoretical models of sperm competition, in that men viewing images of sperm competition produced ejaculates with a higher proportion of motile sperm. Sperm motility is associated with fertilizing capacity (Moghhissi & Wallach 1983) in humans and has also been shown to influence competitive fertilization

capacity in fishes (Vladic & Järvi 2001) and domestic fowl (Birkhead *et al.* 1999). Our within-subject analysis yielded similar conclusions only when men viewed images of sperm competition in their first trials. The influence of previous image viewing on sperm motility raises interesting issues regarding habituation and the use of images in manipulating social context that should be addressed in future studies.

Data on sperm concentration were equivocal. On the one hand, if viewing images of two males and one female was perceived in the context of sperm competition risk we would have expected an increase in sperm concentration (Parker *et al.* 1997). On the other hand, if these images were perceived as high-intensity sperm competition, we should expect a decrease in sperm concentration (Parker *et al.* 1996), as observed in our between-subject analysis. Nevertheless, the within-subject analysis suggested that, after controlling for differences between men, image content may not influence sperm concentration. Further studies are required both to validate our findings and to extend them by incorporating sex ratio variation in experimental images.

Finally, our results have practical implications. Mobile phones have been implicated as being potentially detrimental to semen quality (Dasdag *et al.* 2003; Aitken *et al.* 2005). Our analysis used an extensive survey to control for lifestyle factors that are known to influence semen quality. After other lifestyle variables had been accounted for in our analysis, storage of mobile phones close to the testes had a significant negative impact on sperm concentration and the percentage of motile sperm. These trends suggest that recent concerns over long-term exposure to the electromagnetic irradiation emitted by mobile phones should be taken more seriously, given the growing trend for deterioration in the male germ line (Aitken *et al.* 2004).

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Aitken, R. J., Koopman, P. & Lewis, S. E. M. 2004 Seeds of concern. *Nature* **432**, 48–52.

Aitken, R. J., Bennetts, L. E., Sawyer, D., Wiklendt, A. M. & King, B. V. 2005 Impact of radio frequency electromagnetic radiation on DNA integrity in the male germ line. *Published online 31 March 2005. Int. J. Androl* **28**. (doi:10.1111/j.1365-2605.2005.00531.x.)

Birkhead, T. R., Martinez, J. G., Burke, T. & Froman, D. P. 1999 Sperm mobility determines the outcome of sperm competition in the domestic fowl. *Proc. R. Soc. B* **266**, 1759–1764.

Burness, G., Casselman, S. J., Schulte-Hostedde, A. I., Moyes, C. D. & Montgomerie, R. 2004 Sperm swimming speed and energetics vary with sperm competition risk in bluegill. *Behav. Ecol. Sociobiol.* **56**, 65–70.

Dasdag, S., Akdag, M. Z., Aksen, F., Yilmaz, F., Bashan, M., Dasdag, M. M. & Celik, M. S. 2003 Whole body exposure of rats to microwaves emitted from a cell phone does not affect the testes. *Bioelectromagnetics* **24**, 182–188.

DelBarco-Trillo, J. & Ferkin, M. H. 2004 Male mammals respond to a risk of sperm competition conveyed by odours of conspecific males. *Nature* **431**, 446–449.

Figa-Talamanca, I. *et al.* 1996 Effects of prolonged autovehicle driving on male reproductive function: a study among taxi drivers. *Am. J. Ind. Med.* **30**, 750–758.

Hemsworth, P. H. & Galloway, D. B. 1979 The effect of sexual stimulation on the sperm output of the domestic boar. *Anim. Reprod. Sci.* **2**, 387–394.

Künzle, R., Mueller, M. D., Hänggi, W., Birkhäuser, M. H., Drescher, H. & Bersinger, N. A. 2002 Semen quality of male smokers and nonsmokers in infertile couples. *Fertil. Steril.* **79**, 287–290.

Mader, D. R. & Price, E. O. 1984 The effects of sexual stimulation on the sexual performance of Hereford bulls. *J. Anim. Sci.* **59**, 294–300.

Moghhissi, K. S. & Wallach, E. E. 1983 Unexplained infertility. *Fertil. Steril.* **39**, 5–10.

Parker, G. A., Ball, M. A., Stockley, P. & Gage, M. J. G. 1996 Sperm competition games: individual assessment of sperm competition intensity by group spawners. *Proc. R. Soc. B* **263**, 1291–1297.

Parker, G. A., Ball, M. A., Stockley, P. & Gage, M. J. G. 1997 Sperm competition games: a prospective analysis of risk assessment. *Proc. R. Soc. B.* **264**, 1793–1802. (doi:10.1098/rspb.1997.0249.)

Pilastro, A., Scaggiante, M. & Rasotto, M. B. 2002 Individual adjustment of sperm expenditure accords with sperm competition theory. *Proc. Natl Acad. Sci. USA* **99**, 9913–9915.

Pizzari, T., Cornwallis, C. K., Løvlie, H., Jakobsson, S. & Birkhead, T. R. 2003 Sophisticated sperm allocation in male fowl. *Nature* **426**, 70–74.

Pound, N. 2002 Male interest in visual cues of sperm competition risk. *Evol. Hum. Behav.* **23**, 443–466.

Pound, N. & Gage, M. J. G. 2004 Prudent sperm allocation in Norway rats, *Rattus norvegicus*: a mammalian model of adaptive ejaculate adjusment. *Anim. Behav.* **68**, 819–823.

Sharpe, R. M. & Franks, S. 2002 Environment, lifestyle and infertility—an inter-generational issue. *Nat. Cell Biol.* **4** (Suppl. 1), S33–S40.

Vladic, T. V. & Järvi, T. 2001 Sperm quality in the alternative reproductive tactics of Atlantic salmon: the importance of the loaded raffle mechanism. *Proc. R. Soc. B* **268**, 2375–2381. (doi:10.1098/rspb.2001.1768.)

Wedell, N., Gage, M. J. G. & Parker, G. A. 2002 Sperm competition, male prudence and sperm-limited females. *Trends Ecol. Evol.* **17**, 313–320.

World Health Organization 1999 *WHO laboratory manual for the examination of human semen and sperm-cervical mucus interaction*. Cambridge University Press.

Yamamoto, Y., Sofikitis, N., Mio, Y. & Miyagawa, I. 2000 Influence of sexual stimulation on sperm parameters in semen samples collected via masturbation from normozoospermic men or cryptozoospermic men participating in an assisted reproduction programme. *Andrologia* **32**, 131–138.

Zbinden, M., Largiadér, C. R. & Bakker, T. C. M. 2004 Body size of virtual rivals affects ejaculate size in sticklebacks. *Behav. Ecol.* **15**, 137–140.

The supplementary Electronic Appendix is available at http://dx.doi.org/10.1098/rsbl.2005.0324 or via http://www.journals.royalsoc.ac.uk.