Age and social position moderate the effect of stress on fertility

Jacky Boivin\textsuperscript{a,}\textsuperscript{*}, Kathy Sanders\textsuperscript{b}, Lone Schmidt\textsuperscript{c}

\textsuperscript{a}School of Psychology, Cardiff University, Cardiff, CF10 3AT Wales, UK
\textsuperscript{b}School of Anatomy and Human Biology, University of Western Australia, Crawley WA 6009, Australia
\textsuperscript{c}Institute of Public Health, Department of Social Medicine, University of Copenhagen, Panum Institute, DK-2200 Copenhagen N, Denmark

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Abstract

There is now compelling evidence that psychosocial stress is a cause of reproductive suppression in humans. However, women continue to conceive in the harshest conditions of war, poverty, or famine, suggesting that suppression can be bypassed. The reproductive suppression model (RSM) proposes that natural selection should favor factors that reliably predict conditions for reproduction. In this study, we examine two such factors, age and social position, in women undergoing fertility treatment. We hypothesized that stress-related reproductive suppression would be more likely in younger compared to older women and in women in lower compared to higher social positions. The final sample consisted of 818 women undergoing fertility treatment. Psychosocial stress and sociodemographic data were collected prior to the start of treatment (Time 1), whereas fertility, as indexed by pregnancy or live birth, was assessed 12 months later (Time 2). The results showed that younger women were four times more likely to suppress than older women, and that unskilled and manual workers were more likely to suppress than those in middle social positions (e.g., white collar workers). However, significant associations between stress and fertility were also observed for women in higher social positions (e.g., professionals and executives). The findings provide support for the RSM.

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* Corresponding author.
1. Introduction

One of the most important life history trade-offs is that between current and future reproduction (Chisholm, 1999; Stearns, 1992). Reproduction, particularly for humans, is costly, not only because of the requirement for extra nutrients to support pregnancy and lactation, but also in terms of time and the risk to survival because of childbirth. Thus, investment in current reproduction may incur costs that decrease the opportunity for, or success of, future reproductive efforts. But under what environmental conditions is it better for the individual’s lifetime reproductive success to defer reproduction? One key assumption of the reproductive suppression model (RSM) (Wasser & Barash, 1983) is that not all environmental conditions are equally favorable for investment in reproduction. Similarly, the developmental model of Ellison (1990) proposes that ovarian function is responsive to the quality of ecological conditions, for example, availability of food resources. These, and other (e.g., flexible response model; Vitzthum, 2001), evolutionary models propose that under conditions of environmental stress, reproductive functioning is temporarily suppressed because harsh conditions mean that the animal is either unlikely to be able to provide adequately for itself or the offspring, and/or the offspring is unlikely to survive.

The link between stress and reproductive suppression is well established in nonhuman mammals. In these groups, stress may be indicated by poor resource availability, low social status, competition, and persistent receipt of aggression, and all have been associated with decrements in reproductive potential (e.g., Cameron, 1997; deCatanzaro & MacNiven, 1992; Wasser & Barash, 1983). Physiological and demographic studies in humans also demonstrate variations in ovarian function according to the intensity of ecological stressors (for review, see Ellison, 1990, 1995). In addition to ecological factors, Wasser and Barash (1983) highlight the importance of the psychosocial environment to human survival and reproductive success. Wasser and Barash (1983), Wasser and Isenberg (1986), and Wasser and Place (2001) argue that psychosocial stressors, particularly those that make it difficult to provide adequate care for the child (e.g., lack of social support, anxiety), should also activate the physiological mechanisms that suppress reproductive function. Effects of psychosocial stress on human reproductive function have been shown: negative affect (e.g., anxiety, depression) has been associated with longer cycle lengths (Hjollund et al., 1999) and reduced conception in healthy women trying to conceive (Sanders & Bruce, 1997). Further evidence comes from fertility treatment studies showing that stress indicators are associated with a poorer ovarian functional response to treatment (Lancastle & Boivin, 2005) and reduced fertilization, implantation, and live birth rates (e.g., Facchinetti, Matteo, Artini, Volpe, & Genazzani, 1997; Gallinelli et al., 2001; Klonoff-Cohen, Chu, Natarajan, & Sieber, 2001; Sanders & Bruce, 1999a; Smeenk et al., 2001). These associations remain after controlling for obvious confounders, for example, lifestyle (e.g., smoking) and health (e.g., weight) factors (Klonoff-Cohen et al., 2001; Sanders & Bruce, 1999a).

Given the harsh realities of life, however, reproductive suppression whenever stress is experienced would not, in practice, be efficient. Indeed, women continue to conceive in the harshest conditions of war, poverty, or famine. Moreover, despite the converging evidence in
human studies noted previously, not all human studies find an association between stress and fertility potential and/or the effect size varies among studies (e.g., Anderheim, Holter, Bergh, & Möller, 2005; Merari, Feldberg, Elizur, Goldman, & Modan, 1992; Sanders & Bruce, 1999b). This variability suggests the presence of moderators or constraints on the stress–fertility association.

Wasser and Barash (1983) propose several constraints to reproductive suppression in times of stress. First, the RSM was based on the relationship of present to future reproductive conditions with reproductive suppression proposed to be less likely when future reproductive opportunities were scarce or limited, because the cost of delayed reproduction would outweigh its potential benefits. Consequently, it was proposed that younger women should be more likely to suppress in times of stress than older women (Wasser & Barash, 1983; Wasser & Isenberg, 1986).

Second, because humans are a social species, reproductive suppression should vary according to the economic and social resources available to the individual because these are fundamental tools in the defense against stressful life events (Wasser and Isenberg, 1986, p. 531), regardless of future conditions. Individuals with more resources have stronger defenses and are better able to withstand the physiological effects of stress than those with fewer resources. This is evidenced by, for example, the findings that sustained stress hormone activation (e.g., higher baseline cortisol levels) and altered responsivity to stress situations are more common in individuals from low socioeconomic backgrounds (Kristenson, Eriksen, Sluiter, Starke, & Ursin, 2004), or that socially isolated individuals respond to stress with greater vascular resistance and slower wound healing than nonisolated individuals (Cacioppo & Hawkley, 2003). Therefore, individuals with poorer resources should be at greater risk for reproductive suppression because they lack environmental “buffers” against psychosocial stress (Lazarus & Folkman, 1984).

In the present study, we examine age and social position as moderators of the association between psychosocial stress and fertility in women undergoing fertility treatment. In this population, the most demanding psychosocial stressor is the fertility problem (FP) itself. Accordingly, stress was defined as the extent to which FPs were perceived to be a threat to the individual and couple. Fertility-problem stress has been linked with reproductive suppression (i.e., reduced implantation and pregnancy rates) in previous work (e.g., Boivin & Takefman, 1995; Klonoff-Cohen et al., 2001). We hypothesized that FP stress would be associated with greater reproductive suppression (i.e., treatment failure) in younger vs. older women. Moreover, we hypothesized that low resources, as indexed by low social position, would be associated with greater suppression than high social positions.

2. Method

2.1. Subjects

The final sample consisted of 818 women undergoing treatment at one of five fertility clinics in Denmark and participating in the Copenhagen Multi-centre Psychosocial Infertility
(COMPI) (Schmidt et al., 2003) longitudinal investigation of Danish couples undergoing fertility treatment. The sample consisted of couples who had been referred for fertility treatment, with the expectation that they were physically capable of pregnancy with treatment and who had had at least one cycle of fertility treatment during the 12-month study period. Under the Danish health care system, all couples had equal access to subsidized treatment. Women who had conceived a child with treatment prior to the start of the study, who adopted a child during the study period, and/or who had errors or missing data in their questionnaires were excluded to increase the homogeneity of the sample. The final sample constituted 76.4% of the initial pool of participating couples (n=1070) at study entry.

Women were in their mid-thirties (M=31.5, S.D.=3.5; range, 22–40 years) and most, 88.4% (n=723), participated in the labor force. Women had been living with their partners for almost 8 years (M=7.6, S.D.=3.6), and the average duration of infertility was 4.09 (S.D.=2.12) years. Most couples had had fertility treatment (median, two treatments) prior to study entry, but the majority of couples (75.1%, n=614) had no children either together or from a previous relationship. Couples with children were not different from those with children in their reports of FP stress \(t(816)=.14, p=.89\) or treatment success rates \(\chi^2(1)=.05, p=.83\).

2.2. Materials

Age, social position, and FP stress were assessed at study entry prior to the start of fertility treatment (Time 1, T1), whereas number of treatments and treatment outcome were assessed at the follow-up assessment 12 months later (Time 2, T2).

2.2.1. Time 1

2.2.1.1. Fertility-problem stress. The FP stress inventory (Abbey, Andrews, & Halman, 1991; Schmidt, 1996) was used to assess the overall threat of FPs via ratings of the amount of disruption and stress; the FP was perceived to have produced for the individual (e.g., “It is very stressful for me to deal with this fertility problem”) and the marital relationship (e.g., “Fertility problems have caused thoughts of divorce”). The total score was computed by adding ratings (range, 5–22) with higher scores indicating higher stress.

2.2.1.2. Age and social position. For age, participants provided their year of birth, and this variable was converted to a numerical score, which was rounded to the nearest year. Social position was based on school education, vocational training, and occupational social class, and is an indicator of both social standing and material reward and resources (Hansen, 1984). Seven items were combined using a standardized method (Hansen, 1984) to derive three social positions. Social Position I comprised unskilled and semiskilled workers (e.g., gas station attendant); social Position II, white collar and skilled workers (e.g., small-scale self-employed, nurse); and social Position III, professionals and executives (e.g., lawyers, large-scale self-employed). Ninety-five women (11.6%) could not be classified according to this
scheme (i.e., mainly students and people outside of the work force) and were excluded from social position analyses.

2.2.2. Time 2

2.2.2.1. Treatment outcome. At the 12-month follow-up, participants were asked to indicate whether they had achieved a pregnancy, and if they had, they were asked whether they were currently pregnant or had delivered. Women in the latter two categories comprised the reproductive “success” group. The remaining women had not achieved a pregnancy, or had become pregnant but had a pregnancy failure (e.g., miscarriage, ectopic). These women comprised the “no success” outcome group. We included ongoing pregnancies in the “success” group because we could not predict whether any of these would result in miscarriage. However, because only 39 of the ongoing pregnancies were still in the first trimester when miscarriage is most likely (Nyboe Andersen, Gianaroli, Felberbaum, de Mouzon, & Nygren, 2005), the number of potential miscarriages was expected to be small (~20% of 39 equals 8) and unlikely to affect the results presented. Participants also indicated the number of treatment cycles they had completed between T1 and T2. Treatment included any type of assisted reproductive intervention [e.g., in vitro fertilization (IVF), insemination].

2.3. Procedure

Infertility clinics were contacted to enlist their participation in the COMPI project, and all (n=5) agreed to distribute questionnaires. Clinics were provided with questionnaire booklets and preaddressed stamped envelopes for the return of completed questionnaires. Time 1 questionnaires were given to women by clinic staff 2 weeks before the start of treatment. Participants who wished to participate returned completed questionnaires within 10 days, whereas those who did not returned an enclosed nonparticipating form. The procedure for T2 data collection was the same, except that questionnaire booklets were mailed directly to participants (12 months after Time 1 questionnaires). Data collection occurred between January 2000 and August 2001 (T1) and between January 2001 and August 2002 (T2).

2.4. Data analysis

Moderation was tested according to the techniques proposed by Aiken and West (1991). In each analysis, the main effect of the potential moderator (i.e., age or social position) was entered on the first step of the regression analysis alongside the predictor, that is, FP stress. On the second step of the analysis, the product of FP stress and the moderator (i.e., interaction) were examined. If the specified variable were a moderator, then the interaction term would be significant. This approach allows one to assess the individual effect of each predictor and moderator on the first step and any additional joint effect of predictor and moderator on the second step of the analysis. Continuous variables (i.e., age, FP stress, and, where applicable, number of treatments between T1 and T2) were transformed to standard scores to reduce collinearity between the main effects and product term. Because social class
was a categorical variable with three levels, a set of two dummy variables was created. The reference category for this set of contrasts was the highest social position (i.e., professionals and executives). In analyses for social position, age was entered as a covariate to control for age effects on fertility.

Treatment outcome (0=no success; 1=success) was the outcome variable in these analyses. Because it was dichotomous, logistic regression was used, and the statistics reported were the regression coefficient (±S.E.), the Wald statistic, and the probability value. Simple regression analyses were used to identify the source of significant interactions (Aiken & West, 1991). Analyses with age and social class were repeated, controlling for treatment experience before T1, number of treatment cycles between T1 and T2, and type of treatment undertaken (e.g., IVF vs. insemination), but because these did not substantially alter results of the original analyses, the latter are reported.

3. Results

3.1. Psychological status at Time 1 and treatment outcome at 12-month follow-up (T2)

Fertility-problem stress scores ranged between 5 and 20, and the average score (M=11.14, S.D.=3.39) indicated that women were reporting moderate levels of FP stress. The majority of women were in the middle social position (n=552, 67.5%), with fewer in the low (n=100, 12.2%) or high social position (n=71, 8.7%). Fertility-problem stress was not significantly associated with age [r(818)=−.039, p=.26] or social position [F(2,720)=.834, p=.44].

By the 12-month follow-up (T2), women had undergone an average of 2.11 (S.D.=1.19) treatment cycles. At T2, 59.7% (n=488) of women had become pregnant or had delivered. Women who had become pregnant had had significantly fewer treatments (M=1.83, S.D.=1.14) than those who were unsuccessful (M=2.53, S.D.=1.15) [t(816)=8.56, p<.000].

3.2. Age

Logistic analysis was used to examine whether there was an interaction between age and FP stress in predicting treatment outcome. The overall analysis was significant [model χ²(3)=15.13, p=.002], and the significant main effects indicated that older age [β=−.200±.073, Wald(1)=7.57, p=.006] and greater FP stress [β=−.167±.072, Wald(1)=5.38, p=.020] were associated with treatment failure. The Age by FP stress interaction was marginally significant [β=.122±.076, Wald(1)=2.57, p=.100]. Fig. 1 shows the point–biserial correlation between FP stress and treatment outcome for each age between 25 and 38 years. As shown, correlations below the median age of 31 were generally more indicative of suppression than those above this age. Simple regression follow-up tests revealed that in younger women (<31 years, n=428), there was a significant suppressive effect of stress [β=−.292±.106, Wald(1)=7.61, p=.006], whereas the stress–outcome association was not significant in older women (>31 years of age, n=390) [β=−.062±.099, Wald(1)=0.387, p=.534].
Logistic regression was used to examine the moderating effect of social position on the stress–fertility association. The logit model was significant [model $\chi^2(6)=24.11$, $p<.000$] and as was the case in the previous analysis; the main effects of age [$\beta=-.076\pm.023$, Wald(1)=10.949, $p=.001$] and FP stress [$\beta=-.193\pm.078$, Wald(1)=6.198, $p=.013$] were significant, but the main effect of social position was not [Wald(1)=2.94, $p=.230$]. However, the interaction between social position and FP stress was significant [Wald(2)=6.450, $p=.040$]. Simple regression follow-up tests revealed that people in lower and higher social positions were equally likely to suppress, and both did so more than people in the middle social position. Specifically, there was marginally less suppression in people in the middle social position vs. people in (a) the lower [$\beta=-.413\pm.220$, Wald(1)=3.54, $p=.060$] or (b) higher [$\beta=-.575\pm.300$, Wald(1)=3.68, $p=.055$] social positions. There was no difference in the stress–fertility association between the lowest and highest social positions [$\beta=.182\pm.354$, ‘Wald(1)=0.264, $p=.607$]. The point–biserial correlation between FP stress and outcome (controlling for age) was significant for the low [$r(97)=-.256$, $p=.011$] and high [$r(71)=-.289$, $p<.015$] social positions, but not the middle social position [$r(549)=-.037$, $p=.381$].

4. Discussion

The aim of this study is to identify potential moderators of the association between stress and fertility potential. According to the RSM, stress conditions, including those associated
with psychosocial stressors (e.g., anxiety, depression, and low self-esteem), are expected to produce lower conception rates (Wasser & Barash, 1983). Reproductive suppression is proposed to be adaptive and, in the long term, to lead to increased overall lifetime reproductive success (Ellison, 1990; Wasser & Barash, 1983). However, because no organism is advantaged by never conceiving, there should be some constraints on reproductive suppression. The results of this study provide evidence of reproductive suppression and of the factors that limit this adaptive strategy.

In line with past evidence, it was found that FP stress was associated with a lower probability of reproductive success during a 12-month treatment period. This association was robust in that it remained significant after controlling for female age, social position, and number of treatment cycles. Furthermore, stress ratings were obtained before treatment was initiated and, therefore, were not contaminated by perceptions about the success or failure of the treatment cycle (Boivin & Takefman, 1995). Fertility-problem stress, as measured here, indicated the extent to which this medical condition was perceived as threatening to women because it negatively affected their mood, disrupted their marital relations, or created stress in their everyday life. Reproductive success was defined as an ongoing pregnancy or a live birth with fertility treatment. The findings are consistent with results showing a decreased live birth rate in women who were highly “reactive” to infertility (Klonoff-Cohen et al. 2001) and to results showing that stress, measured by more general mood states (e.g., depression, anxiety, and hostility), is associated with poorer reproductive outcomes (Lancastle & Boivin, 2005; Sanders & Bruce, 1999a; Smeenk et al. 2001). In light of the reliability of this effect, the longitudinal nature of this large-scale study, and the convergence with past research, we feel confident that this finding demonstrates a genuine psychobiological link between the mental well being of the individual and their reproductive functioning.

Stress-induced reproductive suppression has been proposed as an automatic physiological mechanism to counteract the costs of reproducing in less than ideal conditions (Wasser & Barash, 1983; Ellison, 1990). The mechanisms that trigger reproductive suppression have not been fully described but are likely to involve several interacting physiological systems including metabolic signals and activation of the hypothalamic–pituitary–adrenal (HPA) axis (Chrousos, Torpy, & Gold, 1998). The HPA axis is responsive to a wide range of psychosocial, metabolic, and physical stressors (for review see Chrousos & Gold, 1992). Moreover, HPA activation has been shown to disrupt the hypothalamic–pituitary–gonadal (HPG) axis by inhibiting the GnRH pulse generator that regulates gonadal function (Ferin, 1999). Although the pharmacology of fertility treatment affects the neuroendocrine environment, suppression in women undergoing fertility treatment is expected to also operate through modification of HPA–HPG interactions (Lancastle & Boivin, 2005). Stress may also affect lifestyle factors (e.g., increased smoking, poor diet), but such behavioral effects do not fully account for stress effects on reproductive function (e.g., Klonoff-Cohen et al., 2001; Sanders & Bruce, 1999a).

It might seem paradoxical that FP stress can perpetuate a lack of fertility in the same way as do ecological stressors. Moreover, such an effect would seem maladaptive. However, the HPA axis does not appear to discriminate the source of stress triggering its activation, producing the same response across many different types of stressors (Biondi & Picardi,
1999; Chrousos & Gold, 1992). Indeed, Demyttenaere, Nijs, Evers-Kiebooms, and Koninckx (1992) demonstrated that fertility-related anxiety was capable of producing activation of the HPA axis (e.g., increased cortisol) of the sort reported with other psychosocial stressors (e.g., bereavement, occupational demand). A system that lacks specificity to the source of stress may be adaptive because it increases the chance that it will be “turned-on” at the appropriate time and, therefore, naturally selected (Wasser & Isenberg, 1986). We cannot unequivocally say that this is a maladaptive mechanism because stress reactions to FPs may be indicative of other psychopathology, which could (eventually) compromise parenting (e.g., postnatal depression) (Murray, Fiori-Cowley, Hooper, & Cooper, 1996).

Although reproductive suppression in times of stress is a mechanism to redirect valuable energy away from the costly exercise of pregnancy, deferment of reproduction in favor of survival may itself incur costs if favorable opportunities for future reproduction do not arise. Accordingly, Wasser and Barash (1983) hypothesized that suppression would be less likely in older women who have fewer remaining reproductive years (and, therefore, presumably opportunities) than younger women. Consistent with this, we found that the probability of stress-related suppression decreased with increasing female age. The odds-ratio linking FP stress to treatment outcome was 0.747 in women below or at the median age of 31 years, whereas it was 0.940 in women older than the median age. Thus, for a given level of perceived stress, the odds of suppression were about four times greater in younger compared to older women. This effect was not due to fluctuations in the average or variability of FP stress across age groups or age-related variations in sample size.

Age is important because it reflects the greater cost of suppression for older women. All other factors being equal, older women have fewer remaining reproductive years so that each reproductive opportunity should be considered precious (Wasser & Barash, 1983). We do not have direct evidence of the importance of each treatment cycle for women. However, we do know that in the subgroup of unsuccessful women, those older rated the importance of having children at this time as greater than did younger women \( t(300)=3.51, p<.001 \). Furthermore, if the remaining reproductive opportunities were the critical factor, then one would expect greater reproductive suppression in initial vs. later treatment cycles. This was indeed the case in this sample \( \beta=.167\pm.084, \text{Wald}(1)=4.00, p=.048 \) for interaction between FP stress and treatment cycles, after taking into account their individual main effects.

Wasser and Barash (1983) also proposed that reproductive suppression would vary according to economic and social resources. We found a significant link between stress and fertility among those in the lowest social position, which included unskilled and manual workers. In research among nonhuman mammals, poor resource availability and low social status are both associated with decrements in reproductive function, primarily as a consequence of increased energetic stress (e.g., Cameron, 1997; deCatanzaro & MacNiven, 1992). Similarly, several human studies have linked indicators of poor economic resources to reduced ovulatory frequency (Vitzthum et al., 2002) or function (Ellison, 1990). Our study extends these findings and shows that social position also moderates the impact of psychosocial stress on female reproductive function.

However, we also observed suppression in the highest social position, even after controlling for age and number of treatments cycles. Despite a high level of resources,
professionals and executives were as likely to suppress in times of stress as were those in the lowest social position. One possible explanation is that reproductive suppression occurs for different reasons in low and high social positions. In contrast to poor defenses invoked for low social positions, suppression in higher social positions may be due to the additional reproductive opportunities this group can create for itself. Although access to treatment is free in Denmark, people with greater economic resources may be able to access other costly ways of achieving parenthood (e.g., specialist treatment in other countries).

Our findings indicate a robust association between stress and fertility, and suggest possibilities for future research. First, we need more research on the cues that allow the organism to know when it should proceed with reproduction. Second, the process that translates this appraisal or situational awareness into a biological effect needs to be understood. How does the human brain communicate to the reproductive system that now is (or is not) a good time to reproduce? Third, given wide variations in baseline levels of psychosocial and other ecological stressors (Ellison, 1990), it would be important to examine interpopulation differences in the typical threshold at which these cues begin to operate.

Several limitations imposed by the design should be noted. The advantages of the clinical design used in this study is that psychosocial assessments can be taken in advance of “conception attempts,” and relevant biological information about the number of attempts and their outcome during a specified period can be monitored and easily obtained. However, there are also drawbacks to this approach. First, from our design, we cannot say whether mental well-being was the factor that caused reproductive difficulties to begin with. Second, treatment attempts are emotionally stressful and produce higher stress levels than that observed during natural conception cycles (Boivin & Takefman, 1996), potentially leading to an overestimation of stress effects on fertility. Third and as noted previously, fertility treatments modify the endocrine milieu as well as the reproductive context (i.e., treatment vs. sexual intercourse) so that the processes that account for stress effects in couples undergoing fertility treatment may vary according to treatment regimes and differ from those mechanisms involved in natural conception cycles. The use of intraindividual comparisons between a successful and nonsuccessful reproductive attempt would provide better control for noncompositional factors that may influence reproductive success. Finally, we focused exclusively on stress effects in the women being treated, but male partner stress also needs to be examined because it could impact on reproductive success through direct effects on sexual behavior or semen parameters (Clarke, Klock, Geoghegan, & Travassos, 1999) and/or by influencing the female partner’s own perception of stress (Boivin et al., 1998). Despite these drawbacks, however, we feel that data obtained from this population contribute significantly to our understanding of stress-induced reproductive suppression.

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