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Experimentally induced stress decreases ideal female reproductive timing

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ABSTRACT

Previous correlational research shows that childhood adversity is associated with earlier age of reproduction in humans and other species. Such studies, however, cannot show that stressful conditions cause earlier reproduction. Using the cold-pressor task, we built on previous work to test the idea that acute stress influences human reproductive and marital ideals, and that individual stress responses depend on adaptive life history strategies shaped by exposure to adversity during childhood. Acute stress shifted ideal ages of first birth and marriage to earlier ages. We also tested a competing hypothesis, whether stress had a more general impact on time preference, but found no evidence that it did. Furthermore, there was an interaction between childhood adversity and acute stress. Individuals who reported more exposure to childhood adversity responded to acute stress by reporting even earlier reproductive ideals. These findings offer experimental evidence that physiological stress can alter reproductive decision making in humans.

1. Introduction

Like other animals, humans show within-species variation in reproductive behaviour, not least in age of first birth. These adjustments in reproductive timing can be viewed as adaptive behavioural calibrations with the ultimate goal of maximising individuals' reproductive success under particular environmental conditions (Sear et al., 2007). For example, women in high-mortality, resource-poor environments should favour early reproduction in order to bear children before the risk of dying or becoming incapacitated becomes too great. On the other hand, women in low-mortality, resource-rich environments should postpone the onset of reproduction. Through delaying, they give themselves an extended period of somatic investment and resource accumulation that may then be used to produce higher quality offspring (Nettle, 2011). This trade-off in investment that helps an organism to develop its reproductive strategy is know as their life history which falls on a continuum between adopting a fast strategy (earlier age of first birth) or a slow strategy. At its heart these trade-offs are due to allocating limited resources into traits that will maximize fitness. Historically this trade off has been discussed in terms of r/K selection where r selected organisms have more fast life history traits such as short generation times, small body sizes, early maturity and high fecundity. These traits are adaptive in unstable or unpredictable environments with high extrinsic mortality. By contrast, K-selected organisms have long generation times, large body sizes, later maturity and lower fecundity but great offspring survival, traits that are adaptive in stable environments with lower mortality.

While selection should favour a point where the costs and benefits of reproductive tradeoffs are optimized, this ultimate approach focuses on the links between particular ecologies and behavioural responses. An equally important approach is the study of the proximate mechanisms that mediate these links. There seem to be various triggers for the onset of early reproduction (Coall and Chisholm, 2003; Ellis et al., 2005) in humans. One particular area of interest is the relationship between the onset of reproduction and individual stress responsivity. Stress is a term that has been used loosely in psychology to mean things that are close conceptually but are perhaps not interchangeable such as subjective feelings of being overwhelmed and psychosocial adversity. We focus on the biological usage of stress meaning activation of the hypothalamic-pituitary-adrenal axis, which responds strongly to challenging and uncontrollable threats (Dickerson and Kemeny, 2004).

The stress response system is highly plastic, particularly during early development (Boyce and Ellis, 2005; Levine, 2005), and stress is a likely candidate for adjusting individuals' life-history strategies.

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In non-human species, experimental work has already firmly established the causal link between low early-life investment and altered stress physiology through manipulation of levels of rats maternal grooming and licking of their pups (Bagot et al., 2009). In humans, previous research has firmly established an association between exposure to putative childhood stress and calibrated female life history strategies (Chisholm et al., 2005). This includes stressors related to the family environment during childhood such as father absence (Ellis et al., 2003), levels of parental investment (Belsky et al., 1991) and separation of children from their parents (Pesonen et al., 2008). Therefore, in this study we focus specifically on family stress, referring to this as childhood adversity and when using the term stress we mean hypothalamic-pituitary-adrenal axis activation, which has not been established in the case of childhood adversity.

The effects of acute stress on life-history strategies in humans are even less well known, although a few experimental studies have begun to examine causal links between physiological stress and reproductive timing. Griskevicius et al. (2011) showed that priming psychological cues of mortality shifts individual fertility intentions. In the case this study, however, the only measures of stress obtained were subjective stress ratings with no evidence of the participants having experienced physiological arousal. As such, the researchers cannot be sure they measured a physiological stress response whether independent or in conjunction with any other psychological or social mechanisms. More explicitly related to physiological stress, exposure to a social stressor demonstrated a relationship between cortisol reactivity and age of first intercourse in females (Brody, 2002). Women with an earlier age of first intercourse (a potential hallmark of a fast life-history strategy) had decreased cortisol levels in response to the stress task compared with women with older ages of first intercourse (possibly on a slower life-history trajectory). Thus it is reasonable to predict that acute stress has the potential to influence an individual's life-history strategy.

While we may expect a main effect of stress on reproductive timing, there is also reason to predict an interaction between acute stress and life history trajectory from animal behaviour. Lancaster et al. (2008) looked at reproductive behaviour in female side blotched lizards (*Uta stansburiana*), which demonstrate both slow and fast life-history strategies. Administering corticosterone (a glucocorticoid hormone secreted by the adrenal cortex similar to cortisol) to the female lizards delayed reproduction in slow K-strategists, while accelerating reproduction in the fast r-strategists.

Previous research suggests that the stress response system is developmentally sensitive and due to changes during maturation will alter resultant behaviour, to match local social and environmental conditions. Del Giudice et al. (2011) proposed the adaptive calibration model, which predicts that responses to stress will depend on the individual's history of adversity. Specifically, those who developed in a dangerous and unpredictable environment should show higher stress responsivity than those who developed in an environment with moderate adversity. We hope to provide more empirical evidence in support of differentiated stress responsivity to acute stressors based on the level of exposure to childhood adversity, which adjust females' life-history trajectories.

While previous research has shown that there is an association between childhood adversity and adult behaviour, we hope that by experimentally studying acute stress to add to the understanding of both previous mortality priming studies and previous correlational research. Thus, in this paper, we experimentally tested the effects of acute stress on ideal reproductive timing. We also asked about ideal age of marriage. Although this is not a component of life history theory and specific to humans, variation exists in the timing of marriage (in addition to age of first birth), which typically precedes pregnancy (United Nations Department of Economic and Social Affairs, 2004). As such ideal age of marriage is a potential proxy for entering a life-stage associated with having children. We also investigated the interaction between childhood adversity and acute stress, specifically whether women exposed to different levels of adversity during childhood may react differently to acute stress in terms of adjusting their fertility intentions. If so, this would suggest that exposure to both the repeated stressors of childhood adversity and high stress events could alter women's reproductive timing.

Table 1
Descriptive statistics for demographic variables for participants in the warm water and cold-pressor conditions. Data are means (SE) unless otherwise stated.

	Warm water condition ($n = 68$)	Cold-pressor condition ($n = 67$)
Age (range 18–31)	19.86 (0.44)	19.88 (0.55)
Contraceptive use (Count of women using contraception)	36	42
Menstrual cycle stage (Count of women on luteal stage)	34	33
Age of Menarche (range 10–16)	12.94 (0.15)	12.88 (0.17)

Table 2
Descriptive statistics for the Family stress scale and the main dependent variables.

	Range	Mean (SE)
Family stress scale scores	−32–46	18.42 (1.44)
Discount preference	1–7	3.77 (0.23)
Ideal age of first birth	19–35	27.96 (0.23)
Ideal age of marriage	20–32	26.21 (0.19)
Desired number of children	0–4	2.38 (0.08)

2. Methods and materials

2.1. Participants

An opportunity sample of 135 nulliparous and unmarried female undergraduates (mean age 19.84 years ± 3.95) was recruited to take part in the study. Participants were required to refrain from consuming alcohol, caffeine or food for 1 hour before the session so as not to affect cortisol levels. Demographic data for participants can be found in Table 1.

2.2. Measures

2.2.1. Pre-measures

Demographic variables were also collected including participants' age, contraceptive use, age of menarche (measured retrospectively) often associated with life history strategy, days since last menstruation, menstrual cycle position and contraceptive use. There were no significant differences between conditions in terms of any demographic variables.

Level of exposure to childhood adversity was measured using the 12-item Family Stress Scale (see Appendix A). Answers to each statement were given on a bipolar scale from Strongly Agree (4) to Strongly Disagree (−4). Higher scores indicate a less stressful family situation (Cronbach's alpha = 0.81 and for our sample = 0.84) (Mikach and Bailey, 1999). There were no significant differences between conditions for this measure (see Table 2).

2.2.2. Fertility intentions

After the hand immersion participants also completed a free text response to the questions; 'At what age do you want to have your first baby?', 'What would be the ideal number of children you