Assets at Risk

Menstrual Cycle Variation in the Envisioned Formidability of a Potential Sexual Assailant Reveals a Component of Threat Assessment

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ACCEPTED FOR PUBLICATION IN
ADAPTIVE HUMAN BEHAVIOR & PHYSIOLOGY

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Abstract

Situations of potential agonistic conflict demand rapid and effective decision-making. The process of threat assessment includes assessments of relative fighting capacity, assessments of the likelihood of attack, and assessments of the extent to which one's assets are at risk. The dimensions of physical size and strength appear to serve as key parameters in a cognitive representation summarizing multiple constituents of threat assessment. Here, we examine the thesis that this same representation summarizes asset risk. The fitness costs of sexual assault are in part a function of conception risk, as pregnancy due to assault compromises female choice and imperils existing and subsequent male investment. Prior research indicates that women's attitudes and behaviors vary systematically across the menstrual cycle in a manner that would have reduced the likelihood of sexual assault during periods of greatest fertility in ancestral women. If the envisioned size and strength of a potential antagonist is used to represent asset risk, and if the threat that sexual assault poses to a woman's reproductive assets is in part a product of her fertility, then the conceptualized size and strength of a potential sexual assailant should be a function of conception risk. We find support for this prediction in a large sample of naturally-cycling women in urban Southern California, indicating that asset risk is summarized using the same representation as relative fighting capacity and likelihood of attack. Presumably, this elegant use of a single representation for multiple aspects of threat assessment facilitates rapid decision-making in agonistic contexts.

Keywords: threat assessment; relative formidability; asset risk; sexual assault

Introduction

Representations of potential foes and the constituents of threat assessment

Agonistic interactions with conspecifics are a fundamental determinant of fitness in many social species, and, sadly, violence has long been a part of human history as well. Situations of impending violent conflict force the actor to rapidly decide what to do. Given their past impact on fitness, such situations will have been an important context of selective pressure in the evolution of human decision-making mechanisms. Employing an evolutionary perspective on the problem, here we explore one aspect of such decision-making, namely a particular facet of threat assessment.

Assessing the threat that another party will employ force to inflict physical harm or expropriate resources can in part be decomposed into assessments of i) the potential antagonist's fighting capacities relative to those of the self, and ii) the likelihood that the potential antagonist will aggress, as calculated on the basis of both (i) and information regarding the individual's motivations. For example, an individual who possesses substantially greater fighting capacity relative to oneself, but who harbors no ill will, poses no threat, and the same is true of an individual who harbors ill will but has substantially less fighting capacity than oneself. In addition to these factors, discussions of threat assessment often include considerations of vulnerability. Vulnerability can be decomposed into a) the ability to prevent or repulse an attack, and b) the costs likely to be suffered if an attack occurs. Note that (a) is primarily a reframing of (i), that is, relative fighting capacity; in contrast, (b) is a truly independent factor. Consider, for example, two equally formidable individuals, one of whom has just withdrawn a few dollars from the bank, leaving the remainder of his life's savings safely inside the vault, while the other has just withdrawn his entire life's savings in cash. These two individuals step into an elevator

45 together, where they encounter a would-be mugger who has no knowledge of the quantities of
46 money carried by each of them. As specified in our scenario, the fighting capacity of the
47 antagonist does not differ relative to each of his two prospective victims, nor does the likelihood
48 that he will aggress against each of them. However, the costs of being robbed are vastly greater
49 for the second victim than for the first, hence the mugger poses a greater threat to him than to his
50 fellow passenger. For clarity, we refer to this consideration as *asset risk*, as distinct from the
51 issues of relative fighting capacity that are typically included in the larger concept of
52 vulnerability. Hence, threat assessment should include i) the assessment of relative fighting
53 capacity, ii) the assessment of likelihood of attack, and iii) the assessment of asset risk.
54 While threat assessment can sometimes be conducted in a leisurely manner, situations of
55 impending violent conflict demand rapid decision-making. Importantly, numerous features of
56 the antagonist, the self, and the situation contribute to each of the three facets of threat
57 assessment described above. Consider the question of relative fighting capacity. At first glance,
58 purely physical capabilities would seem to be principal determinants of this, yet weapons trump
59 brawn; the presence of allies can make a difference, but numbers alone can be less important
60 than the degree of coordination among them, their level of martial skill, and the quality of their
61 leadership; and so on. Similar complexities plague assessments of the likelihood that an
62 antagonist will aggress, as, in addition to purely tactical considerations influencing the
63 antagonist's decision, this likelihood will be a product of the antagonist's own sensitivity to risk,
64 the antagonist's commitment to conflict, and so on. Finally, asset risk is no more monolithic
65 than the other facets of threat assessment, as numerous considerations can apply: consider how
66 the hypothetical scenario presented earlier changes if we add the wrinkle that the more prudent

victim, while having left most of his money in the bank, nevertheless needs the cash in his pocket in order to purchase vital medication that he must take very soon.

For each of the three categories of threat assessment, the decision-maker is faced with the daunting information-processing task of combining disparate factors. For example, knowing that the opponent is armed should increase one's estimation of his relative fighting capacity, but knowing that his coalition is poorly led should diminish it. These and numerous other considerations must be combined in a single estimation of relative fighting capacity in order to decide how to respond. Moreover, following such a combinatorial process, the decision-maker is faced with an analogous higher-order problem, as the assessment of relative fighting capacity must be combined with parallel assessments addressing likelihood of attack and asset risk – effective decision-making can occur only when all of this information has been processed within the time limits imposed by the exigent nature of the circumstances. Building on our research group's recent work in this area, we propose that the same solution is employed at both higher and lower levels of this combinatorial process, namely the use of a single summary representation that serves as a running tally of relevant considerations.

In the absence of written lists and similar technologies, the complexity of decision-making increases as a function of the need to take account of many variables, as demands on memory and other information-processing components mount rapidly. A single summary representation that acts as a running tally reduces these demands, as the decision-maker need only keep three pieces of information active at any one time, namely a) the product of the assessment to this point in the process; b) the weighted contribution of the factor being considered at the moment; and c) the identity of those factors that have already been considered up to this point (thereby preventing double-counting). When the list of notably relevant factors

has been exhausted, the decision-maker can consult the single representation, confident that it summarizes the entire preceding assessment process. In principle, there are many potential forms that such a summary representation could take. However, both phylogenetic and ontogenetic considerations suggest that, in regard to threat assessment, the dimensions of envisioned bodily size and physical strength will form the core of this representation.

The dimensions of representations of potential foes

In animals possessing limited behavioral repertoires, size and strength are often principal determinants of relative fighting capacity (for examples, see Briffa & Sneddon, 2007). Such species can therefore be expected to have the capacity to represent relative size and relative strength in order to facilitate decision-making in agonistic contexts. Natural selection proceeds through the gradual modification of existing designs, such that the process is often equated to tinkering, rather than engineering (Jacob, 1977). Correspondingly, as the complexity of species' behavioral repertoires increases, rather than crafting new representational systems de novo, natural selection can instead be expected to modify this existing representational capacity in order to capture diverse constituents of relative fighting capacity. Such modification is particularly likely to occur when the core features of the ancestral system remain relevant in the derived context. This is true with regard to both size and strength in humans: Mixed martial arts competitions reveal that height is a factor in human fighting ability (Collier et al., 2012), and observers perceive a man's height as contributing in this regard (Sell et al., 2009a). Likewise, relative size is an important consideration when deciding whether to escalate confrontations (Archer & Benson, 2008), and, consonant with a lower vulnerability to assault, taller men are less sensitive to cues of dominance than are shorter men (Watkins et al., 2010). Even more

113 marked patterns are evident with regard to strength, as it is a key component of fighting capacity
114 in men (Sell et al., 2012). Strength predicts observers' judgments of fighting capacity (Sell et al.,
115 2009a), as well as conflictual self-interested attitudes on the part of the men themselves (Archer
116 & Thanzami, 2009; Sell et al., 2009b; Hess et al., 2010; Sell et al., 2012; Muñoz-Reyes et al.,
117 2012; Petersen et al., 2013; but see also Price et al., 2012 for caveats). Taken together, the above
118 findings indicate that, because size and strength continue to play a role in human fighting
119 capacity, we should expect that natural selection both preserved the ancestral ability to represent
120 these attributes as part of decision-making in agonistic contexts, and, moreover, employed these
121 dimensions as the foundation for a derived capability wherein the diverse constituents of relative
122 fighting capacity are summarized using the same representation.
123 Acting in parallel to the above phylogenetic heritage, in mammals in general, and in
124 humans in particular, individual development will reliably reinforce the postulated
125 representational system. If only by virtue of having experienced conflicts with their caregivers,
126 all immature offspring will come to understand that bodily size and physical strength are
127 elementary determinants of relative fighting capacity. Indeed, experiments reveal that preverbal
128 human infants expect larger agents to dominate smaller agents (Thomsen et al., 2011).
129 Drawing on the findings described above, our research group has proposed that, due to its
130 phylogenetic antiquity and ontogenetic ubiquity, envisioned physical size and strength constitute
131 the dimensions of a representation that summarizes diverse constituents of relative fighting
132 capacity (Fessler et al., 2012). Moreover, this solution is likely applied across levels in the
133 combinatorial process, as the utility of a single summary representation is further leveraged by
134 employing it to represent not only relative fighting capacity, but also likelihood of attack and
135 asset risk. In a series of papers, we have documented the use of the dimensions of bodily size

and physical strength in representations of *relative formidability*, the umbrella term that we have variously used to describe all three aspects of threat assessment.[1]

Turning first to relative fighting capacity, we have documented that, as can be expected from their foundational role in both phylogenetic and ontogenetic experience, bodily aspects of the observer influence the observer's conceptualization of the size and strength of a prospective antagonist. A man's own muscular strength is inversely related to the physical formidability that he envisions an opponent to have, such that stronger men conceptualize their foes as smaller and weaker than do weaker men (Fessler et al., in press). Conversely, temporary physical incapacitation leads men to envision their opponents as larger and stronger, and themselves as smaller (Fessler & Holbrook, 2013a). Although weapons are among the most rapidly changing technologies, their importance in hunting and, by extension, combat predates our species (Wilkins et al., 2012; Sahle et al., 2013); correspondingly, knowing that a target individual is armed leads observers to conceptualize him as larger and stronger (Fessler et al., 2012). Coalitional behavior is widespread across primates (Silk, 2007), and is likewise an elementary determinant of relative fighting capacity in humans; correspondingly, the presence of allies leads men to reduce their estimations of the bodily formidability of a foe (Fessler & Holbrook, 2013b). Synchronized behavior is a component of coalitional signaling in many species (Hagen & Bryant, 2003), and a considerable literature documents the positive effects of synchrony on human cooperation and coalitional solidarity; correspondingly, the experience of synchronized walking decreases men's estimations of the bodily formidability of an antagonist (Fessler &

[1] Claims concerning species-typical aspects of human psychology must be tested using diverse samples. Although we have taken steps in this regard in two of our previous projects described here (Fessler et al., 2014a; Fessler et al., in press), the others exclusively employ U.S. samples, at times including a reliance on university undergraduates, a population that we recognize to be highly unrepresentative along many potentially relevant dimensions. The language of generalizable claims employed in the main text is thus used simply for purposes of readability.

Holbrook, under review). Effective leadership influences the lethality of a fighting force and, correspondingly, knowing that a violent coalition does or does not possess capable leaders causes parallel changes in participants' estimations of the bodily formidability of a typical coalition member (Holbrook & Fessler, 2013). Lastly, findings from other research groups working at a more general level complement our results. Yap and colleagues (2013) showed that leading participants to experience themselves as having greater or lesser social power resulted in correspondingly inverted changes in their estimates of the size and weight of another person. Likewise, Duguid and Goncalo (2012) demonstrated that inducing the feeling of power leads people to overestimate their own height and underestimate another's height.

Turning next to the second component of threat assessment, likelihood of attack, we have documented that inferring that a target individual is a member of an ethnic group stereotyped as prone to violence leads observers to conceptualize him as more physically imposing (Holbrook et al., under review). At the level of forecasts based on cues of individual propensities, target individuals who are prone to take physical risks are conceptualized as more physically formidable than those who are risk-averse, a pattern consonant with the inference that individuals who are relatively indifferent to the possibility of injury or death are more likely to enter into combat, and less likely to retreat (Fessler et al., 2014a).

To date, in only a single project have we explored the use of bodily size and strength as the dimensions of a representation of asset risk. Given the altriciality of human offspring and the correspondingly profound effect of parental welfare on offspring fitness, parents can be expected to be more averse to the risk of injury than non-parents. The direct costs of injury are equal across these two classes, but parents face the added fitness decrement of the diminution or loss of their investment in existing offspring if injury prevents parents from providing for, protecting,

and instructing them. Consonant with this logic, whether their children are physically present or not, parents conceptualize a potential assailant as more physically imposing than do non-parents (Fessler et al., 2014b). While this pattern is consistent with our proposal that the dimensions of size and strength are employed in a representation of relative formidability that includes an assessment of asset risk, parenthood is a sufficiently complex phenomenon as to make it possible that this pattern does not generalize across social contexts. On the one hand, convergent evidence, ranging from cross-species comparisons to hormonal changes accompanying parenthood (Hahn-Holbrook et al., 2011a; Hahn-Holbrook et al., 2011b; Fessler et al., 2014b), suggests that evolved mechanisms play an important role in generating human parental precaution, including inflation of the conceptualized bodily proportions of a potential antagonist as a function of asset risk. On the other hand, parental assessments could reflect the influence of a rich set of cultural schemas regarding the nature of parental responsibilities, the proper comportment of a parent (e.g., Harkness et al., 1992), and the nature of social hazards (Best & Horiuchi, 1985). In order to further explore the representation of asset risk in threat assessment, we therefore turn to another domain in which evolved hazard-avoidance mechanisms are thought to operate, namely the threat posed by the possibility of sexual assault.

Evidence of the existence of adaptations that reduce the risk of sexual assault

As has been articulated by previous authors (see citations below), prior to the advent of contraceptive and abortifacient technology, the potential fitness costs of sexual assault to reproductive-age female victims varied across the menstrual cycle. In addition to the physical and psychological trauma that a sexual assailant may inflict, a primary fitness cost to the victim is the possibility of conception. Pregnancy following assault both removes female choice of

genitor and leaves the mother with a child who, in most cases, will not benefit from paternal investment, and whose presence may deter other men from investing in the woman and any children they might conceive, or have previously conceived, with her. Accordingly, whereas the costs of immediate physical and psychological trauma are independent of the likelihood of conception, other critical costs are contingent on this likelihood, a probability that is markedly elevated periovulatorily relative to other phases of the menstrual cycle. Natural selection can therefore be expected to have generated adaptations that reduce the likelihood of sexual assault as a function of the probability of conception (termed *conception risk* in this literature). A growing corpus of empirical results largely supports the existence of such adaptations.

Pioneering the investigation of rape-avoidance mechanisms, Chavanne and Gallup (1998) surveyed 300 American university undergraduates regarding the extent to which they engaged in behaviors thought to pose a risk of sexual assault. In a cross-sectional design, using self-reported date of last menstruation, Chavanne and Gallup counted forward to estimate women's position in the menstrual cycle at the time of participation, then compared women in high- and low-conception-risk phases, finding that putatively risky behaviors were reported less frequently by the former group. Bröder and Hohmann (2003) subsequently improved on Chavanne and Gallup's work by employing a similar survey in a within-subjects longitudinal study of 51 German university students that increased accuracy regarding menstrual cycle position, replicating the latter's core result as regards reduced rates of behaviors that putatively entail a risk of sexual assault during periods of high conception risk. In contrast to these positive results, however, employing a similar self-report behavior inventory (McKibbin et al., 2009) and using the forward-counting method, in a sample of 466 Slovakian university students, Prokop (2013)

failed to find an effect of menstrual cycle phase on three of four rape-avoidance behavior subscales.

Limitations potentially plague the self-report measures employed by Chavanne and Gallup and Bröder and Hohmann (see McKibbin, 2014), as well as that employed by Prokop (see Snyder & Fessler, 2013b). Fleischman, Perilloux, and Buss (in prep.) reasoned that previous surveys did not adequately distinguish between behaviors that pose a risk for sexual assault and mate-seeking behaviors, an important distinction given that other work indicates that the latter can be expected to rise periovulatorily. They therefore predicted that, even as mate-seeking behaviors increase as a function of conception risk, behaviors that place the individual at elevated risk of sexual assault should decrease. The authors further predicted that, as subjective responses can be expected to undergird behavior, fear and distress concerning the possibility of such assault would follow a similar pattern. Utilizing a cross-sectional design and a sample of 284 American undergraduate women, conception risk was determined using a combination of forward counting, backward counting from reported date of onset of menstruation post-participation (a method that is more reliable than forward-counting by virtue of the lesser variation in the duration of the luteal phase relative to the follicular phase – see Gildersleeve et al. [in press]), and urinary luteinizing hormone assays to identify ovulation (a still more reliable method [Gildersleeve et al., in press]). Results indicate that, after controlling for mate-seeking behaviors, the frequency of actions that place a woman at increased risk of assault is inversely related to conception risk. Subjective responses show a more complex pattern, with increases in fear and distress as a function of conception risk evident only in women who report a more promiscuous sociosexual orientation (which, by virtue of its greater concomitant mate-seeking behavior, entails greater exposure to risk of assault).

Moving away from self-report, in a cross-sectional study of 192 U.S. university students, Petralia and Gallup (2002) measured changes in reaction time and handgrip strength as a function of the interaction of position in the menstrual cycle – determined using a combination of forward counting and urinary luteinizing hormone assay – and exposure to a vignette that either did or did not entail a risk of sexual assault. Although reaction time was unaffected, women in the ovulatory phase who read the sexual assault-risk vignette showed an increase in handgrip strength from baseline measurement, whereas all other groups showed a decrease in handgrip strength relative to baseline. Petralia and Gallup interpret this pattern as indicating that, during the period when conception risk is highest, women who contemplate the possibility of sexual assault marshal greater resources that could be used for defense.

Adjusting behavior in order to reduce the risk of sexual assault is a broad-strokes tactic, potentially of value independent of the particular attributes of any given man with whom a woman may interact. However, the latter consideration can also be strategically deployed, as a man's comportment may reveal the likelihood that he would engage in sexual assault. Garver-Apgar, Gangestad, and Simpson (2007) therefore predicted that conception risk would lead to increased pessimism in women's estimations of the probability that a given man would employ coercive sexual tactics, as the asymmetry between the costs of failing to detect a man who is coercive and the costs of erroneously judging a non-coercive man to be coercive rise as a function of the probability of conception should assault occur. Because individual judgments reflect noise generated by idiosyncratic features of the judge, the sum of a large number of observers' assessments will often be more accurate that any individual's own assessment. The authors therefore predicted that conception risk would increase accuracy in judging male sexual coerciveness, and thus that there would be a positive correlation between conception risk and the

similarity between a participant's assessments of a given target male and the average of all participants' assessments of said target. In a cross-sectional design, 169 American undergraduate women viewed videos of unfamiliar men and judged how sexually coercive they were likely to be; conception risk was determined using the forward-counting method. Both predictions were supported.

Navarrete and colleagues (2009; see also Navarrete et al., 2010) reasoned that, because out-group members are not subject to the same mechanisms of social control as in-group members, women's prejudices against out-group men can be interpreted as in part the output of a mechanism that serves to reduce the likelihood of sexual assault. In a cross-sectional study of 77 White female American university students, the authors demonstrated that implicit prejudice toward Black men is positively correlated with conception risk (calculated using the forward-counting method), and that this pattern is particularly marked among women who feel especially vulnerable in regard to sexual coercion. Using a similar forward-counting cross-sectional design with implicit attitudinal measures, McDonald and colleagues (2011) demonstrated that this effect is not limited to Black male targets: in a sample of 224 White and 28 Black female American university students, the authors found increased prejudice as a function of conception risk toward members of the respective racial out-group. McDonald et al. then extended this work further by showing that the relationship between conception risk and implicit prejudice does not rely on specific cultural stereotypes of race, as they find it using arbitrarily defined minimal groups in a similar sample of 85 American undergraduates.

The present study: Conception risk, asset risk, and representations of a potential assailant

To summarize the above, using diverse dependent measures, multiple prior investigations support the hypothesis that, because, in ancestral populations, the fitness costs of sexual assault were determined in part by the likelihood that conception would occur, natural selection has crafted mechanisms that alter women's motivations and attitudes so as to reduce the probability of sexual assault as a function of conception risk. In evolutionary terms, among women of reproductive age, residual reproductive potential and the social opportunities that are partly contingent upon it are among the individual's principal fitness assets. Accordingly, viewed in terms of threat assessment, elevated risk of conception due to sexual assault corresponds to elevated asset risk. Hence, if representations of potential antagonists summarize asset risk, and if such representations take the form of the envisioned physical size and strength of a foe, then conception risk should positively correlate with women's conceptualizations of the size and strength of men who are likely to engage in sexual coercion. Here, we test this prediction in a large sample of reproductive-age women recruited on the streets of urban Southern California.

In order to explore the hypothesis that the dimensions of size and strength are used during threat assessment to represent asset risk, we seek to determine whether conception risk is positively correlated with the envisioned size and strength of a potential sexual assailant. However, if these dimensions are also employed in other facets of threat assessment, then individual differences orthogonal to conception risk could color the predicted effect. Specifically, if i) the same system represents likelihood of attack, ii) as is plausible, a woman's own physical attractiveness increases the likelihood of attack, and iii) women recognize this either due to the workings of a dedicated evolved mechanism (McKibbin et al., 2011) or due to experience (Snyder & Fessler, 2013b), then assessments of the threat posed by a potential assailant should be positively influenced by a woman's perceptions of her own attractiveness.

Accordingly, it may be useful to measure participants' assessments in this regard. Likewise, individual women will differ in their fighting capacity (including both physical capabilities and access to protective allies and other resources), and this, in potential combination with likelihood assessments derived from experience and environmental cues, may shape threat assessments independent of questions of asset risk. Anticipatory fear (i.e., concern) regarding the possibility of sexual assault and similar violent crimes plausibly reflects this combination of factors (Snyder & Fessler, 2013a; Fleischman et al., in prep.), hence it may be useful to measure this factor independent of conception risk in order to evaluate the separable contribution of the latter. Lastly, for any of a variety of reasons, individuals may differ in their baseline assumptions as to the size of the average man in the population, and this may color assessments of a prospective sexual assailant independent of conception risk. Moreover, this problem is compounded by the observation that social status appears to be represented using the same dimensions of size and strength employed in threat assessment representations, an overlap that is understandable if the mental mechanisms used to represent prestige-based social status were evolutionarily derived from ancestral mechanisms used to represent dominance-based social status (Holbrook et al., under review). Notably, criminals occupy a deprecated social status. Taken together, these considerations indicate that it is important to assess participants' conceptualizations of a non-threatening male criminal in order to provide a participant-specific baseline with which to evaluate any unique contributions of conception risk to the envisioned bodily proportions of a potential sexual assailant.

Methods

Participants and overview of procedure

Because hormonal contraceptives alter a wide variety of psychological phenomena plausibly related to the question of interest (reviewed in Larson, 2014), we sought to recruit women who were not presently using hormonal contraceptives. 993 adult women who initially indicated that they were not using hormonal contraceptives were recruited on the streets of urban Southern California for a study, conducted on the street, advertised as a survey of "Visual Perception Across Domains," in exchange for $3 compensation and the opportunity to enter a $100 prize raffle. Data were pre-screened to eliminate incomplete responses, repeat participation, or unanticipated interruptions (e.g., a fire truck passing by with sirens on). In addition, as screening at initial recruitment was not exhaustive, we excluded participants who reported currently using hormonal contraceptives (including Depo-Provera, an injected hormonal contraceptive) or having used hormonal contraceptives in the last 3 months; using an intrauterine device (some of which inhibit ovulation); having recently used Plan B emergency hormonal contraceptive pills; or being uncertain as to whether or not they had used hormonal contraceptives. In order to maximize the likelihood that the sample included only women experiencing regular ovulatory cycles, we also excluded participants who reported being over 40 years of age; being menopausal; reporting a cycle of less than 24 days (Hampson & Young, 2007), or suffering from hormonal or reproductive medical syndromes or disorders (e.g. endometriosis). Finally, we excluded women for whom we were unable to calculate a legitimate menstrual cycle day (i.e., their calculated values were less than zero or greater than thirty; see Wilcox et al. [2001]). We used forward-counting methods to estimate participants' position in the menstrual cycle on the day of participation, then employed published actuarial figures from the obstetrics literature (Wilcox et al., 2001) to assign a conception risk to each participant based on her calculated cycle day. The final sample consisted of 644 women (33.3% East Asian,

22.4% White, 17.6% Hispanic, 4.7% Black, 4.7% Middle Eastern, 3.6% Pacific Islander, and 13.7% Mixed Ethnicity or Other) ranging in age from 18 to 38 (M = 21.04, SD = 3.03).

Participants were given a survey packet containing a series of visual estimation tasks and brief surveys. Participants first answered a series of demographic questions, including items regarding their health, age, contraceptive use, and attributes of their menstrual cycle, including regularity and length, and date of onset of last menses. Next, embedded within filler visual estimation tasks (e.g., estimating a woman's age based on a cropped image of her face), participants were asked to estimate the bodily attributes of two supposed criminals based on cropped "mugshots" of neutral male faces (see Figure 1). The face stimuli, the crimes attributed to them, and the order of presentation were all fully counterbalanced. The images, presented in greyscale, were actually composites created following procedures outlined by Tiddeman et al. (2001). Each composite was made up of 25 different men (average age for each composite = 24.2 years), all displaying neutral facial expressions. One target was described to participants as a criminal convicted of "tax evasion" (a proscribed, but non-violent, crime), the other was framed as a criminal convicted of "aggravated assault." The targets' bodily traits were estimated in fixed order: height (to the nearest inch), size (assessed using an array of six otherwise identical silhouettes differing only in size; see Figure 1), and muscularity (assessed using an array of six computer-generated images of male bodies differing in muscularity; see Figure 1). Estimated physical formidability was composited using standardized values for estimated height, overall size, and muscularity (tax evasion target α = .65; aggravated assault target α = .74). A difference score was created by subtracting the estimated physical formidability of the non-violent offender from the estimated physical formidability of the violent offender.

Following Snyder et al. (2011; Snyder & Fessler, 2013a), we employed a modified version of the British Fear of Local Crime Survey (Crime Reduction Centre, 2000), which asks participants to rate their level of concern about seven criminal occurrences (e.g., mugging, car theft, etc.) on a 7-point Likert scale (1 = *Not worried at all*, 7 = *Very worried*), including one item asking about the fear of being sexually assaulted. Although we were chiefly interested in this item, we included the other six items ($\alpha = .90$) both to mask the intentions of the study, and to test the domain-specificity of the relationship between fear of sexual assault and conception risk. Next, participants rated their perceptions of their own physical attractiveness relative to other women in the United States by selecting a rung on a 10-rung ladder (a modified version of the MacArthur Scale of Subjective Social Status – Adler et al., 2000). At the conclusion of the survey packet, participants were debriefed, paid, and informed as to how to notify the researchers of the date of onset of their next menstrual cycle in order to enter the prize raffle; participants who expressed interest in this opportunity were given the option of using a self-addressed postcard or sending an email; those who wished could also sign up for a reminder email, to be sent shortly before the anticipated date of their next menses. As an additional reminder, participants were given a brightly-wrapped tampon labeled with information on how to contact the researchers upon the onset of the next menses. Despite these steps, however, perhaps because the incentive was too small, the number of participants who subsequently reported the date of onset of their next menstruation was too small to capture a useful range of variation. In the analyses reported below, we therefore rely exclusively on the forward-counting method for all participants in estimating conception risk at the time of participation.

Results

Estimated bodily traits of violent criminal versus non-violent criminal

A preliminary series of repeated-measures ANOVAs confirmed that, as intended, the target framed as having committed aggravated assault was envisioned as taller, more muscular, and larger overall than the target framed as having committed tax evasion (see Table 1).

Conception risk and estimated bodily traits

Keeping in mind that we collected participants' estimates of the physical features of both a non-violent criminal and a violent criminal so as to use the former as a baseline in assessing the unique contributions of conception risk to evaluations of men who pose a likely risk of sexual assault, consistent with predictions, there was a significant positive correlation between conception risk and the difference between the estimated physical formidability of the violent criminal and the non-violent criminal, $r(644) = .11$, $p < .01$. Follow-up tests revealed that conception risk was positively correlated with the estimated physical formidability of the violent offender, $r(644) = .08$, $p < .05$.[2] There was a nonsignificant negative correlation between conception risk and the estimated physical formidability of the non-violent offender, $r(644) = -.06$, $p > .11$.

Self-rated attractiveness, conception risk, and estimated physical formidability

We next assessed whether participants' subjective perceptions of their own physical attractiveness ($M = 6.23$; $SD = 1.54$) influenced their intuitions about the criminals' physical

[2] Further follow-up tests revealed a marginal positive correlation between conception risk and the individual estimates of the violent offender's muscularity, $r(644) = .07$, $p < .07$, and height, $r(644) = .07$, $p = .06$, but not size, $r(644) = .05$, $p > .25$. The negative correlations between conception risk and the individual estimates of the non-violent offender were all nonsignificant, with a marginal trend for muscularity, $r(644) = -.07$, $p < .08$, but not for height, $r(644) = -.05$, $p > .22$, or size, $r(644) = -.02$, $p > .54$.

formidabilities.[3] Against expectations, self-rated attractiveness was positively correlated with the estimated physical formidability of the non-violent offender, $r(639) = .11$, $p < .01$, whereas there was no such correlation obtained with regard to the violent offender, $r(639) = -.02$, $p = .65$.[4] Consistent with this pattern, self-rated attractiveness was significantly negatively correlated with the difference between the estimated physical formidability of the two targets, $r(639) = -.10$, $p < .02$, such that participants who rated themselves as relatively more attractive envisioned the two targets as less distinct in physical formidability. Importantly, subjective physical attractiveness was not significantly correlated with fear of sexual assault, $r(639) = .03$, $p = .41$, implying either that previous authors' suggestions with regard to the contribution of attractiveness in this regard are in error, or that our method of measuring attractiveness, being reliant on self-ratings, is insufficient for the present purposes.

Fear of sexual assault, conception risk, and estimated physical formidability

We next assessed whether participants' fear of sexual assault ($M = 4.88$; $SD = 1.71$) influenced their intuitions about the targets' physical formidability. Against predictions, we observed no correlations between fear of sexual assault and the estimated physical formidability of the violent offender, $r(644) = .06$, $p = .12$, the non-violent offender, $r(644) = -.01$, $p = .72$, or

[3] Five participants, included in the overall analysis, declined to rate their relative physical attractiveness, hence these correlations relate to a subsample of 639 participants.

[4] The present study does not allow us to determine why self-rated physical attractiveness positively correlated with the envisioned bodily formidability of the tax evader. However, given that physical size is also employed to represent hierarchical social status, we offer the following speculation: If more attractive women aspire to marry wealthier men, and if wealthy individuals are more likely to be convicted of tax evasion than are poorer individuals, then the positive correlation observed may reflect a link between self-assessed mate value and the positive assessment of an affluent potential partner.

the difference between the two targets, $r(644) = .06$, $p = .13$. There was also no correlation between fear of sexual assault and conception risk, $r(644) = -.01$, $p = .89$.

We next tested whether, as predicted, the relationship between fear of sexual assault and envisioned physical formidability was moderated by conception risk, such that women of both higher fear of sexual assault and higher conception risk would inflate the estimated physical formidability of the violent target relative to the non-violent target. We entered conception risk (centered), fear of sexual assault (centered), and the interaction between conception risk and fear of sexual assault simultaneously into a regression, with the difference between the estimated physical formidability of the violent offender and the non-violent offender as the outcome variable. The overall regression was statistically significant, $R = .148$, $R^2 = .022$, adjusted $R^2 = .017$, $F(3, 640) = 4.81$, $p < .01$. There was a significant Fear of Sexual Assault × Conception Risk interaction, $b = 1.62$, $SE = .80$, $\beta = .08$, $p < .05$. In the model, there was also a marginally significant effect of conception risk, $b = 2.71$, $SE = 1.41$, $\beta = .08$, $p < .06$, but not fear of sexual assault, $b = .04$, $SE = .02$, $\beta = .06$, $p = .11$. Thus, consistent with predictions, conception risk significantly moderated the relationship between fear of sexual assault and the difference between the envisioned physical formidability of the violent offender and the non-violent offender (see Figure 2). Simple effects assessed at above and below the median fear of sexual assault revealed that the relationship between conception risk and the difference between the envisioned physical formidability of the two targets was significant when fear of sexual assault was high, $b = 6.03$, $SE = 1.71$, $\beta = .17$, $p < .001$, but not when fear of sexual assault was low, $b = .68$, $SE = 2.05$, $\beta = .02$, $p = .74$.

We next assessed whether overall fear of crime (made up of the six crime items apart from the item directly probing fear of sexual assault) influenced formidability estimates.

Consistent with expectations, overall fear of crime was positively correlated with the estimated physical formidability of the violent target, $r(644) = .09$, $p < .02$, but not the non-violent target, $p > .71$. However, against expectations, there was no significant correlation between fear of crime and the difference between the envisioned physical formidability of the two targets, $r(644) = .06$, $p = .11$. An exploratory test of a potential interaction between conception risk and fear of crime on the difference between the estimated formidability of the two targets, parallel to the moderation test conducted with regard to fear of sexual assault, revealed no significant interaction, $p > .18$.

Discussion

Consistent with our thesis that the dimensions of envisioned physical size and strength are used to represent the risk to a woman's assets posed by sexual assailant, our field survey of 644 women in urban Southern California revealed a positive correlation between the participant's conception risk, calculated on the basis of her estimated position in the menstrual cycle at the time of participation, and her conceptualization of the bodily formidability of a man who, by virtue of having been convicted of a violent crime, poses a risk of committing sexual assault. This pattern is even starker when individual differences in baseline assumptions about men in general, and about law-breakers in particular, are controlled for by comparing the participant's conceptualization of the potential assailant with her conceptualization of a non-violent criminal. Likewise, this pattern is further bolstered by our finding that conception risk moderates the relationship between fear of sexual assault and the envisioned physical formidability of a potential assailant, with those women who are most fearful in this regard displaying the most distinct influence of conception risk.

Given both variation across individuals in normal menstrual cycle length and the frequent occurrence of anovulatory cycles, hormone assays are the gold standard for assessing conception risk in research on psychological changes across the menstrual cycle (Gildersleeve et al., in press). However, cognizant of the potential range of inter-individual variation along many of the relevant psychological dimensions, in the present study we opted to sacrifice such precise measurement of conception risk in favor of a large sample size. The definitiveness of our results is therefore constrained by the indirect nature of our assessment of conception risk. Specifically, while useful, the forward-counting method is not ideal (Gildersleeve et al., in press), as variation both across and within women in the duration of the follicular phase introduces noise into the calculation of conception risk (Mikolajczyk & Stanford, 2005). That said, given our large sample size, it is unlikely that our positive results constitute a Type I error.

The magnitudes of the effects that we have documented are admittedly small. However, in assessing the likely contribution of the phenomenon of interest to actual experience and behavior, it is important to note that, by design, our stimuli did not make any mention of sexual assault, instead merely describing two criminals, one of whom is violent, and one of whom is not. Our core hypothesis holds that threat assessment is an ongoing process, with many components operating rapidly, often outside of conscious awareness. If so, and if considerations of asset risk play a substantial part in this process, then conception risk should influence threat assessment even when issues of sexuality seem irrelevant to the given context. Accordingly, unlike prior experimental investigations of evolved rape-avoidance mechanisms (e.g., Petralia and Gallup, 2002; Garver-Apgar et al., 2007), we did not draw participants' attention to the possibility that the target individual might commit sexual assault. Our method thus constitutes a very conservative test of the prediction at issue, hence it is reasonable to expect that, if more

512 overt stimuli are employed (e.g., describing the focal target as a convicted rapist, etc.), effects of
513 the type that we have documented will be more pronounced.

514 For several reasons, our results are unlikely to be an accidental downstream consequence
515 of physiological changes that occur across the menstrual cycle. First and foremost, if a single
516 representation captures all three components of threat assessment (relative fighting capacity,
517 likelihood of attack, and asset risk), then we can ask whether fighting capacity varies in a manner
518 that could produce the effect we have documented. As noted earlier, physical strength is a
519 contributor to fighting capacity, and, indeed, we have previously shown in men that the
520 perceiver's strength affects his conceptualization of the bodily properties of an individual who
521 may pose a threat (Fessler et al., in press). Accordingly, we can ask whether women's strength
522 varies across the menstrual cycle in such a way as to produce the observed pattern. A large
523 corpus of research explores changes in strength as a function of menstrual cycle position.
524 Although results are inconsistent across studies, the most common pattern – and the pattern
525 evident in the most methodologically rigorous studies – is that there is no effect of the menstrual
526 cycle on strength; moreover, when menstrual cycle effects are reported, they often take the form
527 of a periovulatory *increase* in strength (reviewed in Janse de Jonge, 2003; Constantini et al.,
528 2005; and Lebrun et al., 2013). Accordingly, were endogenous changes in fighting capacity
529 driving changes in overarching threat assessment, the opposite pattern to that which we have
530 found would occur, i.e., conception risk would be negatively, not positively, correlated with
531 women's estimates of a potential assailant's physical formidability. Next, because the relevant
532 self-assessed capabilities likely take the form of subjective experience (Snyder et al., 2011;
533 Prokop, 2013), we can ask whether, independent of actual changes in physical strength, women's
534 perceptions of their physical strength might vary across the menstrual cycle in a manner that

could produce the documented pattern. To our knowledge, only one study has examined changes in perceived physical strength across the menstrual cycle, finding a periovulatory *increase* in this factor (Prokop, 2013); once again, were this the primary driver of threat assessment in this situation, it would generate the opposite pattern to that which we observed.

Might other cycle-related changes account for our findings independent of issues of asset risk? A growing corpus of work indicates that, as judged via a variety of phenotypic features, women's attractiveness increases around ovulation (for review and meta-analysis, see Gildersleeve, 2014), and the same appears to be true for self-rated attractiveness (Schwarz & Hassebrauck, 2008; Röder et al., 2009). As noted earlier, prior work suggests that more attractive women can be expected to be more concerned about the possibility of sexual assault. If so, then either actual or self-perceived attractiveness, or both, could potentially drive a positive correlation with conception risk, given that each of these is itself correlated with that underlying variable. Were such patterns to occur, two possibilities would exist. On the one hand, attractiveness or self-perceptions thereof could be the proximate pathways whereby issues of conception risk – and thus of asset risk – influence the envisioned bodily formidability of a potential assailant. On the other hand, attractiveness or self-perceptions thereof could exclusively be influencing another facet of threat assessment, namely likelihood of attack, such that the apparent correlation with conception risk is an artifact of the influence of the latter on attractiveness. While the latter finding would not be uninteresting, nevertheless, it would not be consistent with our present objectives. We assessed self-perceived attractiveness, finding no indications that this was driving our basic conception risk result. Granted, our measure was limited in this regard, hence it is possible that a more extensive assessment of this factor would

produce a different outcome. We did not measure objective attractiveness, hence we cannot rule out the possibility that this played a role in our results.

To the extent that our interpretation of our results withstands the alternative possibility discussed above, and to the extent that our findings replicate across diverse cultural contexts, then, per our core thesis, these findings complement prior results in indicating that, though logically separable, the three components of threat assessment that we have articulated – fighting capacity, likelihood of attack, and asset risk – appear to be summarized by a single representation that employs the dimensions of envisioned size and strength. While our dependent measures were appropriate for the task of exploring the possibility of such a unitary representation, nevertheless, by virtue of having focused our methods exclusively on this issue, the present investigation is unable to illuminate potential interactions between the three components of threat assessment. Theory suggests that such interactions should indeed occur, and hints of such interactions exist in prior empirical findings.

First, consider the potential relationships between assessments of relative fighting capacity and assessments of the likelihood that the foe will attack. As alluded to in the Introduction, if actors evaluate the likelihood that the foe will attack in part by adopting the perspective of the foe, then such judgments will be colored by considerations of relative fighting capacity, e.g., "The foe has low relative fighting capacity, hence it will be costly for him to attack, hence this reduces the likelihood that he will do so," etc. Interestingly, however, the relationship between these two assessments is likely more complex than mere perspective-taking suggests. Error-management theories propose that evolved decision-making mechanisms should be biased in the direction of the less-costly error (Haselton & Buss, 2000; Nesse, 2001; Haselton & Nettle, 2006; Galperin & Haselton, 2012; Johnson et al., 2013). If the perceiver must assess

the likelihood that the foe will aggress, then, the greater the foe's relative fighting capacity, the more costly it will be to erroneously underestimate the likelihood of attack. Because failing to anticipate an attack launched by a high-fighting-capacity opponent will be more costly than failing to anticipate an attack launched by a low-fighting-capacity opponent, relative fighting capacity should positively inflate estimates of likelihood of attack beyond the level that wholly accurate perspective-taking would produce were it possible. Preliminary evidence in support of this prediction comes from a study of perceptions of the target individual's subjective state. Reasoning along error-management lines, Holbrook and colleagues (2014) successfully predicted that participants would judge a target individual holding tools that could be used as weapons to be angrier than a target holding analogous tools that did not offer such affordances, a pattern consonant with the plausible assumption that anger is a determinant of the likelihood of attack.

Next, consider the relationship between asset risk and likelihood estimation. Once again, error-management considerations apply, as, the greater the assets at risk, the more costly erroneously failing to anticipate an attack will be, and thus the more pessimistic the individual should be in assessing that likelihood. As noted in the Introduction, parenthood increases asset risk, both because children are themselves vulnerable to attack, and because temporary incapacitation entails an added fitness cost for parents, as children who suffer reduced parental provisioning and care are less likely to survive and reproduce. In addition to demonstrating that, per the unified threat-assessment representation thesis, parenthood increases estimates of a prospective antagonist's bodily formidability, our research group showed that parents perceived the target as having more hostile intentions – a pattern also linked to the foe's envisioned size and strength (Fessler et al., 2014b). In other words, it appears that, in the case of parenthood at least, consonant with error-management considerations, asset risk enhances likelihood

estimation. Hence, although in the present study we did not uniquely assess participants' estimations of likelihood of attack, the above results strongly suggest that conception risk will be positively correlated with such estimations, and that this will be one of the pathways whereby conception risk influences conceptualizations of the antagonist's size and strength.[5]

In sum, as illustrated by the case of the threat of sexual assault, the thesis that the three principal components of threat assessment – relative fighting capacity, likelihood of attack, and asset risk – are all summarized using a single unified representational system both reveals the phylogenetic depth of human decision-making systems and offers a productive source of novel empirical predictions.

Acknowledgments

This work was supported by the U.S. Air Force Office of Scientific Research under Award #FA9550-10-1-0511. We thank the many research assistants who contributed to this project, particularly Calli Vargas, Lilit Ter-astvatsatryan, Irene Gilchriese, Stormy Needham, John Hayes, and Jiwon Nam. Benedict Jones kindly supplied the composite images used as target stimuli, and Jennifer Fessler cleverly suggested the tampon reminder.

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[5] Notably, were a positive correlation to be found between conception risk and participants' estimations of the likelihood of sexual assault, then, at least for Western urban participants, such a correlation would not be explicable in terms of any objective patterns of criminal behavior. In the modern urban West, women are not more likely to be sexually assaulted during the high-fertility phase than at other points in the menstrual cycle (Fessler, 2003; Beirne et al., 2011). Instead, the postulated inflated likelihood estimations would best be explained in terms of error management.

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Table 1

Mean Estimated Physical Traits of Violent Criminal Versus Non-violent Criminal

	Non-violent criminal		Violent criminal				
	M	*SD*	*M*	*SD*	*F*	*p*	η^2_p
Height	69.27	2.75	70.05	2.72	50.27	< .001	.07
Muscularity	2.68	1.01	3.26	1.13	112.90	< .001	.15
Size	3.57	.95	3.95	.94	67.13	< .001	.10

Note. $N = 644$. Estimated heights are in inches.

Figure 1. *Top:* Face composites presented to participants as a non-violent criminal (convicted of tax evasion) and a violent criminal (convicted of aggravated assault). Both the faces and the crimes were fully counterbalanced. *Middle:* Array used by participants to estimate the targets' overall size. *Bottom:* Array used by participants to estimate the targets' muscularity; modified with permission from Frederick and Peplau (2007).

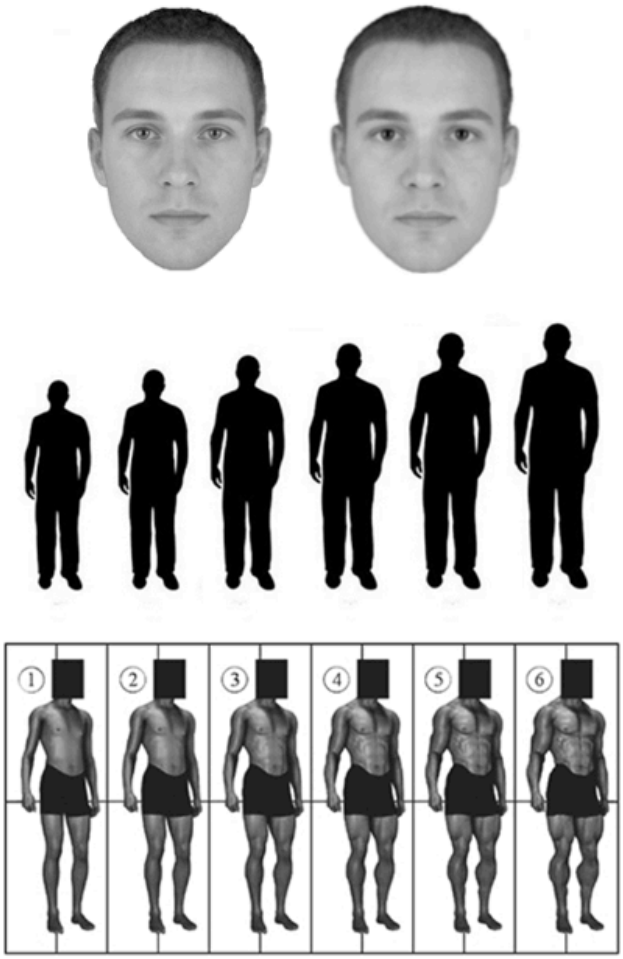

Figure 2. Interaction between conception risk and fear of sexual assault on the difference between the standardized estimated physical formidability of the violent criminal and the non-violent criminal. Higher scores reflect the extent to which the violent criminal was envisioned as larger/stronger than the non-violent criminal.