Evolution and Human Behavior 44 (2023) 1–10

Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.elsevier.com/locate/ens

Beware the foe who feels no pain: Associations between relative formidability and pain sensitivity in three U.S. online studies

Daniel M.T. Fessler [a,b,c,*,1], Wilson Merrell [d,1], Colin Holbrook [e], Joshua Ackerman [d]

[a] Department of Anthropology, University of California, Los Angeles, Los Angeles, CA 90095, USA
[b] Bedari Kindness Institute, University of California, Los Angeles, Los Angeles, CA 90095, USA
[c] Center for Behavior, Evolution, & Culture, University of California, Los Angeles, Los Angeles, CA 90095, USA
[d] Department of Psychology, University of Michigan, Ann Arbor, MI 48109, USA
[e] Department of Cognitive and Information Sciences, University of California, Merced, Merced, CA 95343, USA

ARTICLE INFO

Keywords:
Pain sensitivity
Formidability assessment
Conflict
Error management
Aggression
Anger

ABSTRACT

Pain is a critical internal regulator of current and future behavior. However, pain also constitutes a tactical liability in agonistic interpersonal conflict. Therefore, information about the pain sensitivity of others should play a functional role in assessments of the formidability of prospective foes or allies. Compared to an individual known to be sensitive to pain, an individual known to be insensitive to pain should be assessed as more formidable, as it would be more difficult to deter the latter from aggressing, and more difficult to motivate them to desist should conflict erupt. Further, knowing that a potential antagonist is armed should lead observers to infer relative insensitivity to pain, as the costs of erroneously presuming that an armed individual is sensitive to pain – and thus is both more vulnerable and less likely to aggress – will generally be higher than the costs of erroneously presuming that they are insensitive to pain, and thus are both less vulnerable and more inclined to aggress. Here, we find support for these predictions in three pre-registered studies conducted with U.S. online crowdsource workers ($N = 473$; $N = 204$; $N = 301$). The intimate association between information regarding pain sensitivity and the process of formidability assessment has implications for a variety of pressing social issues, from the use of excessive force by police, to discriminatory racial biases in the provision of medical care.

1. Introduction

1.1. Pain and agonistic conflict

Pain is a critical component of internal behavior-regulation systems, motivating organisms to truncate actions damaging to the self, to learn to avoid such actions in the future, and to take rehabilitative measures to facilitate repair in light of damage suffered. Pain's importance is underscored by the high mortality rates of those rare individuals born without the ability to experience it (Drissi, Woods, & Woods, 2020). By virtue of its effects on attention and behavior, pain necessarily detracts from the ability to pursue other fitness-relevant goals, importantly including success in agonistic conflict. This tradeoff is evident, for example, in the pattern wherein anger, a principal proximate motivator of aggression, downregulates pain sensitivity (Janssen, Spinhoven, & Brosschot, 2001), thereby increasing the ability to persist despite injury in pursuit of victory in combat.

The tactical liabilities that pain entails are further illustrated by the sex difference in sensitivity to pain. Although gender roles contribute to pain sensitivity (Wise, Price, Myers, Heft, & Robinson, 2002), cultural factors are underlaid by fundamental biological differences in pain mechanisms, such that, on average, men report less pain than women for a given intensity of physically aversive stimulus (see Dawes & Bennett, 2021; Mogil, 2012). This sex difference can be understood as the product of intrasexual selection, being aligned with sex differences in total body size, muscularity, muscle type and distribution, aggressivity, risk-taking, and other features that enhance success in male-male contest competition (Daly & Wilson, 2001; Fessler, 2010; Sparks, Fessler, Chan, Ashokkumar, & Holbrook, 2018). In short, while the experience of pain is fundamental to successfully navigating a wide variety of adaptive challenges, it also constitutes a disadvantage in high-stakes violent conflicts.

* Corresponding author at: Department of Anthropology, 341 Haines Hall, University of California, Los Angeles, Los Angeles, CA 90095-1553, USA.
E-mail address: dfessler@anthro.ucla.edu (D.M.T. Fessler).
[1] Denotes equal authorship.

https://doi.org/10.1016/j.evolhumbehav.2022.11.003
Received 5 July 2022; Received in revised form 11 October 2022; Accepted 19 November 2022
Available online 14 December 2022

Optimizing the outcomes of potential agonistic conflicts hinges in part on accurately assessing one's prospective opponent. Consonant with both the direct association between tissue damage and pain, and the effects of pain on attention, motivation, and behavior, ceteris paribus, a foe who is in pain will be easier to deter or defeat than a foe who is not. Indeed, in a variety of species, selection appears to have favored masking cues of pain in the presence of potentially hostile conspecifics or predators in order to conceal this tactical liability (Langford et al., 2011; Plesker & Mayer, 2008; Young, 2006), and substantial evidence suggests similar strategic modulation of pain displays in humans (see Kappesser, 2019; Tiokhin, 2016). Critically, individuals differ substantially in their sensitivity to pain (Nielsen et al., 2008). Information regarding a potential antagonist's characteristics along this dimension should therefore factor into assessments of the likelihood of victory or defeat in a given potential conflict.

1.2. The Formidability Representation Hypothesis

In situations of potential conflict, the decision as to whether to fight, flee, or negotiate can be expedited by the use a single representation summarizing the prospective opponent's tactical assets and liabilities relative to one's own. An emerging corpus of work indicates that, consistent with a long phylogenetic history—and redundant ontogenetic experience—wherein bodily size and strength were principal determinants of fighting capacity, these features are employed in a heuristic representation that summarizes diverse conflict-relevant assets and liabilities of the opponent relative to the self, or *relative formidability* (Fessler, Holbrook, & Snyder, 2012). This has been termed the Formidability Representation Hypothesis, where "formidability" is the sum of another actor's—or another coalition's—tactical assets and liabilities compared to one's own; for clarity, here we add the term *morphological formidability* to indicate stature and muscularity, the physical dimensions employed by the hypothesized representational system.[2] Lastly, it is important to note that assessing a target actor's or target coalition's formidability likely occurs regardless of whether the relationship is actually antagonistic, since formidable targets with whom one has no conflict constitute valuable potential allies. Below, we review evidence supporting the Formidability Representation Hypothesis.

First, with regard to features of the self, reflecting the continued relevance of bodily characteristics even in present-day conflicts, physically stronger men envision potential opponents as less morphologically formidable than do weaker men (Fessler, Holbrook, Tiokhin, & Snyder, 2014); conversely, temporarily physically incapacitated individuals conceptualize an antagonist as more morphologically formidable, and estimate themselves to be physically diminished, relative to when unhindered (Fessler & Holbrook, 2013a). Likewise, having vulnerable children (Fessler, Holbrook, Pollack, & Hahn-Holbrook, 2014) or being in the phase of the menstrual cycle in which the fitness costs of sexual victimization are highest (Fessler, Holbrook, & Fleischman, 2015) increases such estimations. Conversely, being in the presence of friends who could assist in the event of conflict reduces the envisioned physical dimensions of an antagonist (Fessler & Holbrook, 2013b), as does the experience of behavioral synchrony with a confederate (an index of the ability to coordinate in opposition to a foe) (Fessler & Holbrook, 2014), and exposure to primes designed to elicit thoughts of either friends or a powerful supportive deity (Holbrook, Fessler, & Navarrete, 2016). Similarly, confidence in the ability of one's society to defeat opponents using force is inversely related to their imagined morphological formidability (Holbrook, López-Rodríguez, Fessler, Vázquez, & Gómez, 2017).

Next, turning to features of prospective foes, knowing that an unseen individual is armed increases observers' estimates of their morphological formidability (Fessler et al., 2012), while knowing that they are injured has the opposite effect (Lopez, 2018). Mirroring the effects of participating in behavioral synchrony, hearing auditory cues of others' behavioral synchrony enhances listeners' assessments of their physical dimensions (Fessler & Holbrook, 2016). Because effective leadership is a key determinant of the fighting capacity of a coalition, the morphological formidability imagined to characterize a representative member of an armed group tracks the successes (more morphologically formidable) and failures (less morphologically formidable) of the group's leader (Holbrook & Fessler, 2013). Cultural schemas about members of a given social category sometimes include information about the danger they pose, and this is particularly true of some abhorrent racist stereotypes; correspondingly, cues that an individual is a member of a racial or ethnic group stereotyped as violent result in estimations of greater morphological formidability (Holbrook, Fessler, & Pollack, 2016; Wilson, Hugenberg, & Rule, 2017). Because displaying markers of coalitional identity in situations of potential inter-coalition conflict both constitutes an objective commitment to coalitional affiliation and signals willingness to aggress, individuals displaying such markers are conceptualized as more morphologically formidable (Fessler, Holbrook, & Dashoff, 2016). Likewise, because engaging in gruesome violence reveals either an inability to regulate aggression beyond what is necessary for victory; an insensitivity to the costs of additional aggression; disregard for norms of conflict; or all of the above, perpetrators of grisly acts are imagined to be more morphologically formidable and more aggressive (Scrivner, Holbrook, Fessler, & Maestripieri, 2020). Of particular relevance to the present work, because voluntary physical risk taking indexes lower concern regarding the possibility of injury or death, and because an opponent who is indifferent to their own physical welfare is more difficult to deter or defeat, knowing that a target individual engages in recreational physical risk-taking increases estimates of their morphological formidability (Fessler, Holbrook, & Gervais, 2014; Fessler, Tiokhin, Holbrook, Gervais, & Snyder, 2014).

Lastly, complementing work that directly utilizes the Formidability Representation Hypothesis, Yu, Sun, Zhou, Xu, and Shen (2017) document a positive correlation between winning gestures in a rock-paper-scissors game and the recalled size of the hands involved; Yap, Mason, and Ames (2013) demonstrate that altering participants' perceptions of their own social power inversely changes their estimates of another's size and weight; and Duguid and Goncalo (2012) document that feeling powerful causes participants to overestimate their own height and underestimate another's.

1.3. The present research

Combining the above evidence with the observation that susceptibility to pain diminishes fighting capacity leads to the straightforward conclusion that information regarding a target individual's pain sensitivity should contribute to representations of their formidability. This prediction is tested in Studies 1 and 2. Reversing the causal arrow, error-management considerations (Haselton & Buss, 2000; Nesse, 2001) – which here involve minimizing the costs of judgment errors – dictate that knowing that a target individual is capable of inflicting harm (for example, by virtue of possessing a weapon) may lead to the inference that said individual is also relatively insensitive to pain, since it is less costly to erroneously presume that it would be difficult to deter a potentially dangerous individual than it is to erroneously presume that it would be easy to do so. This prediction is tested in Study 3. All preregistrations, data, scripts, and materials are available at https://osf.io/zpyne/. All studies were preregistered, and were approved by the

[2] Note that we are concerned here with cognitive representation, not visual perception. Selection would have strongly disfavored biases in the latter during potentially agonistic interactions (Fessler & Holbrook, 2016) – indeed, there is evidence that evolved mechanisms produce accurate assessments of fighting ability based on morphological cues (Sell et al., 2009). Accordingly, while interesting, results indicating that beliefs relevant to formidability assessments do not markedly impact perceptual judgments (e.g., Johnson & Wilson, 2019) do not speak to the validity of the Formidability Representation Hypothesis.

University of Michigan Institutional Review Board (Health Science and Behavioral Sciences). Data cleaning and analyses were conducted in RStudio using the packages *tidyverse* and *rstatix* (RStudio Team, 2022).

2. Study 1

2.1. Background

Given that sensitivity to pain is a tactical liability, the Formidability Representation Hypothesis yields the straightforward prediction that target individuals known to be relatively insensitive to pain should be envisioned as larger and more muscular than targets known to be relatively sensitive to pain. In testing this core prediction, however, it is important to recognize that, due to the role of serial homology in the evolution of the cognitive representation of social status, such an association might also occur for reasons independent of the assessment of fighting capacity.

Consistent with the phylogenetic relationship between dominance (i.e., status maintained through force or the threat of force) and its evolutionary successor, prestige (i.e., status granted by admirers to those in possession of culturally valued knowledge or skills) (Barkow, 1975, 1989; Henrich & Gil-White, 2001), the morphological dimensions used to conceptually represent formidability can also be used to represent social status (Blaker & van Vugt, 2014; Holbrook, Fessler, & Pollack, 2016). Due to the importance of fortitude in a wide variety of activities, insensitivity to pain may often be a source of prestige, hence information about a target individual's pain sensitivity may inform estimates of the individual's social status. To establish a link between pain sensitivity and implicit assessments of fighting capacity, it is therefore important to account for any contributions that perceptions of social status derived from information about pain might make to estimates of a target individual's morphological formidability.

Returning to the problem of assessing attributes relevant to agonistic conflict, for two reasons, we can expect an association between information about an individual's sensitivity to pain and inferences regarding their propensity for aggression. First, knowing that a target individual possesses a significant tactical asset should increase the costs implicitly assigned to one of two possible errors that an observer might make when attempting to predict that individual's behavior. The individual's possession of some tactical advantage enhances the costs of erroneously presuming that the individual is *not* aggressive when, in fact, they are; in contrast, possession of such an advantage will generally have a lesser effect on the costs of erroneously presuming that the individual *is* aggressive when, in fact, they are not. Because natural selection can be expected to bias decision making toward the less-costly error (Haselton & Buss, 2000; Nesse, 2001), knowing that a target individual is insensitive to pain may precipitate the presumption that the individual is prone to aggression (see Holbrook et al., 2014 for similar reasoning). Second, given pain's association with injury, pain-insensitive individuals can be expected to be less concerned with their physical welfare than pain-sensitive individuals, potentially leading observers to draw inferences about corresponding willingness to take physical risks. Because aggression inherently involves such risks, knowing that an individual is insensitive to pain may lead observers to infer that pain-insensitive individuals are more likely to aggress against others.

2.2. Methods

2.2.1. Materials

All materials are provided in the ESM. Stimuli consisted of two vignettes, one that depicted a man who, readers can infer, is quite sensitive to pain, and another in which the reverse obtains; to minimize any effects that the name of the protagonist might have on formidability assessments (e.g., by evoking racial stereotypes linked to formidability – Holbrook, Fessler, & Navarrete, 2016), four versions of each vignette were used, each with a different protagonist name, with names selected from among those that are fairly common across ethnic groups in the U.S. None of our focal results varied by the specific name that participants saw, so all results reported below are collapsed across this factor. Dependent measures were as follows: Consonant with earlier work examining the Formidability Representation Hypothesis, the envisioned size and muscularity of the target individual were measured using arrays depicting, respectively, silhouettes differing only in size, and bodies differing only in muscularity; participants also provided a numerical estimate of the protagonist's height in feet and inches. Perceived prestige was measured using questions concerning the extent to which the target is financially successful, influential, and respected; overall social status was assessed using a target-focused version of the MacArthur Scale of Subjective Social Status (Adler, Epel, Castellazzo, & Ickovics, 2000). Perceived aggressivity was measured using a version of Buss and Perry's (1992) 9-item scale modified to refer to the protagonist (e.g., "Once in a while [name] can't control the urge to strike another person"; ranging from 1, *extremely uncharacteristic*, to 7, *extremely characteristic*). Inferences regarding the target's propensity to take risks were assessed using twelve items concerning physical risk-taking excerpted from the DOSPERT scale (e.g., "How likely is [name] to engage in: Bungee-jumping off a tall bridge"; ranging from 1, *extremely unlikely*, to 7, *extremely likely*) (adapted from Blais & Weber, 2006). Demographic items included age, gender, and ethnicity.

2.2.2. Participants and overview of procedure

Participants were recruited on August 20–21, 2021 from Amazon Mechanical Turk in exchange for monetary compensation ($1.67, equivalent on average to a rate of $10.00/h). We obtained a final sample of 473 (median age = 37; 60% women; 70% White) after excluding 63 participants who met the exclusion criteria outlined in the preregistration (completed the survey in <30% of the estimated time required to finish the study; provided nonsensical responses when prompted to guess at the purpose of the study; or failed two attention-check questions) and 7 participants who reported nonsensical values for target height (e.g., 50 ft tall); excluding these 70 participants does not change our pattern of results in any way. The experiment used a two group between-subjects design (pain-sensitive target vignette, pain-insensitive target vignette). Sample sizes allowed for detection of effect sizes of $d = 0.28$ at 80% power (a conservative estimate given the medium effect sizes found in past Formidability Representation Hypothesis work; e.g., Fessler, Holbrook, Pollack, & Hahn-Holbrook, 2014 Studies 2, 3, and 4) for the comparisons between pain sensitivity conditions.

Participants first read a vignette about a protagonist who was either relatively sensitive or insensitive to pain, then assessed the protagonist's envisioned morphological formidability, next evaluated the protagonist's perceived social status and aggressivity (in randomized order), and finally gauged his propensity for physical risk-taking.

2.3. Results

We report *t*-tests to compare group differences between conditions for formidability, status, aggressivity, and physical risk-taking (differences in degrees of freedom across these tests are a result of using Welch's t-tests to account for unequal variances between the two groups). The three measures of envisioned morphological formidability (stature, size, and muscularity) were standardized, mean-centered, and combined to create a composite ($\alpha = 0.71$). A score above 0 means that morphological formidability was above the mean for the entire sample, while a score below 0 means that morphological formidability was below the mean for the entire sample. Consonant with our core prediction, knowing that a target individual is insensitive to pain enhanced his envisioned morphologically formidability ($M = 0.34$, $SD = 0.48$) relative to a target individual described as sensitive to pain ($M = -0.43$, $SD = 0.58$), $t(437) = 15.69$, $p < .001$, 95% CI [0.68, 0.87], $d = 1.46$. See Fig. 1.

Compositing our measures of social status ($\alpha = 0.90$), in keeping with

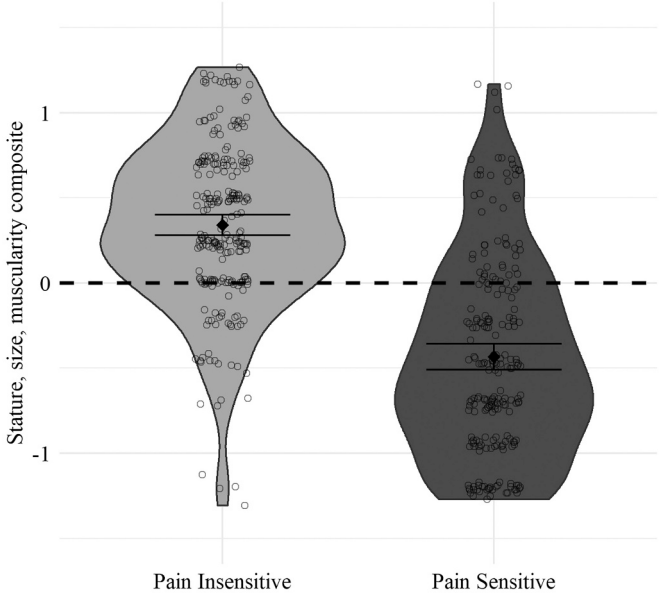

Fig. 1. Envisioned morphological formidability of pain-insensitive and pain-sensitive protagonists.
Violin represents distribution of standardized envisioned morphological formidability composites of stature, size, and muscularity by condition. Error bars represent 95% confidence intervals. Circular points represent individual participant responses; diamond points represent means for each condition.

positive cultural valuations of stoicism and related traits, pain-insensitive protagonists were judged to be higher in status ($M = 0.24$, $SD = 0.78$) than pain-sensitive protagonists ($M = -0.28$, $SD = 0.92$), $t(442) = 6.70$, $p < .001$, 95% CI [0.37, 0.68], $d = 0.62$.

Consonant with considerations of both error management and the risk of injury inherent in aggression, target individuals portrayed as insensitive to pain were seen as more aggressive ($M = 4.07$, $SD = 1.35$) than those described as sensitive to pain ($M = 2.87$, $SD = 1.52$), $t(452) = 9.02$, $p < .001$, 95% CI [0.94, 1.46], $d = 0.83$. Consistent with previous research (e.g., Holbrook, Fessler, & Navarrete, 2016), there was also a strong, positive relationship between aggressivity and morphological formidability, $r(471) = 0.53$, $p < .001$, 95% CI [0.46, 0.59]. Likewise, consistent with logical associations between insensitivity to pain and lesser concern with the possibility of injury, pain-insensitive protagonists were thought to be more likely to engage in recreational physical risk taking ($M = 4.66$, $SD = 1.13$) than pain-sensitive protagonists ($M = 2.70$, $SD = 1.43$), $t(429) = 16.44$, $p < .001$, 95% CI [1.73, 2.19], $d = 1.53$. In line with previous research, recreational physical risk-taking was also correlated with morphological formidability, $r(471) = 0.64$, $p < .001$, 95% CI [0.58, 0.69].

Recall that our multi-part hypothesis predicts that information regarding pain sensitivity should have a direct effect on envisioned morphological formidability, and that a) this should owe to issues of fighting capacity above and beyond any implications regarding status, and b) inferences regarding aggressivity and physical risk-proneness, respectively, while relevant, should be ancillary to the specific relationship between pain sensitivity and envisioned morphological formidability. Consistent with this model, the relationship between pain-sensitivity condition and envisioned morphological formidability persists even when controlling for status, aggressivity, and physical risk-taking, $b = -0.40$, $t(468) = -7.89$, $p < .001$, $f = 0.89$, 95% CI [0.79, 1.00] (see ESM for full regression output).

2.4. Discussion

Consonant with the straightforward fact that pain is a tactical liability during agonistic conflict, results from Study 1 confirm the prediction that information regarding the degree to which an individual is sensitive to pain should influence observers' assessments of the individual's formidability, where such assessments manifest as the envisioned size and muscular strength of the target individual.

Consistent with positive cultural valuations of fortitude, individuals who are insensitive to pain are perceived to have higher social status than those who are sensitive to pain.

In keeping with our expectation that observers would presume that pain sensitivity corresponds with an individual's degree of concern about the possibility of injury, we find that pain-insensitive individuals are perceived both as more aggressive and as taking more risks with their bodily wellbeing than pain-sensitive individuals. In turn, supporting the Crazy Bastard Hypothesis (Fessler, Holbrook, & Gervais, 2014; Fessler, Tiokhin, Holbrook, et al., 2014), physical risk-taking is strongly correlated with envisioned morphological formidability.

Importantly, the elementary association between pain sensitivity and morphological formidability persists even after taking into account the contributions of social status, aggressivity, and risk-proneness. This is consistent with the thesis that other formidability-relevant considerations, such as the capacity to continue fighting despite suffering injury, contribute to the pain-formidability association.

3. Study 2

3.1. Background

Experiments employing hypothetical situations are far removed from the environment in which actual assessments of relative formidability occur. Because such impoverished stimuli can be expected to evoke weaker responses than would occur in real life, it is reasonable to use exaggerated depictions to evoke a measurable response; correspondingly, Study 1's vignettes described individuals outside the typical range of variation in pain sensitivity. This introduces a potential confound: participants might infer that the extremely pain-sensitive individual suffers from some underlying pathology. If so, then the target's envisioned morphological formidability could reflect inferences about the tactical liabilities of the inferred pathology, rather than the ramifications of sensitivity to pain per se. To address this, while also testing the robustness of the results from Study 1, we repeated Study 1, adding a control condition in which the target is described as feeling pain to the same extent as the average man. Additionally, both as a manipulation check and to leverage variation in participants' interpretations of the vignettes, we asked participants to assess the target's sensitivity to pain.

3.2. Methods

3.2.1. Materials

Materials were identical to Study 1 with the addition of a control condition in which the target individual's pain sensitivity was described as average, and a question asking participants to report the target's pain sensitivity using a 0–100 slider scale anchored by “LESS sensitive to pain than 99% of men” and “MORE sensitive to pain than 99% of men” (see ESM).

3.2.2. Participants

Participants, located in the U.S., were recruited from Prolific Academic in exchange for $2.00 (equivalent to an average rate of $10.00/h) on September 15th, 2022. We obtained a final sample of 204 (median age = 34; 46% women; 64% White) after excluding 22 participants per

the exclusion criteria used in Study 1, allowing for detection of effect sizes of $d = 0.41$ at 80% power for the comparisons between pain sensitivity conditions.

3.3. Results

Measures were composited as in Study 1 (morphological formidability $a = 0.82$; status $a = 0.83$; aggressivity $a = 0.91$; risk-taking $a = 0.95$).

As expected, the manipulation check for pain sensitivity varied by condition, $F(2,201) = 454.10$, $p < .001$, 95% CI [1.87, 2.37], $f = 2.13$ (see ESM). More importantly, participants' assessment of the target's sensitivity to pain were highly correlated with their conception of the target's morphological formidability, $r(202) = -0.61$, $p < .001$, 95% CI [−0.69, −0.51]; see Fig. 2.

Envisioned morphological formidability varied by condition, $F(2, 201) = 63.41$, $p < .001$, 95% CI [0.63, 0.95], $f = 0.79$. Pairwise comparisons indicate pain-insensitive targets were seen as more formidable ($M = 0.73$, $SD = 0.79$) than both pain-sensitive targets ($M = -0.58$, $SD = 0.81$), $t(201) = 11.20$, $p < .001$, 95% CI [1.25, 2.16], $d = 1.64$, and control targets ($M = -0.04$, $SD = 0.35$), $t(201) = 6.53$, $p < .001$, 95% CI [0.90, 1.70], $d = 1.26$. Control targets were seen as more formidable than pain-sensitive targets, $t(201) = 4.61$, $p < .001$, 95% CI [0.50, 1.33], $d = 0.87$. See Fig. 3.

Status varied by condition, $F(2, 201) = 11.34$, $p < .001$, 95% CI [0.18, 0.47], $f = 0.34$. Pairwise comparisons indicate pain-insensitive targets were seen as higher status ($M = 0.19$, $SD = 0.80$) than pain-sensitive targets ($M = -0.36$, $SD = 0.99$), $t(201) = 3.92$, $p < .001$, 95% CI [0.27, 0.98], $d = 0.62$, but equivalent to control targets ($M = 0.25$, $SD = 0.65$), $t(201) = -0.38$, $p = .70$. Control targets were seen as higher status than pain-sensitive targets, $t(201) = 4.29$, $p < .001$, 95% CI [0.40, 1.09], $d = 0.73$.

Aggressivity varied by condition, $F(2, 201) = 29.50$, $p < .001$, 95% CI [0.39, 0.69], $f = 0.54$. Pairwise comparisons indicate pain-insensitive targets were seen as more aggressive ($M = 3.96$, $SD = 1.17$) than pain-sensitive targets ($M = 2.54$, $SD = 1.20$), $t(201) = 7.62$, $p < .001$, 95% CI [0.82, 1.66], $d = 1.20$, and control targets ($M = 3.08$, $SD = 0.87$), $t(201) = 4.67$, $p < .001$, 95% CI [0.51, 1.19], $d = 0.85$. Control targets were seen as more aggressive than pain-sensitive targets, $t(201) = 2.90$, $p < .001$, 95% CI [0.18, 0.92], $d = 0.52$. Aggressivity and morphological formidability were correlated at $r(202) = 0.39$, $p < .001$, 95% CI [0.27, 0.50]. Likewise, risk-taking propensity varied by condition, $F(2, 201) = 132.30$, $p < .001$, 95% CI [0.97, 1.32], $f = 1.15$. Pain-insensitive targets were seen as more risk-taking ($M = 4.66$, $SD = 0.89$) than pain-sensitive targets ($M = 2.27$, $SD = 0.87$), $t(201) = 16.10$, $p < .001$, 95% CI [2.26, 3.29], $d = 2.71$, and control targets ($M = 3.79$, $SD = 0.85$), $t(201) = 5.81$, $p < .001$, 95% CI [0.65, 1.41], $d = 1.00$. Control targets were seen as more risk-taking than pain-sensitive targets, $t(201) = 10.20$, $p < .001$, 95% CI [1.38, 2.24], $d = 1.77$.

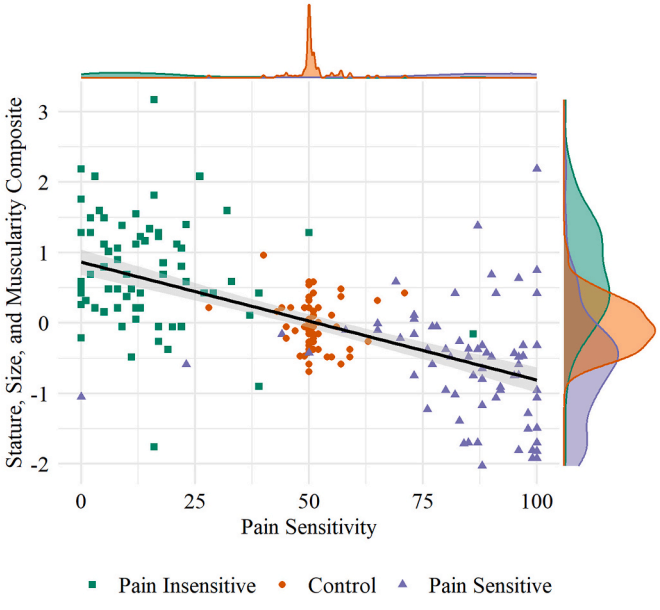

Fig. 2. Envisioned morphological formidability and perceived pain sensitivity across conditions. Band around the regression line represents 95% confidence interval; density plots represent raw distributions of pain sensitivity (x-axis) and formidability (y-axis) ratings.

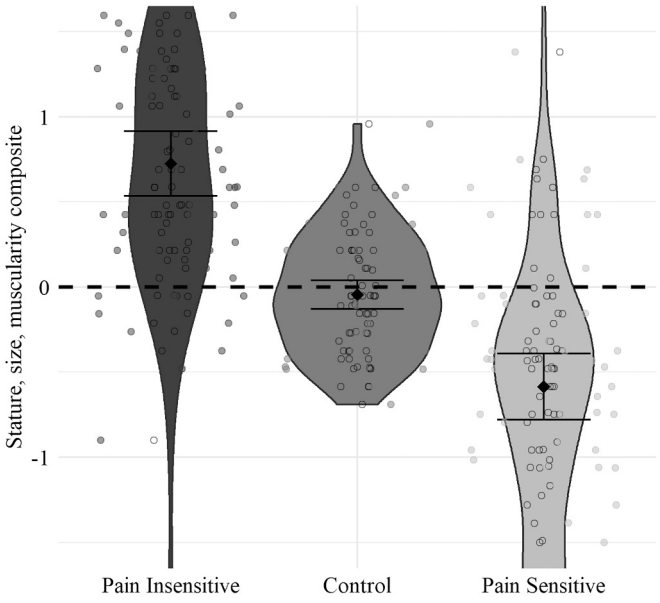

Fig. 3. Envisioned morphological formidability of pain-insensitive, control, and pain-sensitive protagonists. Black diamond indicates mean response; bars indicate 95% confidence intervals.

To further assess the robustness of the observed patterns, we conducted a regression controlling for status, aggressivity, and physical risk taking. Treating the pain-insensitive condition as the referent, both the control target, $b = -0.65$, and the pain-sensitive target, $b = -0.83$, were envisioned to be less morphologically formidable than the pain-insensitive target, $ps < 0.001$ (see ESM for full regression output). In a similar regression treating the control condition as the referent, the control target is less formidable than the pain-insensitive target, $b = 0.64$, $p < .001$, although it does not differ from the pain-sensitive target, $b = -0.18$, $p = .18$ (see ESM).

3.4. Discussion

Study 2 replicated the key results of Study 1, demonstrating that information regarding a target individual's sensitivity to pain influences the envisioned morphological formidability of the target, and that such information similarly affects assessments regarding the target's aggressivity and propensity to take physical risks. These patterns were consistent across the range of variation in pain sensitivity presented, from unusually sensitive, to typically sensitive, to unusually insensitive. Together with the straightforward correlation between participants' ratings of the target's pain sensitivity and their assessments of the target's formidability, these findings indicate that the results of Study 1 likely do not owe to inferences regarding potential pathological

conditions underlying unusual sensitivity to pain. Study 2 similarly replicated an association between pain sensitivity and social status,[3] and documented that the relationship between pain sensitivity and envisioned morphological formidability largely continues to hold when status, aggressivity, and risk-proneness are taken into account. That the latter pattern is driven by differences between the pain-insensitive condition and the other conditions further reinforces the conclusion that our core findings do not reflect inferences concerning unstated liabilities that would handicap the pain-sensitive target.

Optimal decision making in situations of potential agonistic conflict requires estimating both the capacities of a possible antagonist and their behavioral propensities. Evaluations of the latter should be influenced by error-management considerations. Correspondingly, in both Study 1 and Study 2 we find that information regarding a target's sensitivity to pain influences perceptions of their aggressivity. As elaborated in Study 3, the same reasoning leads to a corollary prediction: cues that a potential adversary is formidable should augment representations of them as both insensitive to pain and aggressive.

4. Study 3

4.1. Background

If a potential antagonist is known to possess a significant tactical asset, then error management dictates that, in the absence of additional information, they should be presumed to possess psychological attributes that will enhance the danger posed by that asset, as erroneously inferring enhanced danger will generally be less costly than erring in the opposite direction (i.e., presuming that an antagonist possessing a tactical asset has psychological attributes that would *diminish* the danger posed by that asset). Per this logic, Holbrook et al. (2014) previously demonstrated that target individuals holding everyday implements that could be used as weapons (a kitchen knife; garden shears) were judged to be both currently angrier, and more dispositionally prone to anger, than individuals holding contextually similar implements that do not have affordances as weapons (a spatula; a watering can). Consistent with the above considerations, these differences were unique to emotional states relevant to conflict, as possession of potentially dangerous implements did not increase perceptions of state disgust or fear, but rather led targets to be assessed as less disgust-prone and fear-prone, traits which converge in enhancing the danger posed by the individual in that they indicate general indifference to harm (Fessler, Holbrook, & Gervais, 2014; Fessler, Tiokhin, Holbrook, et al., 2014; Sparks et al., 2018).

Holbrook et al.'s methods provide a ready framework for investigating our second, parallel prediction, namely that if insensitivity to pain makes a prospective antagonist more difficult to deter or defeat, then knowing that said individual possesses a significant tactical asset should lead to the better-safe-than-sorry inference that they are also relatively insensitive to pain. Borrowing methods from Holbrook et al. (2014), we tested this prediction in a third study.

4.2. Methods

4.2.1. Materials

All materials are provided in the ESM. Stimuli, taken from Holbrook et al. (2014, Study 2b), consisted of photographs of three different adult male models ostensibly photographed with an object related to their hobby (i.e., cooking or gardening). Holbrook et al. digitally manipulated each photograph to create four versions thereof, such that each model can be presented as holding a kitchen knife, a spatula, garden shears, or a watering can.

Perceived sensitivity to pain was measured using a condensed, ten-item version of a scale developed by Hoffman, Trawalter, Axt, and Oliver (2016) wherein participants are asked to estimate the amount of pain that the target individual would experience (ranging from 1 = *not painful* to 4 = *extremely painful*) in a variety of mundane contexts (e.g., "He gets his fingers caught in the car door"). Following this scale, in a test of the replicability of Holbrook et al.'s findings regarding perceived states, participants were asked "When the picture was taken, to what extent do you think the man was feeling the following emotions?" (1 = *not at all*, 7 = *extremely*), with "anger," "grossed out", and "fear" presented in randomized order. Next, seeking to replicate Holbrook et al.'s findings regarding perceived traits, participants were asked "In general, do you think this man tends to be more or less angry[grossed out][afraid] than the average person?" (1 = *much less than average*, 7 = *much more than average*). Demographic items were the same as in Study 1.

4.2.2. Participants

Participants were recruited from CloudResearch on October 1–2, 2021 in exchange for monetary compensation ($0.70, equivalent on average to a rate of $10.50/h). We obtained a final sample of 301 (median age = 39; 52% women; 74% White) after dropping 24 participants who met the exclusion criteria outlined in the pre-registration (the same criteria as in Study 1). The experiment used a two-group between-subjects design (holding implement with affordance as a weapon, holding implement with no affordance as a weapon). Sample sizes allowed for detection of effect sizes of $d = 0.36$ (a conservative estimate given the large effect sizes found in Study 1) at 80% power for the comparisons between pain sensitivity conditions.

4.3. Results

We created a composite measure of perceived pain sensitivity by averaging across the ten items ($\alpha = 0.85$). Consonant with error-management considerations, target individuals depicted holding objects having affordances as weapons were seen as less sensitive to pain ($M = 2.44$, $SD = 0.49$) than individuals holding objects with no

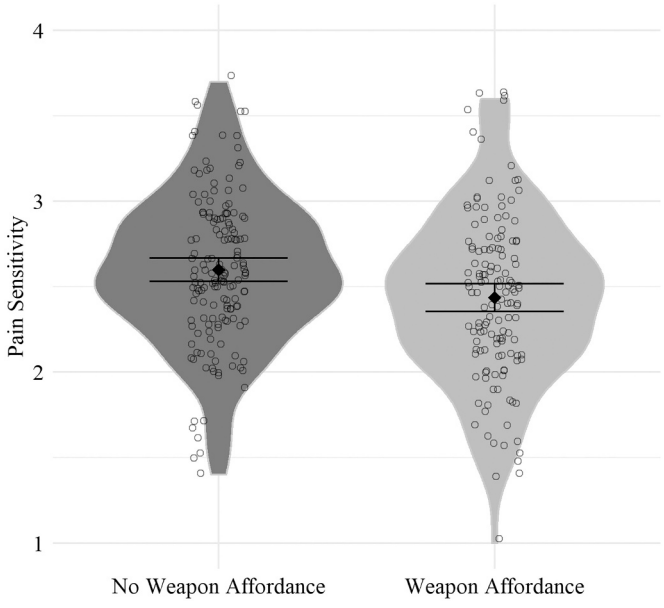

Fig. 4. Envisioned pain sensitivity of individuals holding implements that do, or do not, have affordances for use as a weapon. Black diamond indicates mean response; bars indicate 95% confidence intervals.

[3] Status results deviated slightly from predictions, as the difference between pain-insensitive targets and typical targets was not significant. Speculatively, for our U.S. sample, cultural models of masculinity may penalize sensitivity to pain more than they reward insensitivity to pain, consistent with a moderate valuation of male stoicism (in contrast to the extreme valuation in cultures or sub-cultures in which men's role as warriors is central).

affordances as a weapon ($M = 2.60$, $SD = 0.44$), $t(283) = 3.00$, $p = .002$, 95% CI [0.05, 0.27], $d = 0.35$; see Fig. 4. Next, we fit a 3 (male model) x 2 (object affordance) x 2 (activity context) between-subjects ANOVA to test whether these effects were sensitive to the specific model or activity context (cooking versus gardening). Similarly to the two-group comparison reported above, results of this ANOVA revealed a main effect of object affordance, such that men holding objects with affordances as weapons were seen as less sensitive to pain than men holding objects with no such affordances, $F(1, 288) = 8.93$, $p = .003$, $f = 0.18$, 95% CI [0.06, 0.29]. Neither male model, $F(2, 288) = 0.30$, $p = .74$, nor object context, $F(1, 288) = 0.51$, $p = .48$, had any influence on assessments of pain sensitivity. There were also no two-way interactions, nor a three-way interaction, between the three factors, all $ps > 0.20$. The results of this ANOVA suggest that the effects of weapon-holding on perceived pain insensitivity were not driven by the specific male model, nor by the activity context that participants saw.

Replicating Holbrook et al.'s findings, men holding objects with affordances as a weapon were seen as currently angrier ($M = 4.28$, $SD = 1.94$) than men holding objects with no affordances as a weapon ($M = 2.79$, $SD = 1.74$), $t(283) = 6.94$, $p < .001$, $d = 0.81$, 95% CI [1.06, 1.90]; also replicating Holbrook et al. (2014), there were no effects of weapon affordances on perceived state disgust ($p = .73$) or fear ($p = .06$). Deviating slightly from Holbrook et al.'s findings, the weapon-anger association was particularly pronounced for the images depicting kitchen knives, $F(1, 288) = 12.02$, $p < .001$, f = 0.43, 95% CI [0.08, 0.31], although the weapon-anger association was also evident in the shears condition, $t(164) = -2.93$, $p < .001$, $d = -0.46$, 95% CI [−0.79, −0.17]. Lastly, further replicating Holbrook et al.'s results, men holding dangerous implements were seen as more dispositionally prone to anger, and less prone to disgust or fear, than men holding harmless implements, $ps < 0.02$. See ESM for details.

We conjecture that the linkage between knowing that an individual possesses a significant tactical asset and inferences regarding their pain sensitivity reflects the manner in which formidability assessments generate a variety of error-management suppositions, including both those regarding pain sensitivity and those regarding anger. However, given that anger temporarily reduces pain sensitivity (Janssen et al., 2001), the inference that individuals holding potential weapons are angry could generate the inference that they are less sensitive to pain. Despite this possibility, exploratory analyses reveal that state anger is not correlated with pain sensitivity ($r = -0.07$, $p = .22$), and, correspondingly, the effect of holding potential weapons on pain sensitivity persists when controlling for state anger ($p = .006$) – suggesting that these two inferences are indeed independent consequences of formidability assessment.

4.4. Discussion

Because the implements depicted in Study 3 would normally be held in differing postures, to make the images as similar as possible, Holbrook et al. (2014) kept the arm/hand position relatively constant across the stimuli. One unintended consequence is that the posture of the models holding the knife could be construed as threatening. Together with greater associations between knives and violence, this may account for differences in the strength of the inferred state-anger effect between the knife condition and that of the other implement having affordances as a weapon, garden shears. Notably, however, even though the posture of the models holding the garden shears does not connote threat, this implement too increases perceptions of state anger. More importantly, the effect of greatest interest for the present investigation—that possession of implements having affordances as a weapon decreases inferred pain sensitivity—does not differ between these two implements.

Confirming our predictions, Study 3 demonstrated that the relationship between pain sensitivity and the assessment of relative formidability is bidirectional: whereas Studies 1 and 2 documented that the former influences the latter, Study 3 reveals that the latter also influences the former – a pattern consistent with other inferences regarding unseen attributes, such as aggressivity, that contribute to the threat that a potential antagonist may pose.

5. General discussion

5.1. Overview

Despite pain's value as an internal regulator of behavior, the propensity to experience it is a tactical liability. In three studies of U.S. internet crowdsourcing workers, we find support for a bidirectional relationship between information regarding a hypothetical target individual's sensitivity to pain and assessments of their relative formidability, such that knowing that a target is comparatively insensitive to pain increases estimates of their formidability, while knowing that an individual possesses an implement having affordances as a weapon—causing them to pose a greater potential threat to others—leads to inferences that they are relatively insensitive to pain.

Our findings should be considered preliminary, as our methods are subject to limitations, most importantly including both our dependence on hypothetical situations as stimuli, and the highly parochial nature of our sample relative to the panoply of the world's societies (and even to the range of cultural variation within the U.S.).

While consonant with the logic of the relationship between pain and formidability described here, an alternative explanation of our results exists, one that does not rely on the Formidability Representation Hypothesis. Rather than reflecting a cognitive mechanism that employs the dimensions of size and strength to summarize tactical assets and liabilities, our participants' estimates thereof may derive from their observations of actual correlations in the world. For individuals who are better able to repair bodily damage, the utility of pain is reduced. If individuals who are able to develop larger and stronger bodies are also better able to repair them, and if pain intensity is calibrated to payoffs thereof, then large, strong individuals may be less sensitive to pain than small, weak individuals. This alternative account can encompass participants' inferences regarding aggressivity and physical risk-taking, as stronger individuals may be more prone to precipitate conflict by virtue of greater probability of success (Sell, Tooby, & Cosmides, 2009), and more prone to physical risk-taking by virtue of lower probability of injury. Consonant with these possibilities, there is some evidence that testosterone, which increases muscle mass, aggressivity, and risk-taking, also reduces pain sensitivity (Basaria et al., 2015). To adjudicate between these accounts, it will be necessary to explore population-level correlations between strength, size, and pain sensitivity – data which, surprisingly, apparently do not exist at present.

Our examinations of inferred aggressivity, risk-proneness, and anger were partly motivated by an error-management approach wherein knowledge that a target individual possesses a tactical advantage (insensitivity to pain; an implement that can be used as a weapon) biases inferences toward the presumption of other traits (aggressivity; risk-proneness; insensitivity to pain) that, if possessed, would augment the target's formidability. In situations of potential conflict, such cautious formidability assessments are the inverse of overconfidence, raising the question of how to reconcile results such as ours (and Holbrook et al. 2014's) with findings arguing in favor of both the prevalence and the evolutionary stability of overconfidence in agonistic contexts (Johnson & Fowler, 2011). The solution may partly lie in the stakes at issue. Whereas optimism regarding a foe's formidability relative to one's own may be favored in contests in which winning substantially increases fitness (see Johnson & Fowler, 2011), pessimism may be favored in situations where winning merely prevents a substantial loss in fitness, as pessimism motivates greater investment in avoiding the contest altogether (see Fessler et al., 2015; Fessler, Holbrook, Pollack, & Hahn-Holbrook, 2014). The thumbnail vignettes in our studies contain no information about benefits to be gained through conflict, hence it is

functional for pessimism to govern participants' formidability assessments.

While our results are parochial, they are consonant with cultural models from other societies describing the formidable nature of pain-insensitive individuals. Although both the historical particulars and the degree of cultural uniqueness of such culturally-marked conditions as *berserk* and *amok* are the subject of scholarly clarification (Dale, 2022; Teoh, 1972), the psychiatric literature has long recognized the significance of a pattern of hyper-violent behavior in which the individual exhibits "a certain degree of 'invulnerability' to sustained physical damage," (Simón, 1987:132). This suggests that concepts such as *berserk* and *amok* reflect cultural hypercognizing of a widely understood relationship between pain and formidability.

5.2. Cultural and societal implications

The present findings entail numerous theoretical and translational implications, many of which merit further research. Below we detail some of these possibilities.

5.2.1. Ritual pain induction and signals of formidability

The pain-formidability linkage has plausibly influenced the cultural evolution of practices common in societies in which agonistic conflict is hypercognized. Sosis, Kress, and Boster (2007) document that painful rituals such as scarification or toxin ingestion are more common in societies in which warfare is prevalent. Framing their project in terms of the role of commitment in reducing freeriding during collective violence, the authors argue that such painful rituals produce lasting psychological changes due to negative affect (i.e., the rituals induce *subjective commitment*—Fessler & Quintelier, 2013). Subjective commitment alone, however, cannot explain another facet of Sosis et al.'s findings, namely that painful rituals producing permanent visible morphological alterations are more common in societies in which warfare occurs between cultural groups than in those in which it occurs within cultural groups. We suggest that this pattern owes to signaling considerations that complement Sosis et al.'s model.

Because an individual's existing allegiances are more likely to be known within than across cultural groups, social identity objectively commits (Fessler & Quintelier, 2013) individuals more in the former than the latter. Making coalitional identity indelibly visible through body modification thus creates objective commitment that is independent of personal identity in inter-cultural warfare. Parallel considerations obtain regarding the role of information about pain sensitivity in formidability assessments. Individuals who are either known to have exhibited stoicism during painful rituals, or who are members of communities or coalitions having a reputation for such stoicism, will be assessed as formidable by friend and foe alike. In societies practicing intracultural warfare, painful rituals are thus likely valuable in part by virtue of their reputational effects. In contrast, if warfare primarily occurs between cultural groups, given the lesser availability of such information, overt evidence of the ability to tolerate pain has greater signal value, thus favoring the cultural evolution of rituals that produce visible evidence of this formidability-enhancing trait.

5.2.2. Interactions between law enforcement officers and the public

Existing evidence suggests that law enforcement officers are more likely to use force against individuals exhibiting aberrant behavior due to suspected mental illness and/or substance use (Morabito, Socia, Wik, & Fisher, 2017; Rossler & Terrill, 2017), plausibly in part because such individuals are perceived to be less sensitive to pain (e.g., Rojek, Alpert, & Smith, 2012), and thus, presumably, are assessed as more formidable. The pain-formidability relationship may therefore play a role in the deplorable situation in the U.S. wherein victims' mental illness and/or substance use are evident in a large proportion of injurious or fatal encounters with police (Farkas, Matthay, Rudolph, Goin, & Ahern, 2019; Frankham, 2018).

5.2.3. Interactions between medical providers and patients

The pattern documented in Study 3 has potential direct application to matters of urgent social concern in the U.S. and elsewhere. If assessments of relative formidability do indeed inform inferences regarding [in]sensitivity to pain, this may in part explain a racist folk belief that impacts the provision of medical care. Pain alleviation is among the many dimensions along which Black patients receive measurably poorer treatment than their White counterparts in the U.S. (Meghani, Byun, & Gallagher, 2012; Morales & Yong, 2021). Multiple studies by Trawalter and colleagues document the biologically false belief – including among medical personnel – that Black people are less sensitive to pain than White people (Hoffman et al., 2016; Trawalter, Hoffman, & Waytz, 2012). While these investigators demonstrate that an important component of this belief is the idea that the experience of hardship inures individuals to pain, our findings from Study 3 suggest that, in addition, the widespread, reprehensible racist stereotype that Black people are more aggressive and more violent than White people likely also plays a role.[4] If an initial assessment of relatively high formidability leads to a downstream inference of relatively low sensitivity to pain, then the association between racial identity and formidability (Holbrook, Fessler, & Pollack, 2016; Wilson et al., 2017) can be expected to contribute to beliefs about racial differences in pain sensitivity (see ESM for additional discussion). Future work would benefit from specifying the relative size and implication of such an effect for treatment decisions, as, for example, Mende-Siedlecki, Qu-Lee, Backer, & Van Bavel (2019) showed that the difficulty which White perceivers have in detecting cues of pain in Black faces is a stronger predictor of inequitable pain treatment than are stereotypes about strength. Lastly, to the extent that the belief that Black people are less sensitive to pain becomes concretized as a cultural schema (as has apparently occurred), it likely feeds back on assessments of relative formidability, compounding the effects of racist stereotypes regarding aggressivity and violence on formidability assessments, and, in turn, potentially exacerbating the use of excessive—and all too often lethal—force by law enforcement officers in encounters with Black people in the U.S. (Edwards, Lee, & Esposito, 2019; Lett, Asabor, Corbin, & Boatright, 2020).

5.3. Future directions

Our results suggest additional avenues for exploring the core relationship between pain sensitivity and relative formidability. First, these findings highlight potentially useful tools for investigating the strategic modulation of pain expression in the presence of observers (see Kappesser, 2019; Tiokhin, 2016). By exploring how the degree to which pain is expressed influences observers' estimates of the subject's morphological formidability, researchers could measure one key dimension of the social payoffs that are presumed, but rarely assessed, in discussions of audience effects on pain expression.

Next, previous work documents that multiple features of the self influence representations of relative formidability, including physical attributes, such as one's own physical strength (Fessler, Holbrook, & Gervais, 2014), and the experience of temporary physical incapacitation (Fessler & Holbrook, 2013a). Because individuals vary in their

[4] Although Trawalter et al. (2012) entertain the possibility that these beliefs are undergirded by the racist stereotype that Black people pose a greater threat of violence, they rely on the use of a racially ambiguous facial image, labeled respectively as "Black" or "White", to ostensibly control for the threat posed by the target individual. While features of male facial morphology are indeed interpreted as an indicator of the propensity to engage in violence (Caton, Pearson, & Dixson, 2022), nonetheless, given the widespread racist stereotype regarding differences in aggression, any influence on formidability assessments of subtle facial cues is likely swamped by the influence of the overt racial labels used by the authors.

sensitivity to pain, this dimension too should affect their assessments of the threat posed by another, such that, ceteris paribus, representations of the formidability of a potential antagonist should be negatively correlated with the observer's own pain sensitivity.

Both pain and agonistic conflict are elementary aspects of human experience, and each has inarguably played important roles in the evolution of human social cognition. We therefore expect that the interplay between information regarding pain sensitivity and assessments of relative formidability that we have begun to explore here is but the tip of the iceberg, and that a wide variety of social-cognitive ramifications of information concerning relative pain sensitivity may be illuminated by further study.

Declaration of Competing Interest

None.

Data availability

The data associated with this research, as well as the pre- registrations, scripts, and materials are available at https://osf.io/zpyne/.

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