Bargaining power and adolescent aggression: the role of fighting ability, coalitional strength, and mate value

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1.0 Introduction

An organism can often benefit its own reproduction at the expense of another's. These conflicts of interest can be solved in one organism's favor if it can prevent the other from acting. One way of preventing another organism from acting is to "break" them, i.e. to introduce chaotic elements into their body that prevent the full functioning of their behavioral systems. This is aggression. Using this simple functional framework, biologists have made great strides in mapping the causal pathways that lead to animal, plant and bacterial aggression (Huntingford & Turner 1987).

Natural selection has designed a host of cognitive and perceptual adaptations in a variety of animal species that function to estimate and reduce the costs of aggression. Primarily, animals assess their probability of winning a given conflict, and then cede resources that would cost more to acquire than they are worth (Enquist & Leimar 1983). These assessment mechanisms should – in theory – assess any cue that predicts the probability that pursuing a conflict will be a net cost for the assessor. Empirically, animals have been shown to assess both semi-stable variables (e.g. fighting ability) and variables that fluctuate from conflict to conflict; for example, when fighting over food, animals will be more likely to persist when they have been starved (Enquist & Leimar 1987; Sell 2011a), but they are also less likely to persist if there are perceptible cues that their opponent has been starved. For example, bald eagles will assess the distention of their opponent's stomach and cede food to hungrier opponents (Hansen 1986). More commonly, these assessment mechanisms attend to cues of relative fighting ability (i.e. relative formidability). For example, red deer, toads, and feral horses respond functionally to auditory cues of body size (Clutton-Brock & Albon 1979; Davies & Halliday, 1978; Rubenstein & Hack, 1992). Hermit crabs assess claw size and respond prudently (Neil 1985), and humans attend to visual and auditory cues of upper body strength in men (Sell et al. 2009, 2010; Sell 2012; Trebicky et al. 2013; Zioli et al. 2014). In addition to individual assessment, some animals assess the size of coalitions before group aggression, e.g. chimpanzees (Wilson, Hauser & Wrangham 2001).

The outputs of these assessment mechanisms and the outcomes of any aggression that follow are stored in neural tissue and result in patterns of deference called *dominance hierarchies*. Such hierarchies have been demonstrated in many social species such as domestic chickens (Maier, 1964), dark-eyed juncos (Cristol, 1992), Panamanian insects (i.e. *Zorotypus gurneyi*, Chloe, 1994), chickens (Guhl, 1956), dark chub fish (Katano, 1990), hyenas (Owens & Owens, 1996), cockroaches (Ewing, 1967), and every social monkey and ape (Smuts, Cheney, Seyfarth, Wrangham, & Struhsaker, 1987). While dominance hierarchies are often referred to as a feature of a social group, the hierarchy itself exists in the brains of the individual animals that store information about relative bargaining power. The result is that animals with more bargaining power (i.e. the ability to impose costs, deny benefits or otherwise exert control over the actions of another), leverage this power in ways that let them win conflicts of interest, attain preferential access to territory or mates, and in other ways benefit themselves at the expense of other animals. Indeed, the relationship between an animal's fighting ability (the largest component of bargaining power in many species) and the deference it receives from other animals is one of the most robust findings documented in evolutionary biology (see Archer 1988; Huntingford & Turner 1987; Kelly 2008).

1.1. Evolutionary psychology of aggression

Evolutionary psychologists have applied some of these basic findings to humans, and used them to understand human aggression and bargaining behavior in many contexts (Archer 1988; Eisner & Malti 2015; Petersen et al. 2012; Pietraszewski & Shaw 2015; Price et al. 2012; Sell, Tooby & Cosmides 2009; Tooby et al. 2008). The theories have also been used to create a computational theory of human anger (Sell 2006, 2011a, 2011b) that makes specific predictions about the role of bargaining power on entitlement, anger, and aggression. The recalibrational theory holds that human anger was designed by natural selection to bargain for better treatment both in the immediate environment and over time. Thus, anger deploys tactics both to win conflicts of interest and to recalibrate the target so that they place more weight on the angry individual's interests in the future (i.e. to raise their *welfare tradeoff ratio* or WTR, see Tooby et al. 2008). Because the limits of what one can expect from others can be negotiated with bargaining power, those individuals with more bargaining power should expect and demand higher WTRs from

others (i.e. such individuals should be – and are – more entitled and more prone to anger; Lukasweski 2013, Price et al. 2012; Sell, Tooby & Cosmides 2009). The theory thus predicts that anger-based bargaining (using cost-infliction or benefit-denial) will be tied to bargaining power such that more powerful individuals will deploy anger over a wider range of circumstances, insist on better treatment from others, and more frequently deploy aggressive bargaining tactics (Sell, Tooby & Cosmides 2009).

Anger is one of the evolved mechanisms that trigger aggression, but it is not the only one. Other routes to aggression likely include predatory and hatred-based aggression (Sell 2013), bargaining aggression activated by jealousy (Buss 2000) or fear (Kalin 1999), and others (Archer 1988; Baumeister & Beck 1999; Pinker 2011). Regardless of the route to aggression, the models of animal conflict suggest that bargaining power would have both: i) increased the probability of aggression succeeding and ii) decreased the harmful future consequences of that aggression. In short, the human mind evolved in a context wherein bargaining power was associated with more efficient aggressive bargaining. Therefore, the human mind should be designed such that an individual's bargaining power will regulate the deployment of harmful behavior.

In short, those with more bargaining power should demand better treatment and more commonly threaten or deploy aggression against others. Furthermore, those individuals with bargaining power should believe that aggression is a more appropriate and efficient strategy than those without bargaining power. Finally, because bargaining power can be used to protect individuals against exploitation, those with bargaining power should anticipate that they are more protected from the consequences of aggressive behavior. We refer to this cluster of variables - e.g. entitlement, frequent use of aggression, and belief in the utility of aggression – as “aggressive bargaining.”

1.2 Components of human bargaining power

Reproduction is an inherently difficult task requiring the solving of many adaptive problems. Because of this, there are multiple ways in which one individual can help or hinder the

reproduction of another, giving that individual multiple levers of bargaining power. We focus on three: fighting ability, coalitional strength and mate value.

1.2.1 Fighting ability

As with other animals, the ability to efficiently use physical aggression against a conspecific is a component of bargaining power in humans. Such aggression is particularly common among unmated human males (Wilson & Daly 1985). Furthermore, sex differences in perceptual, motor, muscular, skeletal, energy and behavioral systems show that males are - compared to females – better designed for physical aggression (Sell, Hone & Pound 2012). Research on the ability of humans to assess fighting ability in their conspecifics also supports this premise: both men and women are better able to estimate male fighting ability (Sell 2012). Therefore, among males, those who are better fighters will expect better treatment from others and be more prone to use their fighting ability to bargain during conflicts (DeWall et al. 2010; Hess et al. 2010; Petersen et al. 2013; Price et al. 2012; Sell, Tooby & Cosmides 2009). In short, while fighting ability is a component of bargaining power for both sexes (Burbank 1994; Campbell 2013), it is particularly important for males. This leads to two core predictions: #1 – fighting ability will positively correlate with aggressive bargaining in males and #2 – fighting ability will be less predictive of aggressive bargaining in females.

1.2.2 Coalitional Strength

Although some species engage only in solitary aggression, others combine their efforts to magnify bargaining power (Chapais 1996; Harcourt & de Waal 1992; Silk 2002). Humans are a highly cooperative species that uses coalitions both to enhance fighting ability (Fessler & Holbrook 2013; Wrangham 1999; Wrangham & Glowacki 2012) and to benefit from collective actions (Ostrom 2000; Tooby, Cosmides & Price 2006). Because coalitions can inflate both formidability and cooperative value, the size and strength of an individual's coalition is a component of their bargaining power. Furthermore, factors such as specialized knowledge and skills, health, mutual interests, and many other factors are likely to determine the quality of the coalition one is accepted into, a selection process that occurs in both men and women and functions from at least early childhood (Drewry & Clark 1985). Thus, one's coalition is not only a causal factor in bargaining power but also an indirect indicator of valued personal qualities that

are likely to be components of bargaining power in their own right. For both these reasons, coalitional strength should predict aggressive bargaining in both males (prediction #3) and females (prediction #4).

1.2.3 Mate value

Evolutionary biologists understand mateships in social species to work as a competition, wherein individuals attempt to consort with mates that will be more likely to conceive healthy offspring (Møller & Alatalo 1999) and – in investing species – show traits that predict the mate will be able and willing to invest in the offspring (Møller & Jennions 2001). Humans – and other animals – evolved a sense of beauty that is comprised of perceptual and computational systems that estimate some of these features and output a magnitude that corresponds to the mate’s desirability (Symons 1995). While there are individual differences in mate preferences, there is also substantial agreement in which features are desirable in a mate within any given group (Cunningham et al. 1995; Fink & Penton-Voak 2002). This means that individuals differ in their “mate value” and that this difference enables men and women to bargain with the opposite sex for better treatment based on the contingency of entering a mating or romantic relationship.

Furthermore, many of the components of “mate value” also indicate an individual’s quality as a trading partner or cooperative ally, e.g. health, longevity, competence, skills (Fink et al. 2006; Jones et al. 2001). This is supported by a wealth of literature showing that more attractive people are actually treated better by both sexes; e.g., they are more likely to be hired (Mack & Rainey 1990), given lighter criminal sentences (Stewart 1985), and generally treated better (Langlois et al. 2000). Therefore, mate value, like coalitional strength, is predicted to be a measure of bargaining power both because of its causal effect, but also because mate value itself is an indicator of various facets of bargaining power. This leads to predictions #5 and #6, that mate value will predict aggressive bargaining in both males and females.

Finally, while it must be acknowledged that all three aspects of bargaining power are likely to be related, to the extent that each can be measured distinctly they should all – independently – predict aggressive bargaining (prediction #7).

2.0 Methods

These seven hypotheses were tested on a large sample of Swiss adolescents taking part in a longitudinal study: the Zurich Project on the Social Development of Children and Youths (i.e. z-proso):

1. fighting ability will positively correlate with aggressive behavior in males
2. fighting ability will be less predictive of aggressive behavior in females
3. coalitional strength will predict aggressive bargaining in males
4. coalitional strength will predict aggressive bargaining in females
5. mate value will predict aggressive behavior in males
6. mate value will predict aggressive behavior in females
7. the effects of fighting ability, coalitional strength and mate value on aggressive behavior will be – at least in part – independent

2.1 Subjects

A total of 1447 subjects (697 female) were included in the sample (mean age: 15.4, SD: .36). The subjects were the entire cohort of the Zurich Project on the Social Development of Children and Youths (i.e. z-proso study). While most subjects (1293, 89%) were born in Switzerland with small groups born from Germany (25) and Portugal (21) and Kosovo (12), most of the subjects were also born to at least one immigrant parent. Only 23% were born to a native Swiss mother and father.

2.2 Procedure

The data used in the present study were collected in the sixth wave of the Zurich Project on the Social Development of Children and Youths (z-proso), an ongoing prospective longitudinal study of a cohort of children that entered one of 56 randomly selected primary schools in the City of Zurich in 2004 (Eisner & Ribeaud, 2005; Eisner et al. 2011; Nivette et al. 2014). In wave six, 86.4 % (N=1447) of the initial target sample participated.

Prior to data collection parents were informed in writing and given the opportunity to refuse their child's participation in the study. At the beginning of the survey participants were informed in detail about the study and their rights and were asked to sign a written informed consent form including consent for the teacher assessment. Data were collected by means of paper and pencil surveys in classrooms with 5 to 15 participants. Each session lasted for approximately 90 minutes. Participants were guided through the questionnaire by two or three trained staff members, and received a cash incentive worth approximately \$50 (USD).

Teachers assessed each participant on a one page questionnaire and returned it by mail. Because some teachers were unavailable due to maternity leave, relocation or refusal to participate, the teacher assessment was only obtained for 1292 (or 89.2%) of the wave 6 participants.

2.3 Measures

Core predictions were tested with three measures of bargaining power: fighting ability, coalitional strength and mate value.

2.3.1 Fighting ability

Aggression among our ancestors involved both weapon use (Brues 1959; Keeley 1996) and bare-handed aggression (Morgan & Carrier 2013; Walker 1997). In both cases, it was upper body strength that was the primary determinant of the amount of force one was capable of applying to an opponent. While many other competences will calibrate fighting ability (e.g. reaction time, visual acuity, efficient respiration, spatial intelligence; see Sell, Hone & Pound 2012) the importance of upper body strength as a predictor of fighting ability is well established by multiple lines of research (Price et al. 2012; Sell, Tooby & Cosmides 2009; Sell et al. 2009; Sell, Hone & Pound 2012), including research specifically on adolescents (Muñoz-Reyes, et al. 2012; Piko, Keresztes & Pluhar 2006; Tremblay 1988).

Previous research has shown that upper body lifting strength in adult men can be reliably predicted by a composite measure of flexed biceps circumference, self-report and ratings of photographs of the upper body (see supplemental information in Sell et al. 2009). Photographs

of our subjects were unavailable, so our final measure of fighting ability included flexed biceps circumference, self-reported physical strength and self-reported fighting ability. Flexed biceps circumference was measured in centimeters from the dominant arm. Self-reported strength and fighting ability were assessed with one-item self-report measures (see Table 1). These measures were converted into z-scores (within sex) and averaged for a composite measure of fighting ability.

2.3.2 Coalitional Strength (CS)

Humans coordinate their efforts in order to magnify their own bargaining power. This amplification affects both formidability and cooperative value and is predicted to be a correlate of bargaining power for both males and females.

The primary measure of coalitional strength in this sample was from self-reported measures of membership in groups (though see supplementary information for additional measures and analyses). Several questions about coalitional strength were asked, prefaced with the following statement: “The next few questions are about the friends and peers with whom you spend your free time. Adolescents often have a group of friends or ‘clique’ that regularly meet up to do things, or just to hang around.” The first measure of coalitional strength (CS1) was a dichotomous question posed immediately after the preface, “Do you have a group of friends like that?” Those subjects who answered “yes” to CS1 were also asked questions that assessed:

- a) the group size - “How many people – including you – are part of this group?” Subjects indicated either: 2 people, 3-10 people, 11-20 people, 21-50 people, 51-100 people, or 100+. Answers were scored from 1 to 6 on that scale.
- b) age of group members - “How old are they on average?” Subjects indicated: under 12, 12-15, 16-18, 19-25, 25+. Answers were scored from 1 to 5 on this scale.
- c) the longevity of the group - “For how long has this group existed?” Subjects indicated: less than 3 months, 3 months to 1 year, 1 to 4 years, more than 4 years. Answers were scored from 1 to 4 on this scale.

Each of these three items was z-scored and those z-scores averaged to create CS2. Thus, more coalitional strength was assigned to subjects who had larger, more long-lasting groups composed of older peers. See Table 1 for more details.

Finally, because CS2 leaves out the 50% of males and 40% of females who report no group membership, their inclusion in regression models would compromise the power of other analyses. CS3 was created to include the entire sample (like CS1) but allow subjects who are members of a group to have their scores accurately reflect the coalitional strength of that group. CS3 was computed by averaging CS1 (z-scored within sex so that males without groups were given -1.0, females without groups -1.28) and coalition submeasures *a-c* for those who report having a group. This results in some oddities in the data, e.g. males without groups may still have a higher coalitional strength score than males with extremely small, short-lived, groups of younger members (though this only happened in 1 case). On the other hand, CS3 enables the full sample to be used in more detailed analyses.

2.3.3 Mate value

Following the method outlined in Sell, Tooby & Cosmides (2009), a one-item self-report measure of attractiveness was given to subjects, e.g. for male subjects: "Out of 100 boys my age, I am more attractive than ____ (*between 0 and 100*) of them." In addition to physical attractiveness, two additional measures of mate value were used: whether the subject was in a romantic relationship and whether they had had sex with their romantic partner (see Table 1). Females were slightly more likely to be in a relationship (49%) than males (44%), Mann-Whitney Test, $z = -2.016$, $p = .044$, but less likely to have had sex (11%) than males (22%), $z = -5.42$, $p < .0001$. This discrepancy could indicate deception on behalf of the subjects, the use of different definitions of sexual intercourse or relationship by males and females, a tendency for younger males to have sexual relations with older females, or for a small number of females to have sex with multiple males.

The nature of the relationship between current sexual behavior and mate value is likely to be complex, but females who are in relationships or having sexual relationships are presumably trading on their mate value in ways that would enhance their current bargaining power. In addition, both males and females who have been picked as romantic partners are presumably of higher mate value than those who have not been picked.

Measures of self-reported attractiveness, being in a relationship and having sex were converted to z-scores and averaged to create a single mate value score.

Table 1: Measures of Bargaining Power

Measure	Valid N m/f	Mean (SD) m/f	Details of measure	Sex differences in raw measure
Fighting ability	750/697	N/A	Composite of z-scored FA a-c	N/A
FAa) Biceps circum, (mm)	744/688	299, (35.0) 274, (30.3)	Flexed biceps circumference, measured on dominant arm.	male bias $t(1430) = 14.2$ $d = .75***$
FAb) Self-reported physical strength	749/695	57.9 (21.7) 49.1 (22.3)	Out of 100 girls(boys) my age, I am physically stronger than ____ (<i>between 0 and 100</i>) of them.	male bias $t(1442) = 7.6$ $d = .40***$
FAC) Self-reported fighting ability	748/694	56.8 (24.0) 47.7 (24.0)	Out of 100 boys(girls) my age, I would beat ____ (<i>between 0 and 100</i>) of them in a physical fight.	male bias $t(1440) = 7.3$ $d = .38***$
Coalitional Strength 1 (CS1)	749/696	50.5% yes 62.0% yes	“Are you in such a group?”	female bias $t(1443)=4.4$ $d = .23***$
CSa) Group size	378/431	2.29 (.71) 2.03 (.51)	“How many people (including you) are part of this group?”	male bias $t(807)=5.9$ $d = .42***$
CSb) Age of group members	378/430	2.46 (.53) 2.42 (.50)	“How old are they on average?”	<i>n.s.</i>
CSc) Longevity of group	378/428	2.65 (.82) 2.61 (.72)	“How long has your group existed?”	<i>n.s.</i>
Coalitional Strength 2 (CS2)	379/432	N/A	Composite of z-scored measures CS a-c	N/A
Coalitional Strength 3 (CS3)	749/696	N/A	Composite of z-scored measures CS1, CSa, CSb, CSc	N/A
Mate value	750/697	N/A	Composite of z-scored SV a-c	N/A
SVa) Self-reported attractiveness	744/692	58.1(21.2) 47.8 (22.3)	Out of 100 girls my age, I am more attractive than ____ (<i>between 0 and 100</i>) of them.	male bias $t(1434) = 9.0$ $d = .48***$
SVb) In relationship	747/695	43.7% yes 49.1% yes	(In the last two years), you had (or still have) a romantic relationship with another boy or a girl.	female bias $t(1440) = 2.0$ $d = .11*$
SVc) Sexually active	742/693	21.7% yes 11.2% yes	(In the last two years), you had sex with your romantic partner.	male bias $t(1433) = 5.5$ $d = .29***$

* $p < .05$, ** $p < .01$, *** $p < .001$, two-tailed

2.3.4 Measures of aggression

The Zurich Project on the Social Development of Children contains a number of aggression measures that relate to direct agonistic bargaining. Measures were chosen that best conformed to the theoretical outcome of higher bargaining power: a willingness to directly impose costs on

others in order to benefit oneself, a belief that aggression is efficacious, and an intolerance towards costs directed at oneself from others. See Table 2. The following measures were used:

Teacher rating of aggression. This scale was composed of 13 responses from the subject's primary school teacher, measuring the subject's frequency of proactive, reactive and physical aggression (indirect aggression was not included). Specific items asked whether the student behaved aggressively when teased, humiliated others, engaged in a violent attack and so on. Questions were answered on a 1 to 5 scale: 1 – never, 2 – rarely, 3 – sometimes, 4 – often, 5 – very often (see Tremblay et al. 1991).

Subject rating of aggression. This scale was the same as the teacher rating of aggression scale, but was answered by the subject about herself (see Tremblay et al. 1991).

Aggressive Conflict Coping Scale. This self-report scale contains four items that measure the subject's tendency to use aggressive bargaining tactics during conflicts of interest. Individual items include measures of the subject's willingness to threaten aggression, get mad and yell, and intimidate others. Answers were given on a 1 to 5 scale identical to the ratings above.

Violent Delinquency. Subjects were asked three “yes or no” questions about three types of aggressive delinquency: had the subject (in the past year) committed an assault, committed a robbery, or illegally carried a weapon in public. For each “yes” given the subjects were scored +1, leaving a 0 to 3 scale. The alpha reliability of this measure is poor, but this stands to reason as it contains only three dichotomous measures. Furthermore, it measures distinct forms of delinquency rather than three measures of the same type.

Norms of Masculinity. This three item self-report scale measures the subject's legitimization of male aggression. Items included “a real man must defend himself”, “a real man is ready to fight” and “a real man protects his family” and were sourced from Enzmann, Brettfeld & Wetzels (2003). Subjects responded on a 1 to 4 scale: 1 = fully untrue, 2 = somewhat untrue, 3 = somewhat true, 4 = fully true.

Moral Neutralization of Violence. This measure was composed of a subset of items from a larger “moral neutralization of aggression” scale measuring the degree to which subjects made moral exemptions for various anti-social behaviors. Only items that referred to physically aggressive acts were included, resulting in a seven item scale, e.g. “It is acceptable to solve problems with violence,” “It is okay to fight somebody if they disrespect your group.” Responses were given on the same 1 to 4 scale as the norms of masculinity scale (Ribeaud & Eisner 2010).

Global Aggression Measure. To allow for ease of analysis and solitary answers to research questions, we created a single global aggression measure from the scales above. All six of the aggressive measures were z-scored and averaged to compute the global aggression measure. Alpha reliability (wherein each of the scales above served as one item) showed good agreement (see Table 2).

2.3.5 Controls

The z-proso survey contains several psychological scales and measurements that served as controls when testing the robustness of the effects of bargaining power on aggression. In order to test against various counter-hypotheses (see results) the following psychological control measures were included in our analyses. Responses were given on the same 1 to 4 scale as the norms of masculinity scale.

Self-control. This ten item measure contained statements about the subject’s ability and willingness to control their own behavior. Specific measures included statements about the subject’s tendency to lose control, engage in risky behavior, to act without considering consequences and so forth. Three items directly relating to aggression or conflict with others were eliminated to avoid direct confounding with our dependent variable, leaving a seven item scale. The inclusion of these three removed items did not change the significance of any hypothesis test.

Optimism Scale. This self-report measure of the subject’s general optimism consisted of four items: “I’m happy”, “Life is beautiful”, “I’m full of energy,” and “I laugh often.”

Competent Conflict Coping. This measure complements the aggressive conflict coping scale. It contains four items that measure non-aggressive means of resolving conflicts, e.g. “I take the other person’s perspective”, “I listen to avoid misunderstanding,” and “I try to control my anger.”

Legal Cynicism Scale. This six-item measure is designed to assess the subject’s belief in the legitimacy of the legal system. It contains items such as: “It is okay to do whatever you want if you’re not hurting anyone”, “It feels good to bypass the rules”, and, “Rules are made to be broken” (Karstedt & Farrall 2006).

General Trust Scale. This three-item self-report measure estimates the subjects’ general trust, i.e. “Most people are trustworthy”, “People are mostly helpful,” and, “most people are fair.”

Anthropometric measures. In addition to these psychological scales the following physiological control variables were recorded. Height and weight were reported by the subjects; note that previous research shows adolescents can report their height and weight accurately (Kuczmarski, Kuczmarski & Najjar 2011; Strauss 1999). These measures were used to compute body mass index (BMI) as well. Age was computed (in months) from their date of birth. Finally, subjects answered questions relating to their physical maturity (i.e. pubertal development scale, see Watzlawik 2009).

Table 2: Measures of aggression and control variables

Aggression Measure	Valid n (female)	Mean (SD)	Sex differences	α reliability (# of items)
Teacher-Rating of Aggression	1287 (619)	1.35 (.52)	male bias, $M = .15$ $t(1285) = 5.58, d = .31^{***}$	.93 (13)
Self-Rating of Aggression	1447 (697)	1.69 (.57)	male bias, $M = .27$ $t(1445) = 9.81, d = .52^{***}$	.87 (11)
Aggressive Conflict Coping	1440 (696)	1.62 (.61)	male bias, $M = .25$ $t(1438) = 8.09, d = .43^{***}$	.67 (4)
Violent Delinquency	1442 (695)	.21 (.52)	male bias, $M = .21$ $t(1440) = 7.77, d = .41^{***}$	.45 (3)
Norms of Masculinity	1436 (690)	2.47 (.74)	male bias, $M = .34$ $t(1434) = 8.99, d = .47^{***}$	.73 (3)

Moral Neutralization of Violence	1446 (697)	2.13 (.63)	male bias, $M = .51$ $t(1444) = 16.86, d = .89^{***}$	.82 (7)
Global Aggression Measure	1447 (697)	0.00 (.71)	male bias, $M = .49$ $t(1445) = 14.01, d = .74^{***}$	.83 (7)
Controls				
Self-Control Scale	1445 (696)	2.37 (.47)	female bias, $M = -.11$ $t(1443) = -4.25, d = .22^{***}$	.69 (7)
Optimism Scale	1435 (694)	3.30 (.53)	male bias, $M = .15$ $t(1433) = 5.27, d = .28^{***}$	.75 (4)
Competent Conflict Coping Scale	1440 (696)	3.34 (.80)	female bias, $M = -.15$ $t(1438) = -3.50, d = .18^{***}$	.71 (4)
Legal Cynicism	1445 (696)	2.20 (.56)	male bias, $M = .15$ $t(1443) = 4.97, d = .26^{***}$	.72 (6)
General Trust	1445 (697)	2.41 (.58)	<i>n.s.</i>	.78 (3)
Height (centimeters)	1444 (696)	169 (8.8)	male bias, $M = 10.25$ $t(1442) = 27.0, d = 1.42^{***}$	N/A
Weight (kilograms)	1438 (692)	60.9 (11.6)	male bias, $M = 9.3$ $t(1436) = 16.5, d = .87^{***}$	N/A
BMI	1436 (691)	21.1 (3.2)	male bias, $M = .62$ $t(1434) = 3.7, d = .20^{***}$	N/A
Age	1432 (697)	185.3 (4.3)	<i>n.s.</i>	N/A
Pubertal Development	1447 (691)	3.77 (.63)	female bias, $M = -.76$ $t(1430) = -28.4, d = 1.50^{***}$	N/A

* $p < .05$, ** $p < .01$, *** $p < .001$, two-tailed

3.0 Results and Discussion

Results are summarized in Table 3 and discussed in more detail below, grouped first by the core hypothesis and then by the specific analysis.

Table 3: Zero-order correlations between components of bargaining power and aggression

	Global Agg.	Teacher Rating	Self Rating	Aggressive Conflict Coping	Violent Delinquency	Norms of Masc.	Moral Neutral.
Male adolescents							
Fighting ability	.26***	.13***	.17***	.20***	.15***	.25***	.23***
Coalitional Strength (CS3)	.24***	.11**	.21***	.24***	.21***	.10**	.15***
Mate value	.36***	.26***	.25***	.26***	.26***	.25***	.25***
Female adolescents							
Fighting ability	.17***	.10*	.15***	.15***	.08*	.08*	.13***
Coalitional Strength (CS3)	.07	.03	.06	.08*	.09*	.04	.03

Mate value	.24***	.13***	.22***	.19***	.08*	.17***	.16***
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* $p < .05$, ** $p < .01$, *** $p < .001$, two-tailed

3.1 Core hypothesis #1: Does fighting ability predict aggressive bargaining among adolescent males?

Yes. Table 3 shows the zero-order correlations between our measure of fighting ability and measures of aggressive bargaining. Furthermore, each subcomponent of fighting ability significantly predicted aggression in males (biceps circumference, $r = .14$, $p < .0001$; self-reported strength, $r = .24$, $p < 10^{-10}$; self-reported fighting ability, $r = .27$, $p < 10^{-12}$).

The effect size of this relationship was comparable to previous research on adults using measures of body size (Piko, Keresztes & Pluhar 2006) or simple measures of strength (Archer & Thanzami 2007), though smaller than research that assessed fighting ability with comprehensive measures of upper body strength (Sell, Tooby & Cosmides 2009). Consistent with the view that fighting ability – rather than strength per se – predicts aggressive bargaining in males, a linear simultaneous regression showed that of the three components of fighting ability, only self-reported fighting ability predicted unique variance in aggressive bargaining: std. Beta = .22, $p < .00001$; both biceps circumference (std. Beta = .05, $p = .23$) and self-reported strength (std. Beta = .05, $p = .40$) were no longer significant once self-reported fighting ability was in the model. This data is also consistent with the prediction that an individual's own perception of their bargaining power (rather than objective measures) that calibrates their use of aggression (Lukaszewski, 2013).

The association between fighting ability and aggressive bargaining was robust to a number of controls and counter-hypotheses. The following analyses test aspects of core hypothesis #1 and were thus done only with male subjects:

3.1.1. Is the relationship between fighting ability and aggressive bargaining the result of self-report bias?

The fighting ability composite was composed of two self-reported items and one objectively measured item (biceps circumference). Although self-reported fighting ability may be a more accurate measure of actual fighting ability and the subject's internal calibration of their aggressive bargaining power, it is also subject to a number of self-presentation biases. Indeed, males showed evidence of a self-presentation bias in their self-reported strength ($m = 57.9$) and probability of winning a fight ($m = 56.8$), as indicated by their mean deviating from 50. Furthermore, most of the aggression measures involved self-reported aggression, which may suffer from a number of self-presentation biases. To avoid both of these sources of error, a simple correlation was computed between the only objective measure of fighting ability – the flexed biceps circumference – and the only measure of aggression that is not self-reported: the teacher's ratings of the student's aggression. The results showed a small but significant relationship ($r = .11, p = .004$). Furthermore, flexed biceps circumference correlated with all three of the subsets of teacher rated aggression, reactive ($r = .11, p = .005$), proactive ($r = .11, p = .007$) and physical ($r = .10, p = .01$). This indicates that using only the most objective measures of fighting ability and aggression, hypothesis #1 is again confirmed.

3.1.2 Are these results compromised by steroid-users?

No. While 11 male subjects did report steroid use, the results remained unchanged when they were removed. Fighting ability in males continued to predict all of the aggression measures significantly.

3.1.3 Are these relationships the result of co-variance with lack of self-control, dysfunction, cynicism, or distrust?

No. The hypothesis that more aggressive males suffer from cognitive or neurological dysfunction (Fromm 1973) has been downplayed by aggression researchers who focus on laboratory aggression (Baumeister & Beck 1999). There is evidence, though, from some criminologists and others studying more extreme aggression (Blake, Pincus & Buckner 1995; Bufkin & Luttrell 2005; Raine 2014; Raine & Yang 2006) that show aggressive individuals may have various neurological abnormalities. Furthermore, there is good criminological and psychological evidence demonstrating that aggression is related to lower self-control

(Baumeister & Boden 1998; Eisner 2015) and to legal cynicism (Reisig, Wolf, & Holtfreter 2011).

Regardless, for cognitive abnormality or low self-control to be a confound capable of explaining the link between fighting ability and aggression, males with greater fighting ability would need to have lower self-control and more dysfunction. Correlating our measure of fighting ability with scales of self-control, optimism, competent conflict coping, legal cynicism and general trust showed few such relationships. In fact, males with higher scores on the fighting ability measure were more optimistic than their weaker counterparts ($r = .11, p = .003$), though they had more legal cynicism ($r = .08, p = .03$), less general trust ($r = -.10, p = .007$), and slightly less self-control ($r = -.08, p = .03$). There were no significant differences on competent conflict coping ($r = -.05, p = .19$). Regardless, when all of these covariates were put in a simultaneous regression analysis predicting the global aggression measure, fighting ability remained a significant predictor: std. Beta = .20, $p < .00001$. This does not imply that self-control and legal cynicism, for example, do not predict aggression; they do (see Table 5), but they do not explain the relationship between fighting ability and aggression.

3.1.4 Is this effect the result of differential maturity between weaker and stronger males?

During male development there is a marked increase in combat design triggered by testosterone and distributed throughout the muscular, skeletal, perceptual, respiration and immune systems (Archer 2006). Because of this, males at the later stages of development will have greater fighting ability. If later stages also involved increased aggression associated with mate competition or status rivalry, this could create an artificial relationship between fighting ability and aggression for adolescent males. To control for general development, a simultaneous linear regression was run predicting the global aggression measure from fighting ability, age (in months), and the subject's score on the pubertal development scale. Results showed that fighting ability remained a significant predictor, std. Beta = .27, $p < .00001$. Neither age nor pubertal development significantly predicted aggression, though they did predict each other: $r = .16, p < .00001$. Note however that the nature of the study resulted in subjects that were very similar in age ($SD = .36$). These results show that differential maturity cannot account for the relationship between fighting ability and aggressive bargaining in adolescent boys.

471
472 *3.1.5 Is the relationship between fighting ability and aggressive bargaining dependent on body*
473 *size?*

474 It is common practice in evolutionary biology to use body weight as a measure of fighting ability
475 (Huntingford & Turner 1987; Petrie 1984). This is reasonable when dealing with frightened and
476 uncooperative subjects that are easily placed on a scale; but there is both theoretical and
477 empirical evidence that human fighting ability can be better predicted by upper body strength
478 than by body weight. For example, in humans, upper body strength is much more sexually
479 dimorphic than body weight per se (Lassek & Gaulin 2009). Furthermore, analyses of ancient
480 human weapons shows that they all depended on the upper body strength for effectiveness
481 (Brues 1959). Finally, the evolved assessment mechanisms that humans use to estimate fighting
482 ability in others track and respond to cues of upper body strength more so than cues of height,
483 weight or body size generally (Sell et al. 2010, 2011; Sell 2012).

484
485 Therefore, aggressive bargaining in adolescent males should be moderated by fighting ability
486 rather than body size per se. While height bore no zero-order relationship with the global
487 aggression measure ($r = .07, p = .06$), weight did ($r = .15, p = .00003$), as did BMI ($r = .14, p =$
488 $.0001$). To test the predictive power of our fighting ability measure against body size measures,
489 we ran a simultaneous regression predicting the global measure of aggression from fighting
490 ability and subject's body weight. The effect of fighting ability on aggressive bargaining
491 remained identical (std. Beta = $.26, p < .00001$), while the effect of weight disappeared (std. Beta
492 = $-0.03, p = .95$). Substituting height for weight revealed no effect of height (std. Beta $-.05, p =$
493 $.19$) but a significant effect of fighting ability (std. Beta = $.28, p < .00001$). Similarly, a
494 simultaneous regression with BMI and fighting ability showed no significant effect of BMI on
495 global aggression (std. Beta = $.03, p = .47$) but a significant effect of fighting ability (std. Beta =
496 $.25, p < .00001$). Finally, a series of regressions were run with all possible combinations of
497 height, weight, BMI and fighting ability predicting the global aggression measure. Fighting
498 ability was always a significant predictor, and no body size variable was ever significant when
499 fighting ability was in the model. Fighting ability – rather than body size *per se* – is predicting
500 aggressive bargaining.

3.2. Core hypothesis #2: Is fighting ability less predictive of aggression among adolescent females?

Yes. While Table 3 shows a significant relationship between fighting ability among adolescent females and the seven aggressive bargaining measures, the size of that relationship is less than that of males for every scale. Most importantly, the Fisher r-to-z transformation test of significance between the correlations reveals that the male correlation between fighting ability and the global aggression measure is significantly higher than the female correlation between fighting ability and global aggression, $z = 1.93$, $p = .05$.

As with males, the effect of fighting ability in females was primarily driven by the self-reported fighting ability subcomponent. When all three components of the fighting ability scale were entered into a regression predicting global aggression, only self-reported fighting ability accounted for unique variance: std. Beta = .15, $p = .006$, while biceps circumference (std. Beta = .01) and self-reported strength (std. Beta = .04) became non-significant.

The following analyses test aspect of core hypothesis #2 and are performed on only the females in the sample.

3.2.1 Is the relationship between fighting ability and aggression the result of self-report bias?

Possibly. Unlike males there was no evidence that females exaggerated their fighting ability or physical strength (means = 47.8 and 49.1 respectively). Nonetheless, there was no significant relationship between the two objective measures of fighting ability and aggressive bargaining: flexed biceps circumference and teacher ratings of aggression: $r = .05$, $p = .22$.

3.2.2 Are the results compromised by steroid-users?

No female reported steroid use.

3.2.3 Are these relationships the result of co-variance with lack of self-control, dysfunction, cynicism or distrust?

No. In general there was no significant relationship between fighting ability in females and control variables including the optimism scale, competent conflict coping and legal cynicism. There was a small negative relationship between fighting ability and general trust ($r = -.09, p = .02$) and self-control ($r = -.08, p = .04$). Regardless, as with males, when all of these covariates were put in a simultaneous regression analysis predicting the global aggression measure, fighting ability remained a significant predictor: std. Beta = .13, $p < .00001$.

3.2.4 Is the effect the result of differential maturity between weaker and stronger females?

No. A simultaneous linear regression was run predicting the global aggression measure from fighting ability, age in months, and the subject's score on the pubertal development scale. Fighting ability remained a significant predictor, std. Beta = .18, $p < .00001$. Age was unrelated to aggression, though there was a small negative relationship with pubertal development, std. Beta = $-.08, p = .04$.

3.3 Core hypothesis #3: Does coalitional strength predict aggressive bargaining in males?

Yes. As can be seen in Table 3, a subject's coalitional strength was a significant predictor of aggressive bargaining for males across all measures. Effect sizes were comparable to that of fighting ability. Furthermore, the global aggression measure was significantly positively correlated with all of the measures of coalitional strength in males: CS1 ($r = .13$), CS2 ($r = .34$), and CS3 ($r = .24$), all $p < .0001$. Additionally, all of the subcomponents of CS2 predicted aggressive bargaining in males, i.e. boys who were members of groups became more aggressive when their groups were large in size ($r = .27, p < .00001$), had existed for a longer period of time ($r = .15, p = .003$), and contained older members ($r = .27, p < .00001$). In summary, boys who reported being part of a coalition were more aggressive than boys who did not. Among those boys who had a coalition, those with stronger coalitions in terms of the average age of its members, its longevity, and size were more aggressive than boys whose coalitions were smaller, made of younger members, and relatively new. Additional measures of coalitional strength are reported in supplemental information and replicate this effect.

562 *3.3.1 Is the relationship between coalitional strength and aggressive bargaining the result of*
563 *self-report bias?*

564 Unfortunately, there are no objective measures of coalitional strength, but one can test against
565 the confounding hypothesis that subjects who exaggerate their coalitional strength also
566 exaggerate their aggression by examining teacher ratings of aggression. The bivariate correlation
567 between coalitional strength (CS3) and teacher ratings of aggression did show a small but
568 significant effect, see Table 3. Furthermore, teacher ratings significantly predicted all three
569 subcomponents of coalitional strength such that boys whose groups were larger ($r = .26, p$
570 $< .0001$), composed of older members ($r = .14, p = .01$), and more long lasting ($r = .16, p = .002$)
571 were rated as more aggressive. Teacher ratings did not, however, significantly predict whether
572 the boy was a member of a group (CS1, $r = .01, n.s.$).

573
574 *3.3.2 Are these relationships the result of co-variance with lack of self-control, dysfunction,*
575 *cynicism, or distrust?*

576 No. Coalitional strength in males predicted slightly lower competent conflict coping ($r = -.09, p$
577 $= .02$), less general trust ($r = -.09, p = .01$), and less self-control, ($r = -.15, p < .0001$). It also
578 predicted more legal cynicism $r = .16, p < .001$. There was, however, no relationship between
579 optimism and coalitional strength, $r = -.04, p = .28$. Regardless, when these co-variables were put
580 in a simultaneous regression analysis predicting the global aggression measure, coalitional
581 strength (CS3) remained a significant predictor: std. Beta = .13, $p < .00001$.

582
583 *3.3.3 Is this effect the result of differential maturity?*

584 No. A simultaneous linear regression was run predicting the global aggression measure from
585 coalitional strength, age in months, and the subject's score on the pubertal development scale.
586 Coalitional strength (CS3) remained a significant predictor, std. Beta = .25, $p < .00001$. Age and
587 pubertal development were unrelated to aggressive bargaining when coalitional strength was in
588 the model.

589
590 *3.3.4 Does fighting ability predict coalitional strength in males?*

591 Yes. Membership in powerful groups can be seen as a resource that boys compete over, and
592 access to a group can be seen as a benefit bestowed only on those whose inclusion benefits the

members of the group. For both of these reasons, it is predicted that boys with more fighting ability will be more sought after as friends and coalition mates, and be better able to insert themselves into groups. Consistent with this prediction, boys with more fighting ability are more likely to report having a coalition (CS1, $r = .15$, $p < .0001$). Furthermore, among only those boys in coalitions, fighting ability positively related to having larger, longer-lived coalitions composed of older members (CS2, $r = .20$, $p = .0001$). Finally, fighting ability is a significant predictor of the combined measure of coalitional strength (CS3, $r = .15$, $p < .0001$).

While these relationships support the general theoretical framework taken here, they also present potential confounds for predictions #1 and #3. The confound can be ruled out by looking for independent effects of fighting ability and coalitional strength on aggressive bargaining.

3.3.5 Do fighting ability and coalitional strength each independently predict aggressive bargaining in males?

Yes. A simultaneous simple linear regression with both fighting ability and coalitional strength (CS3) predicting the global aggression measure showed significant independent effects for both measures: fighting ability: std. Beta = .23, $p < .00001$, coalitional strength: std. Beta = .21, $p < .00001$. Moreover, fighting ability and coalitional strength remained significant independent predictors of the subcomponents of global aggression (with one exception), see Table 4.

Table 4: Simultaneous linear regressions show fighting ability and coalitional strength independently predict aggressive bargaining in boys

	Global Agg.	Teacher Ratings	Self Ratings	Agg. Conflict Coping	Violent Delinq.	Norms of Masc.	Moral Neutral.
Fighting ability (std. Beta)	.23***	.11**	.15***	.17***	.12**	.24***	.21***
Coalitional Strength – CS3 (std. Beta)	.21***	.10*	.19***	.21***	.19***	.06	.12**

* $p < .05$, ** $p < .01$, *** $p < .001$, two-tailed

3.4 Core hypothesis #4: Does coalitional strength predict aggressive bargaining in females?

Generally not. As can be seen in Table 3, female subjects who had stronger coalitions showed more aggressive conflict coping and violent delinquency, however they were not rated as more

aggressive by their teachers or themselves, did not endorse norms of masculinity, morally neutralize violence or score higher on the global aggression measure. Furthermore, Fisher's r -to- z transformation test for significance between correlation coefficients shows that the correlation between coalitional strength (CS3) and global aggression is significantly smaller for female subjects compared to male subjects ($z = 3.31, p = .0005$). In short, coalitional strength – as measured here – is not as powerful a predictor of aggressive bargaining for female subjects. Additional tests are reported in supplemental information.

3.4.1 Does fighting ability predict coalitional strength in females?

No. While females, like males, compete for access to more powerful, higher-status coalitions, they are presumably less likely to use physical fighting ability to gain access to the group and to appeal to the group members for entry. Therefore, fighting ability in females is predicted to be less highly correlated with a female's coalitional strength. Consistent with this, fighting ability was generally not predictive of coalitional strength in females. Females with higher fighting ability were no more likely to have coalitions (CS1), $r = .03, p = .45$, and no more likely to be members of larger, long-lived coalitions with older group members (CS3), $r = .07, p = .06$. Unlike with males, when both coalitional strength (CS3) and fighting ability were put in a simultaneous regression predicting the global aggression measure in females, only fighting ability remained a significant predictor (fighting ability: std. Beta = .16, $p < .0001$; CS3: std. Beta = .06, *n.s.*)

Core hypothesis #5: Does mate value predict aggressive bargaining in males?

Yes. As can be seen in Table 3, males with higher mate value scored higher on every measure of aggressive bargaining. Furthermore, each of the subcomponents of the mate value measure predicted global aggression. Males were more aggressive if they reported being more physically attractive, $r = .17, p < .00001$, being in a romantic relationship, $r = .24, p < .00001$, or having had sex $r = .35, p < .00001$.

3.5.1 Is the relationship between mate value and aggressive bargaining the result of self-report bias?

No. While questions about being in a relationship and having had sex can be lied about, and there is variance in definitions of “romantic relationships” and “sex” that can lead to bias, those questions are less subjective than the question measuring the subject’s physical attractiveness. Therefore, both of these measures were correlated with teacher ratings of aggression to control for some of the error inherent in self-reports. Results showed that these subcomponents of mate value were significantly correlated with teacher ratings of aggression: being in a relationship, $r = .19, p < .00001$, and having had sex, $r = .27, p < .00001$. For completeness: the self-reported measure of attractiveness was also significantly predictive of teacher ratings of aggression, $r = .11, p < .01$.

3.5.2 Are these relationships the result of co-variance with lack of self-control, dysfunction, cynicism, or distrust?

No. Males with more mate value did report less general trust ($r = -.21, p < .00001$), more legal cynicism ($r = .21, p < .00001$), less competent conflict coping ability ($r = -.13, p = .001$), and less self-control ($r = -.30, p < .00001$). However, they were somewhat more optimistic, $r = .09, p = .02$. A simultaneous linear regression model was run to determine whether mate value remained a predictor of global aggression controlling for these relationships. Results showed that the mate value measure was a robust predictor of global aggression, std. Beta = .18, $p < .00001$.

3.5.3 Is this effect the result of differential maturity?

No. Controlling for the subject’s age and pubertal development score did not change the relationship between mate value and global aggression, std. Beta = .36, $p < .00001$.

3.5.4 Do fighting ability and coalitional strength predict mate value in males?

Yes. Mate value in males is predicted to be – partly – a function of their fighting ability and coalitional strength. Female mate choice mechanisms are known to respond to a man’s physical prowess (Fink, Neave & Seydel 2006; Maisey et al. 1999), and his social status (Townsend & Levy 1990); and previous research shows that physical strength in men is predictive of their sexual behavior (Hughes & Gallup 2003). Consistent with this, a subject’s mate value predicted his fighting ability ($r = .31, p < .00001$), his access to a coalition (CS1, $r = .11, p = .002$), his coalition’s strength (CS2 $r = .25, p < .00001$), and the summary coalitional strength measure

(CS3, $r = .19$, $p < .00001$). These results support the general theoretical framework used here, but they also highlight potential confounding variables that could mediate the link between mate value and aggressive bargaining.

3.5.5 Does mate value predict aggressive bargaining in boys when controlling for fighting ability and coalitional strength?

Yes. A simultaneous linear regression was run with each of the three primary independent variables (fighting ability, coalitional strength [CS3] and mate value) predicting global aggression. Results showed that mate value remained a significant predictor: std. Beta = .28, $p < .00001$.

3.6 Core hypothesis #6: Does mate value predict aggressive bargaining in females?

Yes. As can be seen in Table 3, females with higher mate value scored higher on every measure of aggressive bargaining. Furthermore, each of the subcomponents of the mate value measure predicted global aggression. Females were more aggressive if they reported being more physically attractive, $r = .10$, $p = .01$, being in a romantic relationship, $r = .21$, $p < .00001$, and having had sex $r = .17$, $p < .00001$.

3.6.1 Is the relationship between mate value and aggression the result of self-report bias?

Not fully. Mate value was predictive of teacher ratings of aggression (see Table 3), and two of the three subcomponents of the measure also significantly predicted teacher ratings: self-reported attractiveness, $r = .09$, $p = .03$ and being in a relationship, $r = .11$, $p = .006$, but not having had sex, $r = .06$, $p = .12$.

3.6.2 Are these relationships the result of co-variance with low self-control, dysfunction, cynicism, or distrust?

No. Much like male subjects, females with more mate value reported less general trust, ($r = -.13$, $p = .001$), more legal cynicism ($r = .12$, $p = .002$), less competent conflict coping ability ($r = -.08$, $p = .05$), and less self-control ($r = -.25$, $p < .00001$). However, they were no less optimistic ($r = -.05$, $p = .19$). A simultaneous linear regression model was run to determine whether mate value

remained a predictor of global aggression controlling for these relationships. Results showed that the mate value measure was a small but robust predictor, std. Beta = .11, $p = .001$.

3.6.3 Is this effect the result of differential maturity?

No. Controlling for the subject's age and pubertal development score did not change the relationship between mate value and global aggression, std. Beta = .25, $p < .00001$.

3.6.4 Do fighting ability and coalitional strength predict mate value in females?

Somewhat. To our knowledge there is no peer-reviewed evidence suggesting male mate choice mechanisms are calibrated to prefer females with more fighting ability, and there is little evidence that high status in females is appealing to young males (Townsend & Levy 1990). Nonetheless, our data showed that mate value in females was related to fighting ability, $r = .17$, $p < .00001$. Coalitional strength was inconsistently related to mate value in females. Females without coalitions scored no higher or lower than those with coalitions on the mate value measure, $r = .06$, $p = .13$. Those girls in coalitions that were longer-lived, larger and made up of older individuals were more likely to have high mate value (CS2, $r = .12$, $p = .013$). Finally, mate value was positively related to the global coalitional strength measure CS3 ($r = .09$, $p = .01$).

3.6.5 Does mate value predict aggression in girls when controlling for fighting ability and coalitional strength?

Yes. A simultaneous linear regression was run with each of the three primary independent variables (fighting ability, coalitional strength [CS3], and mate value) predicting global aggression. Results showed that mate value remained a significant predictor: std. Beta = .21, $p < .00001$.

3.7 Core hypothesis #7: Do fighting ability, coalitional strength and mate value have independent effects on aggression?

Fighting ability, coalitional strength, and mate value are all components of bargaining power, and are – to some extent – based on common constituent features (e.g. upper body strength in

males is hypothesized to – and in fact does – predict all three). Nonetheless, this overlap is incomplete and each component of bargaining power is predicted to have an independent effect on aggression, and to be independent of body size, age, pubertal development, optimism, cynicism, trust, self-control and competent conflict coping. Two two-step least-squares regression analyses were run – one for male subjects and one for female subjects – predicting the global aggression measure from all three measures of bargaining power (step 1) and then with all control variables added (step 2). Results are shown in Table 5, and reveal that for male subjects all three components of bargaining power are significant independent predictors of aggression. For female subjects only mate value and fighting ability are significant predictors (though see supplementary information for more analyses).

Table 5: Standardized Betas predicting global aggression in two-stage least-squares regression

Predictors	Male subjects		Female subjects	
	Step 1	Step 2	Step 1	Step 2
Fighting ability	.14***	.11**	.13***	.14***
Coalitional strength (CS3)	.18***	.10***	n.s.	n.s.
Mate value	.28***	.14***	.22***	.10***
Age		n.s.		n.s.
Pubertal Development		n.s.		-.10**
Height		n.s.		n.s.
Weight		n.s.		n.s.
Body Mass Index		n.s.		n.s.
Optimism		-.07*		n.s.
Competent Conflict Coping		-.19***		-.21***
Legal Cynicism		.25***		.23***
General Trust		-.10**		-.11***
Self-Control		-.23***		-.27***
R	.42	.68	.28	.64
Adj. R ²	.17	.45	.08	.41

3.7.1 Are these relationships due to extreme scores from subpopulations of children from other countries?

No. Swiss adults are – as measured by conviction rates – among the most peaceful people on the planet. Recorded crime in Switzerland is heavily driven by perpetrators with a Non-Swiss nationality who make up an absolute majority of criminal convicts in the country (Swiss Federal Statistical Office, 2012). If the children of immigrants are more aggressive and differ on measures of bargaining power, then the results here may be invalid as tests of evolved calibration of aggression. There was very limited support for this hypothesis in our data: males born in

Switzerland were slightly lower in global aggression than non-Swiss males (mean difference = .21, SE = .10, $t(747) = 2.3$, $p = .02$), but did not differ significantly on teacher ratings of aggression or any measure of bargaining power. Finally, running the regressions from Table 5 using a truncated sample of only native-born Swiss adolescents did not change the pattern of significance for any measure of bargaining power in either stage of the regression.

3.8 Additional analyses

Additional analyses reported in supplemental information replicate many of the effects above with two different measures of coalitional strength. Further analyses show that individuals with more fighting ability, coalitional strength, or mate value also anticipate fewer negative consequences for using aggression. This was found for both males and females. See supplemental materials for more information.

4.0 General Discussion

The results show that adolescents with more bargaining power are more likely to deploy aggression, harbor aggressive attitudes, and believe in the appropriateness of aggression. Each of the three tested components of bargaining power: fighting ability, coalitional strength and mate value independently predicted aggression in males and females, with one exception: coalitional strength (as measured) did not independently predict aggression in females.

The failure of coalitional strength to predict aggression in females could be an artifact of our measures or a robust finding that illustrates how female aggression and bargaining are regulated. With reference to the first possibility, the effects of coalitional strength for females may have been limited to more indirect aggression, rather than the more direct aggression reported here (Hess & Hagen 2006). Furthermore, the lack of effect may be due to the way coalitional strength was measured: by the number of individuals in the group, its longevity, and the age of the group members. These coalitional traits may be better predictive of a group's aggressive formidability than its ability to coordinate information, functionally exclude others, and otherwise navigate the complex social networks that characterize the lives of adolescent females (Giordano 2003).

Indeed, using a different measure of coalitional strength based on the frequency of activity with friends, females do show a significant relationship between coalitional strength and aggressive bargaining (see supplementary information). This would suggest that coalitional strength is a significant part of female adolescent bargaining power, but would need to be measured in ways that capture the psychological criteria they use.

On the other hand, it may be that coalitional strength in females is actually a much less important aspect of bargaining power. There is substantial theoretical and empirical work that suggests the formation of groups in order to magnify one's bargaining power is, and has been, predominately a male activity (McDonald, Navarrete & Van Vugt 2012; Sidanius & Pratto 2001).

In concluding, there are limitations to this study that should be addressed. For one, the measures of fighting ability, coalitional strength and mate value were – both empirically and theoretically – related. This is not a problem if there is little measurement error, but given the sample size and the limitations inherent in measuring neural networks distributed within and across the brains of large social groups (e.g. “coalitional strength”), we can be reasonably sure that much of the variance in bargaining power remains unmeasured. The conclusions from core hypothesis #7 – that each component of bargaining power has an independent effect on aggressive attitudes – should be treated with caution until it is replicated with different measures on different populations or demonstrated experimentally.

Secondly, bargaining theory predicts that increases in bargaining power should be causally related to increased entitlement, bargaining and aggression. The results from this cohort – so far – are consistent with that theory but cannot provide confirmation that changes in bargaining power *cause* increased aggressive behavior (though see Petersen et al. 2015).

Thirdly, the effect sizes – particularly when controls were entered – were small in size. Many of the controls were highly related to the variables of interest (e.g. legal cynicism correlates with aggressive bargaining at .49 for males and .46 for females; fighting ability was highly predicted by weight in both sexes: $r \sim .60$, and so on). Nonetheless, the zero-order correlations were reasonable in size given the inherent measurement error, and the effects of bargaining power were robust to extensive controls.

Furthermore, the origin of individual differences in bargaining power has not been explained. For example, why aren't all boys physically strong? It is possible that the components of bargaining power result from calibrational mechanisms that respond to ecological circumstances (Tooby & Cosmides 1990). The developmental mechanisms that give rise to these individual differences presumably mediate the tradeoff between current bargaining position and future investment (Kaplan & Gangestad 2005). For example, in adolescent boys, increases in testosterone will generate additional muscle fibers and thicken existing fibers (Kadi et al. 1999), leading to increased fighting ability and mate value, but testosterone inevitably involves costs of other kinds, e.g. risks of starvation from loss of fat (Mårin 1995) and possibly compromising the immune system (Min, Lee & Park 2012, though see Roberts, Buchanan & Evans 2004). Similarly, young women can engage men in sexual relationships which can increase coalitional strength and access to male attention, resources, and bargaining by proxy, but this comes at the expense of long-term mate value (Buss et al. 1990). Thus variables such as future discounting based on expected lifespan (Wilson & Daly 1997) or pathogen load (Thornhill & Fincher 2011), may be higher-order predictors of the components of bargaining power measured here and, thus, aggression.

Finally, these higher order variables presumably have their effect via evolved learning mechanisms that track cues in their local environment; cues that shift over developmental time. This means that we currently do not know how stable these measures of bargain power will be (e.g. a boy could go to the gym and build muscle; a girl could move and enter a more prestigious peer group). Regardless of their stability, the recalibrational theory and basic models of evolutionary biology still predict that humans should be sensitive to their own bargaining power – whatever its source – and their bargaining power should calibrate their aggressive behavior. The data provided here are consistent with that hypothesis.

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