Evolution and Human Behavior 37 (2016) 315–322

Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.ehbonline.org

Original Article

Local competition increases people's willingness to harm others

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ARTICLE INFO

Article history:
Initial receipt 12 April 2015
Final revision received 5 February 2016

Keywords:
Scale of competition
Harming
Contests
Conflict
Hostility
Spite

ABSTRACT

Why should organisms incur a cost in order to inflict a (usually greater) cost on others? Such costly harming behavior may be favored when competition for resources occurs locally, because it increases individuals' fitness relative to close competitors. However, there is no explicit experimental evidence supporting the prediction that people are more willing to harm others under local versus global competition. We illustrate this prediction with a game theoretic model, and then test it in a series of economic games. In these experiments, players could spend money to make others lose more. We manipulated the scale of competition by awarding cash prizes to the players with the highest payoffs per set of social partners (local competition) or in all the participants in a session (global competition). We found that, as predicted, people were more harmful to others when competition was local (study 1). This result still held when people "earned" (rather than were simply given) their money (study 2). In addition, when competition was local, people were more willing to harm ingroup members than outgroup members (study 3), because ingroup members were the relevant competitive targets. Together, our results suggest that local competition in human groups not only promotes willingness to harm others in general, but also causes ingroup hostility.

1. Introduction

Humans and other animals frequently engage in competition, for example over resources or territories, mating opportunities, and social status (Cheng, Tracy, Foulsham, Kingstone, & Henrich, 2013; Dechenaux, Kovenock, & Sheremeta, 2014; Griskevicius et al., 2009). Such competition may be interference (e.g. physical aggression) or exploitative (e.g. use of the same resources at different times) (Cant, 2012). Many of the first studies in the discipline of behavioral ecology were concerned with predicting evolutionarily stable investments in competition in non-human animals, for example based on ecological factors such as resource distribution, and characteristics of the competitors, such as fighting ability (Maynard Smith, 1974, 1982; Maynard Smith & Parker, 1976; Maynard Smith & Price, 1973; Parker, 1974; Riechert, 2013). This logic has successfully been applied to human interactions to predict when people should engage in costly conflict with others (DeScioli & Wilson, 2011).

Much of the previous research on competition has focused on how the costs of competition can be *avoided*, for example due to conventions of resource ownership or to honest signals (Bradbury & Vehrencamp, 2011; Maynard Smith & Harper, 2003; Zahavi, 1975). However, it is clear that in many situations, costly competition does indeed occur in humans (Frank, 2012; Griskevicius et al., 2009; Hauser, McAuliffe, & Blake, 2009; Jensen, 2010; Simunovic, Mifune, & Yamagishi, 2013; Zizzo, 2003; Zizzo & Oswald, 2001) and other organisms (Cant, English, Reeve, & Field, 2006; Gardner & West, 2004a; Gardner, West, & Buckling, 2004; Inglis, Gardner, Cornelis, & Buckling, 2009; Keller & Ross, 1998; Le Boeuf, 1974; Wilson & Wrangham, 2003). In these cases, an actor pays a cost to inflict a (usually greater) cost on one or more recipients; the costs are paid in any currency, such as food intake or somatic condition, that normally impacts an individual's lifetime fitness.

Here we investigate why people are willing to engage in costly harming behavior. We use this term to refer to cases where both the actor and recipient incur short-term costs, such as physical costs from fighting or social costs from gossip. For present purposes we do not examine behavior where the actor retaliates for the recipient's past actions, i.e. not "revenge" or "punishment" (Jensen, 2010; Raihani, Thornton, & Bshary, 2012), and we also note that harming (or other types of conflict) is not simply the absence of cooperation (Brewer, 1999; Strassmann & Queller, 2010). Specifically, we address how the fitness payoffs of costly harming vary according to the scale of competition. The scale of competition is defined as the extent to which individuals compete with neighbors (for example, in social groups) versus with members of the broad population (Gardner & West, 2004b; West et al., 2006). At one extreme, when competition is local, individuals compete only with social partners in close proximity, as in a spatially structured population. At the other, when competition is global, individuals compete with the entire population and not just with their immediate social partners.

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http://dx.doi.org/10.1016/j.evolhumbehav.2016.02.001
1090-5138/

1.1. Fitness payoffs of harming others

An organism's fitness is determined by its genetic contribution to the next generation in a given environment; competition among individuals (via interference or exploitation) over resources that affect fitness can ultimately be translated into alleles competing for transmission to the next generation. Here, we focus on individuals' direct fitness, often defined as the number of grand-offspring that an individual produces (Davies, Krebs, & West, 2012). When considering selection for a behavior or any other trait, we consider the effects of that trait on an actor's fitness, and compare the actor's fitness to the fitness of the members of the population with whom the actor competes (Fisher, 1930; Haldane, 1932; Wright, 1931). In some populations, individuals only compete with a subset of other members of that population, for example if dispersal is limited or there are geographic barriers to movement. That is, these "structured populations" consist of patches of individuals that compete with each other over resources within each patch but not over resources on other patches (Johnstone, 2008; Taylor, 1992; Wilson, Pollock, & Dugatkin, 1992). In patch-structured populations, an individual's fitness is strongly influenced by its success relative to local competitors within its patch.

When direct fitness depends on success relative to local competitors, it can be beneficial to inflict a cost on those competitors, even at an absolute cost to the actor. That is, when competition is local, costly harming may decrease the actor's absolute payoffs, but it may ultimately increase the actor's payoffs relative to close competitors', and thus increase the actor's overall lifetime direct fitness (Foster, Wenseleers, & Ratnieks, 2001; Gardner & West, 2004b; Johnstone, 2008). Because both actors and recipients incur a cost, the costly harming behavior that we study here is sometimes referred to as "spite" (Gadagkar, 1993; Jensen, 2010). However, because it can allow an actor to outcompete a neighbor and translate a short-term cost into a lifetime direct fitness benefit to the actor itself, such costly harming is not typically called true evolutionary spite (Foster et al., 2001; Gardner & West, 2006; Krupp, 2013).

A simple numerical example illustrates how the scale of competition affects harming: imagine a population of 10 individuals, each of which has 3 units of some currency that translates into fitness. Suppose first that the population is structured into 5 isolated patches of resources, each containing two competing individuals (local competition). Finding an individual's reproductive success in a structured population requires two steps: first, we determine an individual's within-patch fitness by comparing her payoff to her patch-mates' (i.e. her local competitors); and second, we compare that individual's within-patch fitness to the within-patch fitness for all members of the population across all patches. So if A spent 1 unit to reduce B's payoff by 2 units, this would result in a 2:1 within-patch fitness advantage for A, compared to a 1:1 ratio if A had not harmed B. If individuals on other patches do not harm each other (and thus each has a 1:1 within-patch fitness ratio), A's within-patch fitness is high relative to the rest of the population. Harming is thus beneficial to A under local competition.

In contrast, if competition occurs against the broader (global) population, the benefit of outcompeting local interactants via costly harming will not outweigh its cost. To illustrate this, now we imagine that the 10 individuals instead live in an unstructured population. In this case, all individuals can access all the resources and not just local ones, i.e. all members of the population compete globally. To find an individual's reproductive success in a population without structure, we simply compare her payoffs to the payoffs of all others in the population. If A spent 1 unit on making B lose 2, this harmful act would mean she has 2 units relative to 25 held by all 9 others in the population. If she had not harmed B, she would have 3 units relative to the 27 held by all 9 others. A is thus relatively better off if she does not invest in harming B, because harming B does not increase A's reproductive success (2:25 fitness advantage from harming versus 3:27 from not harming) when competition is global.

This shows why individuals should adopt different strategies regarding costly harming behavior in different competitive situations (Gardner & West, 2004b; see also Supplementary material, available on the journal's website at www.ehbonline.org), for example when competing locally in spatially structured populations (Rand, Armao, Nakamaru, & Ohtsuki, 2010). As humans likely encounter both local and global competition within their lifetimes, one should expect human psychology to have evolved to respond to cues of local competition with more harmful behavior, as this has direct fitness benefits, and to be less harmful when such cues are absent. For example, one would predict that people will assess how many others they compete with over a given resource, and incur greater costs to harm any single given competitor if there are few competitors than if there are many competitors (Garcia & Tor, 2009).

1.2. Evidence for the effects of the scale of competition

There is some empirical evidence to suggest that local competition does foster costly harming in non-humans (Bshary & Bergmüller, 2008; Foster et al., 2001; Gardner & West, 2006; Krupp, 2013; Muir, 1996; West & Gardner, 2010). Virulent bacteria produce antimicrobial chemicals (bacteriocins) which kill close competitors, but whose production is also costly for the producer (Riley & Wertz, 2002). Bacteriocin production increases with the proportion of competition occurring locally (Chao & Levin, 1981; Gardner et al., 2004; Inglis et al., 2009). In the parasitoid wasp *Copidosoma floridanum*, some individuals develop as sterile soldiers that attack their siblings (Gardner, Hardy, Taylor, & West, 2007; Giron, Dunn, Hardy, & Strand, 2004). However, competition is likely always local (Gardner & West, 2004a), and in general few studies have manipulated the scale of competition explicitly. Similarly, the scale of competition was not addressed in other empirical studies of costly harming, e.g. in *Wolbachia* bacteria (Hurst, 1991), a green-beard gene in *Solenopsis invicta* fire ants (Keller & Ross, 1998), social insect worker policing and sex ratio manipulation (Foster et al., 2001; Gardner & West, 2004b), and sperm of *Fusitriton oregonensis* snails (Pizzari & Foster, 2008). Thus, while there is evidence from various taxa that costly harming behavior exists, there are no explicit tests of the effect of the scale of competition, and no studies in humans.

1.3. Overview of the present research

In a set of three studies, we tested the prediction that people will be more willing to incur costs to harm others when competition is local than when it is global, and in doing so, obtain higher payoffs. We provide a game theoretic illustration of this prediction in the Supplementary material (available on the journal's website at www.ehbonline.org). Our empirical test was a laboratory economic game where each player could harm two partners by spending money from her own endowment to make each partner lose four times that amount (Abbink & Herrmann, 2011; Abbink & Sadrieh, 2009; Zizzo & Oswald, 2001). Players competed to be the highest earner within sets of three partners who could harm each other (local competition) or among all sets of participants in the experimental session (global competition). A potential issue with such games is that people may behave differently with money they have just been given arbitrarily than with money that they have earned (Harrison & El Mouden, 2011; Zizzo, 2004). One could predict that a person would be less willing to spend her own money on reducing others' when she and others have earned their money. We tested this prediction in study 2, where participants had to complete short tasks before receiving their endowments.

In these two studies, people had the option to harm two social partners, who were also their competitors in local competition. One would expect that if people had the opportunity to also harm other players, the predicted increase in harming under local competition should be targeted toward those local competitors, and not toward other players. Although people tend to behave more favorably to perceived neighbors

and with more hostility toward others (Bernhard, Fischbacher, & Fehr, 2006; Fehr, Bernhard, & Rockenbach, 2008; Hewstone, Rubin, & Willis, 2002; Tajfel, 1982), we predict that local competition should override any such "parochial altruism". We tested this prediction in study 3, where each participant was grouped with two people with whom she competed locally, but could also harm people in the other groups in the experimental session.

2. Study 1: basic money-burning

We used a "money-burning" game (Abbink & Herrmann, 2011; Abbink & Sadrieh, 2009; Zizzo & Oswald, 2001) to quantify people's willingness to pay a cost to harm others: people could choose to spend any amount of an initial endowment to reduce others' endowments by four times that amount. Similar games have previously been used to investigate costly fighting (DeScioli & Wilson, 2011) and punishment (Fehr & Fischbacher, 2004). Our game additionally incorporated the scale of competition by offering bonus payoffs to the highest-earning participant(s) per set of three social partners or across all the participants in a session (West et al., 2006). That is, the number of competitors changed with the scale of competition: in local competition, participants were competing against two other people whom they could harm, whereas in global competition, participants were competing against their two partners plus the six other people in the room (i.e. eight people in total).

2.1. Study 1 methods

This study took place at the University of Arizona, Tucson, USA. We recruited 54 participants (26 female and 28 male; mean age 24.24 years ± s.e. 1.47 years) by advertising on the University of Arizona and Pima Community College campuses and on community notice boards in Tucson. Participants received endowments in US dollars, and used pens and paper to make their decisions during the game. Participants were separated by screens so that decisions were anonymous, and were identified by code numbers that participants drew out of a hat. All experimental procedures were approved by the University of Arizona Institutional Review Board.

Each experimental session consisted of nine participants divided into groups of three partners. Participants were told they each had an endowment of US $10, and that they could choose how much to keep and how much to invest in "burning" the money kept by each of their two partners. That is, a "group" consisted of players who could harm each other (i.e. "partners"). ("Burning" was called "elimination" in the game to avoid framing problems (Zizzo & Oswald, 2001).) Every cent spent on burning another player's money reduced that player's earnings by four cents. The game consisted of a single round of money-burning, and participants made separate decisions about how much to burn each other player: that is, instead of deciding on a single amount that was divided equally between the two other players, participants could spend different amounts on each of their two partners. All players made their decisions simultaneously, did not know the identities of those they were burning, and could not retaliate or otherwise interact again with others.

After the round of money-burning, a participant's earnings would be the amount of her $10 endowment that she initially kept minus four times the amount that each of her two partners had spent on burning her money. In addition, three high-earning participants received a bonus of US $10, according to the experimental condition. In the local competition condition, the participant from each set of three partners with the most amount of money remaining won the prize, whereas in the global competition condition, the three participants among the total of nine players with the most money remaining received the bonus (West et al., 2006). If there was a tie between two or more people, the $10 bonus was divided equally between those players. Participants in a given session experienced only one of these two experimental conditions (i.e. a between-subjects design). Participants were fully informed before the experiment how the bonuses would be awarded in their particular session, and were tested on their understanding prior to making any decisions. At the end of each session, participants filled out a questionnaire on demographic and personality data, and were given a US $5 show-up payment, plus the money they made from the game. We ran 6 sessions of this study, i.e. 3 with global competition and 3 with local competition.

We analyzed all data using R version 2.15.1 (R Core Team, 2012). Because the data were not normally distributed, we used non-parametric statistical tests, and present the medians and interquartile ranges (parametric statistics for all data are included in the Supplementary material, available on the journal's website at www.ehbonline.org). In both conditions, people could burn their two partners, so we analyzed the average amount spent burning each of these partners (i.e. the total amount spent on burning, divided by two).

2.2. Study 1 results

Participants spent significantly more on burning each partner's money under local competition than global competition (Wilcoxon rank sum test: $W = 213.5$, $p = 0.009$, Cohen's $d = 0.80$; local median = $1.50, interquartile range = $1.50; global median = $0.60, interquartile range = $0.78; Fig. 1). In fact, participants in the local competition condition tended to burn each other's entire $10 endowment: spending $1.50 on average to burn each of two other people means spending $3 in total, and having one's own endowment reduced by both of one's competitors by $12.

When a participant's entire endowment was burned, she received $0 from her endowment, and her only earnings were her show-up payment and a share of the bonus money. This happened to the majority of participants (24 out of 27) in the local competition condition, but significantly fewer (11 out of 27) in global competition ($\chi^2 = 11.69$, $p < 0.001$). Overall, earnings from endowments were significantly lower in the local competition condition than the global competition condition ($W = 558.5$, $p < 0.001$, Cohen's $d = 1.22$; local median = $0.00, interquartile range = $0.00; global median = $2.50, interquartile range = $7.05).

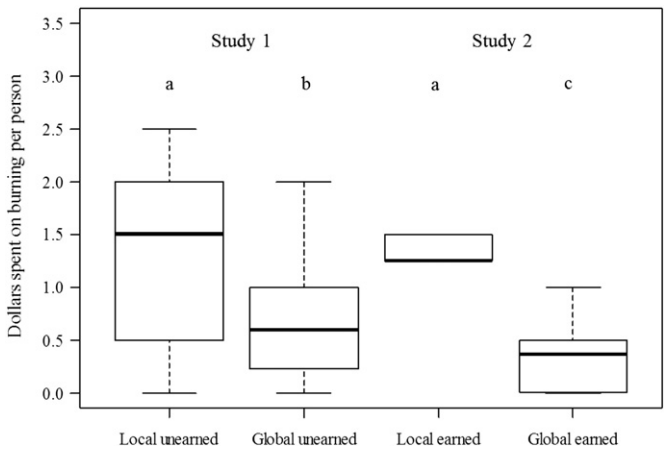

Fig. 1. The mean amount spent on burning each partner's money was significantly higher when competition was local compared to global, regardless of whether the money was simply given to participants (study 1) or "earned" by doing a short task (study 2). Under global competition, people spent less on burning when money was earned than when money was unearned, but this was not the case under local competition. Because these are the amounts spent burning each other person, the 4:1 burning ratio in the experiment means that participants in local competition usually had no money left in their endowments. Boxes show the interquartile range, and lines show 1.5 times the range. Letters denote significant differences.

2.3. Study 1 discussion

Study 1 tested the prediction that people will be more willing to harm partners when competition is local rather than global (see Section 1.3 and Supplementary material, available on the journal's website at www.ehbonline.org). The results support this prediction: participants spent more on burning their partners' endowments when they were competing for a bonus prize with partners only (local competition) than with all the participants in the room (global competition). This is because, despite paying an absolute cost (at least temporarily) in some currency, an actor who harms a local competitor will gain a relative advantage compared to that competitor, but not compared to the global population. As competition becomes more local (i.e. fewer competitors: neighboring interactants or group members only), payoffs *relative* to those neighbors are more important. Thus, costly harming behavior (exemplified by money-burning in our experimental game) may be favored because it potentially allows an individual to outcompete others (Gardner & West, 2004b).

3. Study 2: earned endowments

One could explain people's willingness to burn others' money in study 1 from the fact that participants were given money by the experimenter to use during the game, and that they might not be so willing if they were spending their own money (Clark, 2002; Levitt & List, 2007). For this reason, we carried out a second study where participants had to "work" to receive their endowment (Harrison & El Mouden, 2011), by completing a numerical task before playing the money-burning game.

3.1. Study 2 methods

The money-burning game and scale of competition were implemented exactly as in study 1 (see Section 2.1). However, before being given the US $10 endowment, participants were informed they would have to "earn" it by completing two tasks (Harrison & El Mouden, 2011): they had to 1) complete a number-searching task by finding two numbers in a matrix that added up to ten (Mazar, Amir, & Ariely, 2008), and 2) answer a set of arithmetical questions about the decisions they would be making during the game (these were identical to the practice questions that participants in study 1 answered before they were automatically given their endowments). After a player showed the experimenter her correct answers to these tasks, she was told that she had earned $10, any amount of which she could choose to keep or invest in eliminating others' $10 endowments.

We recruited 36 participants (19 female and 17 male; mean age 23.11 years ± s.e. 1.13 years) from the University of Arizona, Pima Community College, and the Tucson community, as in study 1 (see Section 2.1). Participants similarly made anonymous decisions using pens and paper, and the study was approved by the University of Arizona Institutional Review Board. We ran 4 sessions of this study, i.e. 2 global and 2 local competitions. We analyzed all data using R version 2.15.1 (R Core Team, 2012). As in study 1, we calculated the average amount spent to burn each of the other two partners (see Section 2.1).

3.2. Study 2 results

Participants spent significantly more on burning each partner's money under local competition than global competition (Wilcoxon rank sum test: $W = 44.5$, $p < 0.001$, Cohen's $d = 1.67$; local median = $1.25, interquartile range = $0.25; global median = $0.37, interquartile range = $0.49; Fig. 1). This corresponds to the result from study 1 (see Section 2.2). Similarly, significantly more participants in the local competition condition received $0 from their endowments (14 out of 18) compared to participants in global competition (0 out of 18; $\chi^2 = 19.75$, $p < 0.001$). As in study 1, earnings from endowments were significantly lower in the local competition condition (median = $0.00, interquartile range = $0.00) than global competition (median = $6.71, interquartile range = $3.44; $W = 317$, $p < 0.001$, Cohen's $d = 2.91$).

To compare studies 1 and 2: When competition was global, participants spent significantly less on burning each partner's money when they earned their endowments in study 2, rather than were given their endowments in study 1 ($W = 333.5$, $p = 0.036$, Cohen's $d = 0.69$; Fig. 1). However, there was no difference in the amounts spent on burning in each study when competition was local ($W = 253.5$, $p = 0.815$, Cohen's $d = 0.02$).

3.3. Study 2 discussion

Study 2 investigated whether people's willingness to burn others' money was an artifact of being given endowments by the experimenter, as opposed to feeling ownership over money that was earned. We found that the result from study 1 – that people spent more to harm others under local versus global competition – held even with earned endowments, suggesting that using unearned endowments was not problematic in these experiments (Clark, 2002; Harrison & El Mouden, 2011). The effect of the scale of competition was in fact bigger when people used earned versus unearned endowments: under global competition, participants burned less money when it was earned, but under local competition, participants burned just as much as when they were given unearned endowments. This is likely because, when competition was global, people were hesitant to spend money that they had "worked" to obtain or to take away money that "belonged" to others, but this motive was overridden when competition was local, because the benefit of money-burning was higher.

4. Study 3: ingroups and outgroups

In studies 1 and 2, each participant only had the option to burn endowments of the two partners with whom she also competed when competition was local. What happens if one can burn the money of anyone in the population, regardless of whether one is competing with them? We investigated this in Study 3.

4.1. Study 3 methods

This study took place at the University of Guelph, Canada, recruiting from the psychology department participant pool. Participants received endowments in Canadian dollars, and played the game on computers programmed with z-Tree software (Fischbacher, 2007). As in studies 1 and 2, participants were separated by screens and made anonymous decisions, identifiable only by code numbers. These procedures were approved by the University of Guelph Research Ethics Board.

The money-burning and scale of competition procedures were identical to those in studies 1 and 2 (see Sections 2.1 and 3.1). In addition, each session in study 3 began with a group task, using similar number-searching matrices to study 2 (Mazar et al., 2008). Participants could share solutions with their two group members, who could then count those solutions for themselves. All group members were paid CAN $0.10 for each matrix solved by anyone in the group: thus, participants benefited from sharing answers with group members. This task was intended to delineate sets of players who would later compete locally (this was not necessary in studies 1 and 2 because sets of local competitors were defined by players who could harm each other; this could not work in study 3 because players could harm anyone in the session), as well as to foster a sense of group membership. We term the people in a focal player's group "ingroup members" and others in the room "outgroup members".

After this group task, participants played the money-burning game as in studies 1 and 2, with one difference. Instead of being limited to burning money of only the two other players in her group (i.e. the people competing with each other when competition was local), a participant could choose to burn money of any of the other eight players in

the session. That is, participants made eight separate decisions about how much to burn each other player. Participants were aware of the money-burning game and the potential bonuses they could be awarded before they played the group task.

We ran 8 sessions of this study (4 global and 4 local competition) with 72 participants (56 female and 16 male; mean age 19.04 years ± s.e. 0.40 years). One session was interrupted by a computer error, but excluding this from the analyses did not qualitatively change the results. We analyzed all data using R version 2.15.1 (R Core Team, 2012). As in studies 1 and 2, we calculated the amounts spent burning each person (i.e. each of two other ingroup members plus each of the six outgroup members). Note that because study 3 differs in key respects from studies 1 and 2 (promotion of group membership with a pre-game task, implementing the experiment on computers, different study population), we cannot compare the results of study 3 to those of studies 1 and 2. Instead, we compare people's decisions within study 3 to burn ingroup versus outgroup members under local versus global competition. In the Supplementary material (available on the journal's website at www.ehbonline.org), we present the results of an additional experiment (study 4) that addresses the increase in the number of partners who could be harmed in study 3 compared to studies 1 and 2.

4.2. Study 3 results

People spent significantly more on burning each other person's money when competition was local than when it was global (Wilcoxon rank sum test: $W = 408.5$, $p = 0.006$, Cohen's $d = 0.84$; local median = \$0.25, interquartile range = \$0.49; global median = \$0.02, interquartile range = \$0.19). This resulted in lower earnings when competition was local versus global ($W = 1105$, $p < 0.001$, Cohen's $d = 1.71$; local median = \$0.00, interquartile range = \$2.19; global median = \$6.14, interquartile range = \$1.35). 23 out of 36 participants experiencing local competition had remaining endowments of \$0, compared to only 1 out of 36 participants experiencing global competition ($\chi^2 = 27.56$, $p < 0.001$). These findings corroborate the results of studies 1 and 2 (see Sections 2.2 and 3.2), despite the methodological differences and different study population.

The higher burning under local versus global competition was due to increased burning of each ingroup member's money ($W = 371.5$, $p = 0.001$, Cohen's $d = 0.89$; local median = \$0.50, interquartile range = \$1.32; global median = \$0.00, interquartile range = \$0.10; Fig. 2). There was no change in burning each outgroup member's money under local versus global competition ($W = 790.5$, $p = 0.089$, Cohen's $d = 0.05$; local median = \$0.00, interquartile range = \$0.12; global median = \$0.02, interquartile range = \$0.18; Fig. 2).

To test for ingroup hostility, we can compare the burning of ingroup members versus outgroup members for a given scale of competition. Consistent with our prediction, participants spent significantly more on burning ingroup members' money than outgroup members' when competition was local: this is true whether we analyze the total spent on burning ingroups and outgroups ($W = 870.5$, $p = 0.008$, Cohen's $d = 0.63$; ingroup median = \$1.00, interquartile range = \$2.65; outgroup median = \$0.00, interquartile range = \$0.70) or the amount spent burning each individual ingroup or outgroup member ($W = 946.5$, $p < 0.001$, Cohen's $d = 0.89$; Fig. 2). By contrast, when competition was global, participants spent significantly more in total on burning outgroup members' money than ingroup members' ($W = 423$, $p = 0.008$, Cohen's $d = 0.65$; ingroup median = \$0.00, interquartile range = \$0.20; outgroup median = \$0.12, interquartile range = \$1.05). This latter effect may look like ingroup favoritism, but could simply be because there were six outgroup members and only two ingroup members, such that the total burning of outgroup members is higher but the per capita burning is not. When we analyze amounts spent burning each other person, there was no difference in the amount spent on burning per person under global competition ($W = 505.5$, $p = 0.093$, Cohen's $d = 0.05$; Fig. 2), possibly because the very low burning under global competition caused a floor effect.

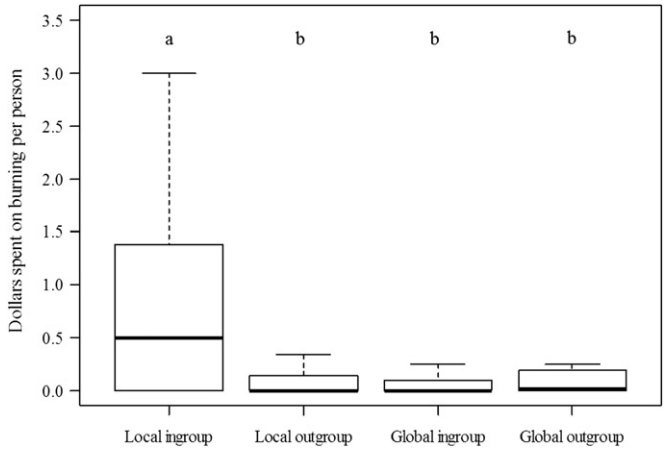

Fig. 2. In study 3, people spent more on burning each ingroup member's money under local competition compared to global, but the scale of competition had no effect on the amount spent burning each outgroup member's money. When competition was local, people spent more on burning each ingroup member than each outgroup member, but there was no such difference when competition was global. (Note that if total amounts spent, rather than amounts spent per person, are considered, participants spent more on burning outgroup members than ingroup members when competition was global.) Boxes show the interquartile range, and lines show 1.5 times the range. Letters denote significant differences.

4.3. Study 3 discussion

The results of study 3 support the prediction that local competition causes an increase in willingness to harm ingroup members (by paying a cost to burn their money) but not outgroup members. This can be explained by the increased benefits of reducing an ingroup member's payoff relative to an outgroup member's when competition is local, because at this scale of competition, success is measured relative to ingroup members but not outgroup members. We also found that, for the same reason, under local competition people spent more on burning each ingroup member than on burning each outgroup member.

Under global competition, people did not spend more to burn the endowments of each outgroup member than each ingroup member. That is, participants did not show the ingroup favoritism found in many other laboratory experiments with arbitrary groups (Efferson, Lalive, & Fehr, 2008; Hewstone et al., 2002; Tajfel, 1982; Tajfel, Billig, Bundy, & Flament, 1971) or in the results from study 4 presented in the Supplementary material (available on the journal's website at www.ehbonline.org). This could be because of floor effects with low burning under global competition, because we fostered ingroup favoritism without any corresponding outgroup hostility (e.g. Brewer, 1999; Duckitt & Mphuthing, 1998), because people are less likely to show ingroup favoritism when allocating negative stimuli (such as harm) to others (Mummendey & Otten, 1998), or because the group task in study 3 was somehow less effective at inducing ingroup favoritism than the "minimal group" tasks in previous experiments (Hewstone et al., 2002; Tajfel, 1982). If the latter, then we have managed to uncover an even more "minimal" group than in previous studies using a "minimal group design". Nevertheless, regardless of the reason, study 3 shows an effect of ingroup hostility fostered by local competition, suggesting that ingroup hostility (more harming of ingroup members than outgroup members) can be created when ingroup members are also one's main competition (see study 4 in Supplementary Material (available on the journal's website at www.ehbonline.org) for a replication of this).

5. General discussion

Under what conditions are people – and other organisms – willing to pay a cost in order to harm competitors, and why is such behavior maintained by natural selection? In three empirical studies (plus a supporting experiment and mathematical model in the supplementary material), we investigated a possible function of costly harming behavior: that it confers a *relative* advantage when individuals are competing with close associates. That is, when competition is local, people are predicted to invest more in harming their competitors. The results of all three studies supported this prediction: people spent more of their endowments on burning others' money in the local competition conditions versus global competition. Put another way, when the number of competitors increases, willingness to inflict costly harm on those competitors should decrease (the "*N*-effect": Garcia and Tor (2009); see game theoretic model in the Supplementary material, available on the journal's website at www.ehbonline.org): this has implications for many situations in the modern world such as politicians competing for votes or businesses competing for customers.

Spending money on burning others' reduces players' absolute payoffs: in fact, in the local competition conditions, most people's endowments were completely eliminated by their own and others' harming behavior. Thus, local competition can lead to a "tragedy of the commons" (Hardin, 1968), an outcome where everyone does worse through wasteful spending on costly competition (Frank, 2012). Many apparently "spiteful" behaviors, where both actor and recipients incur costs, may generally be responses to increase fitness payoffs relative to local competitors (Gardner & West, 2004b).

Study 3 showed that the negative effect of local competition was primarily incurred by ingroup members, rather than outgroup members. It should be noted that our group task did not create strong ingroup favoritism (or at least not the outgroup hostility that often co-occurs, e.g. Brewer (1999), Duckitt & Mphuthing (1998)). Nonetheless, the results of study 3 demonstrate that even where people are generally predicted to either target positive behavior to ingroup members (Hewstone et al., 2002; Tajfel, 1982) or not allocate harm differentially among ingroup versus outgroup members (Mummendey & Otten, 1998), these effects are overridden by local competition, because of the benefits of harming close competitors (Gardner & West, 2004b). This is analogous to kin competition: all else equal, organisms are predicted to cooperate more with closer relatives (Hamilton, 1964), and there is abundant evidence to support this (Abbot et al., 2011). However, when kin are also competing with each other, such cooperation is reduced (Hamilton & May, 1977; West, Pen, & Griffin, 2002).

The present research adds to a growing literature on the importance of the scale of competition in human interactions. For example, people are less willing to contribute money in a prisoner's dilemma game under local competition, because doing so puts the actor at a payoff disadvantage relative to local but not global competitors (West et al., 2006). Similarly, people are more willing to reject unfair offers in an ultimatum game under local competition, as this functions to reduce disadvantages relative to local but not global competitors (Barclay & Stoller, 2014). Our results show that the scale of competition can also explain why people will actively incur a (temporary) cost upon themselves to harm others, because harming one's direct competitors reduces their competitiveness.

5.1. Willingness to harm outside the laboratory

The three studies presented here demonstrate that costly harming is fostered by local competition in a controlled laboratory setting. We expect this result to hold in real-life situations outside the laboratory, wherever local competition is strong enough. One such scenario is academic classes that are graded on a curve. In this case, a student's performance is measured relative to her classmates' performance (local competition), rather than based on her absolute performance (competition is more global). In such classes, each student gets a better final grade if her classmates receive lower interim scores. One would therefore predict that in "curved" classes, students may attempt to improve their grade not only by performing better themselves, but also by reducing the performance of their class-mates, whereas the latter is less likely to happen in classes without curved grades. Such willingness to harm others in curved classes could manifest itself as removing books from the library, or giving class-mates misleading information; the cost to the actor would be time that is not spent studying, or the risk of such behavior being found out.

Another context in which people may be willing to incur a cost to harm competitors is sports contests, as athletes in a given discipline compete locally with each other. One example is the figure skater Tonya Harding's sabotage of her teammate (and competitor) Nancy Kerrigan in 1994. This resulted in costs to both parties: Kerrigan suffered an injured leg, and Harding risked disgrace and a ban from competitions if her role in the attack was discovered (which did indeed occur). Local competition and costly harming may also occur in competition for partners, such as salespeople attracting customers by denigrating their competitors or those competitors' products, or politicians using negative advertising campaigns (which voters often dislike) to make their competitors lose votes. We note that people's willingness to harm on others may be reduced by factors such as social norms suppressing costly conflict or repeated interactions with potential competitors. However, we would still expect people to be more willing to harm others when competition is local versus global, and thus predict more or stronger social norms under local competition, so that these costs will be avoided. In addition, as the examples above demonstrate, social norms and other incentives to not to harm others still do not mean that costly harming will be entirely eliminated, as there may still be net benefits to gaining advantages relative to competitors.

5.2. Limitations and future directions

One aim of the present research was to investigate whether people respond adaptively to variation in the competitive context and thus to changes in incentives for harming others. However, players in economic games may not always make decisions that are optimal for maximizing their payoffs (Kümmerli, Burton-Chellew, Ross-Gillespie, & West, 2010). For example, there is variation among people according to disposition (Peysakhovich, Nowak, & Rand, 2014). The key point is the relative amounts given in the different conditions, not the absolute amounts that people invest. Study 2 addressed one aspect of this: that using "house money" can lead people to make unrealistic decisions. We not only found that the main result still held when using earned endowments, but also that there was an even bigger difference in money-burning between local versus global competition. Money in experiments is an imperfect proxy of reproductive fitness, but does provide a currency that contributes to success on average and is easily measured and implemented (e.g. Barclay & Benard, 2013; Barker, Barclay, & Reeve, 2012; Milinski, Semmann, & Krambeck, 2002).

Players in economic games may exhibit strategic behavior based on the incentives they perceive (Camerer & Fehr, 2006). In our experiments, we overtly manipulated the scale of competition (participants were told how the bonus prizes would be awarded). We are agnostic about the proximate psychological mechanisms underlying our effect, and whether participants are aware of their strategic behavior or whether this occurs unconsciously (or both). The scale of competition that people experience outside the laboratory is likely to vary across time and space as people interact with different competitors over different resources. Thus, it is most likely that our psychology has evolved to be sensitive to cues of the scale of competition and to respond accordingly; an explicit strategic incentive is merely a very strong cue. When there is more error and selection is weaker, costly harming can evolve even when competition is global (Rand, Tarnita, Ohtsuki, & Nowak, 2013).

How do people recognize fluctuations in the scale of competition, and what cues do we use to assess them? Likely cues are the number of competitors (Garcia & Tor, 2009), and one's similarity and proximity to them (Kilduff, Elfenbein, & Staw, 2010). Future work could investigate this further by incorporating more implicit manipulations than the different bonus prizes we used in our studies. If the benefit of winning or cost of losing the competition is high, we would predict that people would be sensitive even to very subtle cues of the scale of competition. Future research could also investigate which specific emotions are involved in people's motivations to engage in costly harming of others, such as the desire to come first in a competition, or feelings of dislike toward one's competitors.

The payoffs of costly harming behavior are likely to be affected by many additional factors, such as the relatedness between interactants (decreased harming when relatedness is higher), the anticipated length of future interactions (decreased harming in longer interactions), social norms related to harming others (leading to decreased harming), the value of winning (increased harming for more highly valued prizes), or the presence of third parties observing people's behavior (increased or decreased harming, depending on whether the actor seeks to deter competitors or attract partners). These predictions could be tested experimentally, for example by allowing third parties to know people's reputations for costly harming. The effect of unequal endowments on willingness to harm is another important direction for future studies. Researchers could also investigate whether local competition similarly promotes costly harming behavior in non-human organisms: if it were shown that the scale of competition had a similar effect on costly harming behavior in organisms ranging from bacteria (as has been suggested: (Gardner et al., 2004; Inglis et al., 2009)) to humans, this would be a powerful demonstration of principles that apply not just to one particular group, but across the taxonomic spectrum.

Supplementary Materials

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.evolhumbehav.2016.02.001.

Acknowledgements

This study was funded by National Institutes of Health grant 5K12GM000708-13 and Social Sciences and Humanities Research Council grant 430115. We thank Raymond Kwong, Kellen Fortier, Jed Tanada, Salina Castillo, Cameron Wilson and Amanda Sarcevich for assisting with experiments, and Caitlin Stern, Daniel Krupp and anonymous reviewers for valuable comments on the manuscript.

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