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The language of cooperation: shared intentionality drives variation in helping as a function of group membership

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While we know that the degree to which humans are able to cooperate is unrivalled by other species, the variation humans actually display in their cooperative behaviour has yet to be fully explained. This may be because research based on experimental game-theoretical studies neglects fundamental aspects of human sociality and psychology, namely social interaction and language. Using a new optimal foraging game loosely modelled on the prisoner's dilemma, the egg hunt, we categorized players as either in-group or out-group to each other and studied their spontaneous language usage while they made interactive, potentially cooperative decisions. Both shared group membership and the possibility to talk led to increased cooperation and overall success in the hunt. Notably, analysis of players' conversations showed that in-group members engaged more in shared intentionality, the human ability to both mentally represent and then adopt another's goal, whereas out-group members discussed individual goals more. Females also helped more and displayed more shared intentionality in discussions than males. Crucially, we show that shared intentionality was the mechanism driving the increase in helping between in-group players over out-group players at a cost to themselves. By studying spontaneous language during social interactions and isolating shared intentionality as the mechanism underlying successful cooperation, the current results point to a probable psychological source of the variation in cooperation humans display.

1. Introduction

Humans cooperate with unrelated individuals to an unprecedented degree. The amount and complexity of cooperation humans engage in exceeds that in other species. This is related to our willingness to punish defectors [1,2] and the importance we give to reputational effects [3,4]. There is increasing evidence that strong between-group competition is a key ecological factor that selected for such extreme cooperation [5,6]. This conclusion is consistent with a large literature in social psychology that has documented in-group bias, or favouritism shown to members of one's own group, across a range of behaviours (e.g. [7,8]), even extending to increased cooperation within groups that are randomly formed [9].

However, the ubiquitous variation in human cooperation is less well understood. From previous research, it seems that variation in cooperation could stem from many factors, from cultural differences to degree of understanding of the games or methods used. For instance, in public goods games in which people must decide how much of their private funds to donate to a shared public pool, cooperation varies as a function of both culture and understanding. That is, people from cooperative cultures contribute more than those from less cooperative cultures [10], while a lack of understanding of the rules of the game, that is, how to maximize one's monetary benefit, also leads to increased contributions [11].

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Differences in social learning rules across cultures may potentially explain this variation [12,13], but the proximate psychological processes that function to actually produce this variation in cooperation are not well defined.

Although they are clearly crucial mechanisms, the ways in which psychological capacities affect actual cooperation are less well understood. Most studies on psychological capacities involved in cooperation have either included said psychological states in models of cooperation (for a review see [14]) or assessed the correlation of certain psychological states or abilities with cooperation at a later time. For instance, 'theory of mind', or our ability to reason about others' mental states, has been incorporated into models predicting when agents will cooperate based on their knowledge of others' belief states. These models allow for the possibility that players in cooperative games are motivated not only by a rational drive to increase their monetary reward, but also by beliefs about and sympathy for the other players (e.g. [15]). Theory of mind also correlates with the degree of cooperation children engage in: those who can pass a typical false belief test cooperate more in an ultimatum game [16] and children who are better at ascribing emotions to others offer more in a dictator game [17]. To our knowledge, however, no game-theoretical study has examined how psychological processes influence cooperation in real-time social interactions. This is partly because game-theoretical research designed to assess the impact of social factors on cooperation typically restricts natural face-to-face social interaction (e.g. studies using mechanical turk; for a review see [18]). Even when assessing the effect of social factors like shared group membership on cooperation, many studies use computer-based paradigms with players in isolation (e.g. [19]). Consequently, such research also neglects a fundamentally human capacity: language [20]. Studies that do allow language use often limit it to a window of time preceding potentially cooperative decisions with subsequent games again played in isolated silence (e.g. [21–25], but for an exception see [26]). To our knowledge, no game-theoretical study has both allowed communication during a potentially cooperative task and then assessed the impact of the content of such communication on cooperation. From its simpler to its more complex forms, human cooperation is facilitated by linguistic exchange [27]. It is therefore odd that so many studies opt for cooperation games played in isolation and/or silence.

With these caveats restricting the ecological validity of many paradigms, it is difficult to draw conclusions about the psychological forces that have evolved to facilitate human-specific cooperation. Our aim was to examine cooperative behaviour in a more natural social interaction in order to identify the psychological processes underlying the variation in human hyper-cooperation. A likely process driving our cooperation is shared intentionality [28]. This rather specific human ability allows people to understand that others intentionally act to then share in common goals [29]. Unlike other species, humans have not only a clear understanding that others act intentionally towards goals, but we are also motivated to share these goals and communicate about the coordinated strategies necessary to achieve them. This occurs via mental representations of the 'common ground' (or mutual knowledge) people establish as they coordinate themselves during conversation [27], and specifically with mental representations that encode a partner's intentions and goals as one's own [30]. It is likely that shared intentionality is both necessary and active during effective cooperation as people coordinate to achieve shared goals. Thus, to better understand how human cooperative decisions vary, we aimed to focus on shared intentionality in actual social interactions.

In order to address the issue of ecological validity, we designed the egg hunt, a joint foraging game designed to simulate the conditions under which human hyper-cooperation is thought to have evolved, specifically as a result of collaborative foraging in a social context within groups [31]. To maximize the ecological validity of the task, we used a design in which we manipulated whether players were part of the same group or not and whether they were allowed to talk naturally or not during the hunt. We manipulated group membership in order to standardize the spontaneous categorization that occurs in natural social interactions. As people spontaneously categorize others during natural social interactions as either in-group or out-group relative to themselves based on a variety of factors from gender to age to culture [32,33], the exact type of categorization that occurs in an unstructured interaction is difficult to predict. So by standardizing players' group membership relative to each other we could examine the effects of communication in relation to this key social factor.

In the egg hunt, unisex pairs of players hunted for screws of three colours—red, blue and green—but each individual was only rewarded for either the reds or the blues. Screws were hidden inside small, plastic Kinder Eggs (Ferrero, Alba, Italy). We used a minimal-group paradigm based on responses to a 10-item questionnaire about food preferences to assign pairs to in-group and out-group conditions (but without overtly lying to players about their categorization; see Methods section for complete methods and instructions details). In two separate conditions, pairs were either allowed to talk naturally or forbidden to talk. Players were told to screw any screws they wanted to collect into small, portable boards and that they would be rewarded CHF 1 (approx. USD 1) for either 'each of the red screws collected' or 'each of the blue screws collected', and that no one would be rewarded for green screws. The hunt time was limited to 5 min and players were informed that it would be very difficult to collect all screws of their colour in this time period. As a result, each player could have some success independently but mutual helping would increase payoffs. Crucially, players were not told this, nor were they told that they could collect screws for each other, but instead we observed whether helping would emerge spontaneously. As the hunt ranged around a room of approximately 10 m × 6 m, individual behaviour and speech would have been difficult to record with stationary video cameras. We therefore used eye-tracking glasses to film individual actions on each screw and to record players' communication. Our aim was to assess the degree to which players approached the hunt as a shared activity with common strategies and goals as a function of their relative group membership and the possibility of using language.

2. Methods

(a) Participants

Players were recruited using posters displayed throughout the university and via announcements in various undergraduate courses. Thirty-six males and 102 females took part in the study. This formed a total of 69 pairs of players. Data from 10

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pairs were discarded as players did not follow instructions (they ignored instructions not to talk and conversed prior to the task). All pairs were tested in single sessions lasting approximately 40 min. Experiments were conducted in French (all methods and electronic supplementary information regarding the procedure are provided as translations into English). All players were naive to the experimental hypothesis, gave informed consent and were aware they could leave at any time. They were also told that their data would be treated confidentially and used anonymously in publication. All players were fully debriefed at the end of each experiment, and earned CHF 10 as a show-up fee and up to CHF 20 as a top-up payment as a function of their performance in the experiment. Mean payment was CHF 19.04 (s.e. = 0.25).

(b) Procedure

The experiment was conducted at the Biology Institute at the University of Neuchâtel between 4 February and 31 November 2015. Prior to the experiment, it was confirmed that players did not know each other in any way. The experiment was a 2 × 2 design (in-group versus out-group × talking versus not talking) and players were arbitrarily assigned to each condition before arrival in order to have an equal proportion of males and females in each condition. Players arrived at the laboratory at the same time and were given a consent form with a brief description of the experiment that they were then asked to sign if they wished to participate.

Players were then asked to complete a short questionnaire that gauged their food preferences (see 'Food preferences questionnaire' in electronic supplementary material). The questionnaire consisted of 10 items that asked players for their level of agreement (using a 7-point Likert scale from 'totally disagree' to 'totally agree'). Their responses on the questionnaire, they were told, would be important for the 'purposes of the experiment'. In fact, this questionnaire was the basis of the minimal group paradigm (discussed below) which was used to categorize players into out-group and in-group conditions [34].

Players were then given instructions that were presented automatically via a Microsoft PowerPoint presentation. (see 'Instructions' in electronic supplementary material). Players were told that the aim of the experiment was to study how people make decisions in a physical space in order to maximize their foraging success, and to that end they would be asked to complete a short egg hunt. They were also told they would be asked to give two saliva samples as another goal of the experiment was to study the naturally produced levels of the hormone oxytocin (hormone analysis and results will not be discussed in this paper).

After providing the first saliva sample the minimal group paradigm was conducted. Players were arbitrarily categorized as either an 'apple' or an 'orange'. Importantly, to avoid providing false information, players were never told that this categorization was a direct result of their responses. We simply never explained that there was no actual link between their responses and their categorization. This minimal group paradigm allowed us to form the out-group condition (one 'apple' and one 'orange') and the in-group condition (either two 'apples' or two 'oranges'). Players put on laboratory coats indicating their group (green with an apple on the back and the front pocket for apples, orange with an orange on the back and the front pocket for oranges), which they were told was to help 'the experimenter to see who was what' on the videos. We again did not mention the main function of the laboratory coats, which was to make players' group membership salient to them as they carried out the egg hunt.

Players were then fitted with eye-tracking glasses, which they were told would film their actions during the egg hunt (ETG 2.1 models provided by SensoMotoric Instruments GmbH, Germany). The PowerPoint instructions then informed players that during the egg hunt they would be required to hunt for eggs containing screws of different colours. The eggs used were the yellow plastic eggs found inside the children's chocolate Kinder Eggs, and each had either a red, blue or green screw within. The instructions informed players that one of them would be rewarded for all the red screws collected (at CHF 1 each), one would be rewarded for all the blue screws collected (also at CHF 1 each), and that the green screws were not rewarded. Players were given boards onto which they were told to screw any screws they wished to collect and they were asked to leave the eggs in the same position as they found them. Apart from these requirements, players were told they could carry out the hunt in any way that they felt would allow them to maximize their reward. Importantly, they were never explicitly informed they could collect the other's colour or cooperate in any way, but instead that 'all red and blue screws collected' would be rewarded. They were also informed via the instructions whether they were allowed to talk during the hunt or not.

The egg hunt was carried out in a laboratory room that was approximately 10 m × 6 m and contained nine laboratory tables and one long window-sill surface. At each surface 10 eggs were hidden: two containing red screws, two containing blue screws and six containing green screws (see electronic supplementary material for a laboratory set-up). Players were not told the location or arrangement of any of the coloured screws. Players were told that the egg hunt would commence after a 60 s countdown (during which those in the talking condition were allowed to talk) and that the hunt itself would last 5 min. After the countdown players were let loose in the laboratory and allowed to hunt for eggs and collect screws at will, meaning that they could either track each other's movements and decisions by staying close to the other or hunt at a distance. After the hunt players' screws were counted, they were paid their show-up fee of CHF 10 plus any reward (again, CHF 1 per screw of their own colour), and they were debriefed as to the actual nature of the experiment.

3. Results

(a) Helping behaviour analysis

From the eye-tracking videos we first analysed behaviour directed towards the screws. To assess helping behaviour, we coded players' behaviour each time they found a screw of their partner's colour into one of the three categories: no helping (leaving the egg as found with the partner's screw inside), no-cost helping (leaving the partner's screw visible next to the egg after discovery) and costly helping (taking the time to carry the partner's screw, with or without screwing it into one's own board). This differentiation in helping type was relevant as no-cost helping both cost the helper less in terms of time taken away from their own hunt and helped the target less than costly helping (see electronic supplementary material for complete behavioural coding information). Each category was calculated as a proportion of other's screws found given that players did not find a standard number of each other's screws.

All results presented used the pair as the unit of analysis (see electronic supplementary material for statistical analysis details).

(1) Costly helping. To confirm that costly helping was indeed costly, we assessed whether this type of helping cost players in terms of the amount of screws they collected for themselves. A regression showed that players who engaged in more costly helping collected fewer screws for themselves ($R^2 = 0.13$, $F_{1,134} = 19.94$, $\beta = -0.36$, $p < 0.01$). Next we conducted GLMs to assess the impact of

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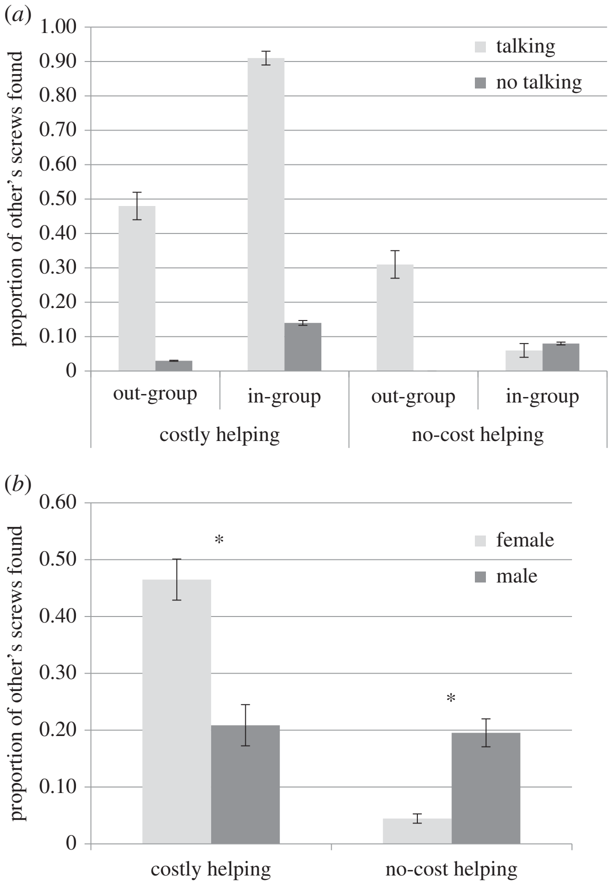

Figure 1. (*a*) Types of helping behaviour (proportions of other's screws found) as a function of group membership and talking (estimated marginal means with standard error bars shown). Showing significant main effects of group membership and talking on costly helping and a significant main effect of talking and an interaction of group membership and talking on no-cost helping. (*b*) Types of helping behaviour (proportion of other's screws found) shown as a function of gender (estimated marginal means with standard error bars shown). Showing significant main effects of gender on both costly and no-cost helping.

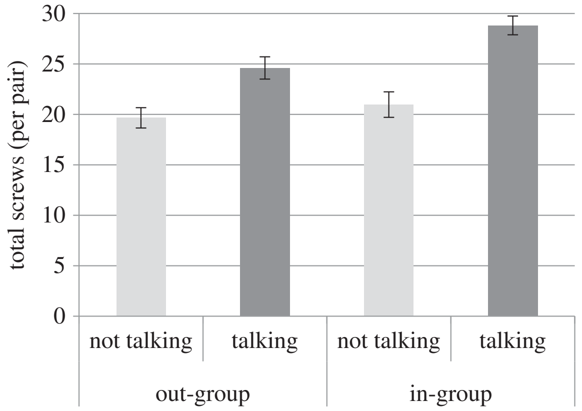

Figure 2. Hunt success (total screws collected per pair), which translated into monetary payoffs, as a function of group membership and talking (estimated marginal means with standard error bars shown). Showing significant main effects of group membership and talking.

group membership and talking on costly helping. In-group membership and talking both led to higher levels of costly helping (group: $\chi^2_{(1,53)} = 15.59$, $p < 0.01$; talking: $\chi^2_{(1,53)} = 70.81$, $p < 0.01$; figure 1*a*) with no interaction between the two ($\chi^2_{(1,53)} = 0.82$, $p > 0.3$). There was an additional main effect of gender in that females did more costly helping than males did ($\chi^2_{(1,53)} = 6.58$, $p < 0.01$; figure 1*b*). Interestingly, players seemed to match each other's costly helping, in that within-dyad rates correlated (Pearson's $r = 0.791$, $p < 0.001$).

(2) No-cost helping. We found a significant interaction between group membership and talking on no-cost helping ($\chi^2_{(1,53)} = 18.79$, $p < 0.01$; figure 1*a*), mainly driven by out-group members doing less in the no-talking condition (EMM = 0) than in the talking condition (EMM = 0.31). Males did also did more no-cost helping than females ($\chi^2_{(1,53)} = 44.24$, $p < 0.01$; figure 1*b*).

(3) Overall success. These effects on helping translated into effects on overall success on the hunt. In-group membership and talking both increased pairs' overall success on the hunt: in-group members and players who could talk collected more screws during the hunt and received correspondingly greater monetary rewards (group: $\chi^2_{(1,53)} = 6.83$, $p < 0.01$; talking: $\chi^2_{(1,53)} = 36.64$, $p < 0.01$; figure 2). There was no interaction of group membership and talking on overall success ($\chi^2_{(1,53)} = 1.89$, $p > 0.2$). In contrast, the observed higher levels of costly helping in females did not translate into a gender difference in overall success: females did not earn more than males did ($\chi^2_{(1,53)} = 0.01$, $p > 0.9$).

(b) Talk analysis

Transcriptions of conversations were segmented into utterances, and each utterance was coded into one of the following categories: (i) shared intentionality talk, (ii) individual goal talk, (iii) task talk or (iv) other talk. (i) Shared intentionality talk consisted of any reference to the hunt in terms of a shared or common goal, which included both planning the shared goal before the hunt (e.g. 'we should collect both colours and trade at the end') and referencing the shared goals during the hunt (e.g. 'I've got one of yours'). (ii) Individual goal talk consisted of any reference to the task in terms of distinctly separate goals that were never shared (e.g. 'you collect your reds and I'll get the blues'). (iii) Task talk consisted of any reference to the practical aspects of the task that involved neither shared nor individual goals (e.g. 'how much time do we have left?). (iv) Other talk consisted of all utterances not falling into the above categories (e.g. 'I am from Neuchâtel'). For complete details of coding criteria see electronic supplementary material.

For the analysis of players' talk, generalized estimating equations revealed effects of group membership and gender on the four types of talk. (i) Shared intentionality talk: in-group members produced significantly more 'shared intentionality talk' than out-group members ($\chi^2_{(1,53)} = 8.46$, $p < 0.01$; figure 3*a*), and there was a trend toward the same in females compared with males ($\chi^2_{(1,53)} = 3.06$, $p < 0.1$; figure 3*b*). Interestingly, a χ^2 test also showed that only in-group members used shared intentionality to explicitly agree upon a mutual hunting strategy prior to the hunt (in that they planned the collection of each other's screws) more than expected ($\chi^2_{(1)} = 5.66$, $p < 0.02$). (ii) Individual goal talk: conversely, out-group members discussed individual goals more than in-group members did ($\chi^2_{(1,53)} = 10.28$, $p < 0.01$; figure 3*a*), as did males compared with females ($\chi^2_{(1,53)} = 10.79$, $p < 0.01$; figure 3*b*). (iii) Task talk: there was a trend towards out-group members engaging in more 'task talk' than in-group members ($\chi^2_{(1,53)} = 3.05$,

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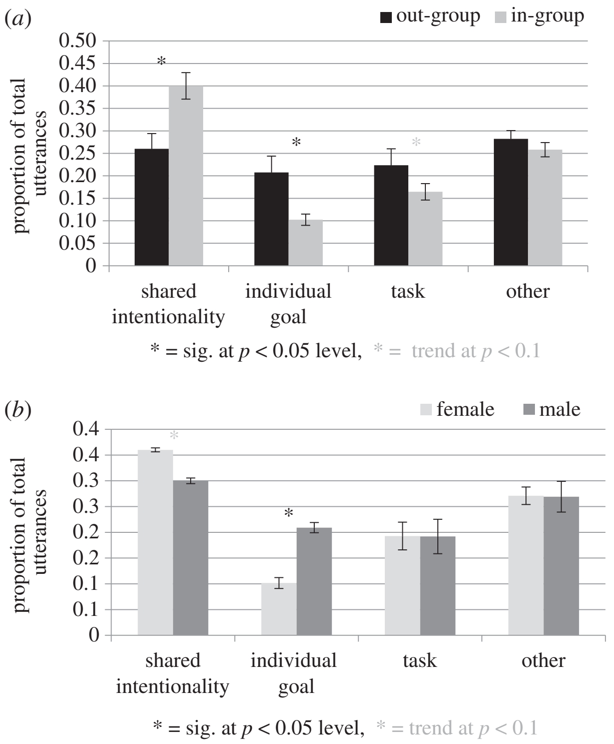

Figure 3. (*a*) Type of reference players used during their conversations as a function of group membership (estimated marginal means and standard error bars shown). (*b*) Type of talk players used during their conversations a function of gender (estimated marginal means with standard error bars shown).

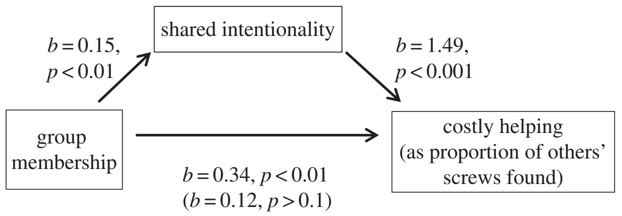

Figure 4. The relative impact of shared intentionality and group membership on costly helping. Mediation analysis showing unstandardized regression coefficients for the relationship between group membership and costly helping as mediated by shared intentionality. The unstandardized regression coefficient between group membership and costly helping drops to a non-significant level (shown in parentheses) when shared intentionality is added to the model.

Table 1. Regressions coefficients for the two models produced by the hierarchical regression, showing the unstandardized coefficient (*B*), the standard error for the unstandardized coefficient (s.e. *B*), the standardized beta (β), the *t*-test statistic (*t*) and the probability value (*p*).

source	*B*	s.e. *B*	β	*t*	*p*
model 1					
group membership	0.343	0.113	0.374	3.042	0.004
model 2					
group membership	0.125	0.080	0.136	1.562	0.124
shared intentionality	1.494	0.178	0.733	8.409	0.000

$p < 0.1$; figure 3*a*), and no effect of gender on task talk ($\chi^2_{(1,53)} = 0$, $p > 0.90$; figure 3*b*). (iv) Other talk: there were no effects of either group membership ($\chi^2_{(1,53)} = 1.14$, $p > 0.2$; figure 3*a*) or gender ($\chi^2_{(1,53)} = 0.01$, $p > 0.9$; figure 3*b*) on the frequency of 'other talk'.

Next, to determine whether any of the types of talk influenced levels of cooperation, a hierarchical multiple regression analysis was conducted using all participants to determine the degree to which the types of talk each impacted costly helping. While the first model with group membership predicted 14.0% of the variance in costly helping ($R^2 = 0.14$, $F_{1,57} = 9.26$, $\beta = 0.34$, $p < 0.01$), the second model in which all talk types were entered along with group membership explained significantly more. Specifically, the model with group membership and shared intentionality predicted 62.0% of the variance in costly helping ($\Delta R^2 = 0.48$, $R^2 = 0.62$, $F_{1,56} = 45.64$, $\beta = 1.49$, $p < 0.001$) whereas neither individual goal talk ($\beta = -0.083$, $p > 0.3$) nor task talk ($\beta = 0.13$, $p > 0.3$) nor other talk ($\beta = -0.010$, $p > 0.91$) predicted a significant amount of the variance in costly helping. See table 1 for full regression coefficients of each model.

Most importantly, using a mediation analysis again including all participants, we found that the effect of group membership on costly helping is mediated by shared intentionality talk. That is, while being an in-group member has a direct effect on costly helping in isolation of other variables ($b = 5.40$, $p < 0.01$), this effect drops to non-significance when shared intentionality is controlled for. In other words, in-group membership increases the degree to which players use shared intentionality ($b = 0.17$, $p < 0.01$) and it is this increase that drives variation in costly helping itself ($b = 19.18$, $p < 0.01$, Sobel test: $z = 2.77$, $p < 0.01$, $\kappa^2 = 0.23$; figure 4).

Lastly, to confirm that costly helping impacts success on the hunt, we ran a regression which showed that those individuals who engaged in more costly helping also earned more screws in total. That is, costly helping predicted 28.4% of the variation in individual hunt success, or total screws collected ($R^2 = 0.284$, $F_{1,134} = 53.02$, $\beta = 0.532$, $p < 0.001$).

4. Discussion

With the egg hunt we present a new game that is loosely modelled on the prisoner's dilemma in that mutual helping would yield higher payoffs than a mutual lack of helping, but as helping was costly in terms of time, helpers were vulnerable to defectors. However, the egg hunt differed from a typical prisoner's dilemma game in three ways: first, the egg hunt was not framed as a shared game with discrete behavioural options and a 2 × 2 payoff matrix. Consequently, pairs that did not cooperate apparently failed to realize it was possible and did not perceive their individual hunting strategies as defection. Helping could only emerge from the realization that the foraging task offered a shared component if desired. Second, the design was such that helping decisions were not made simultaneously and then displayed to the other participant. Instead, decisions to help were a function of each individual's encounters with the other's screws, typically out of sight of the other participant, meaning precise monitoring of helping decisions was rarely possible. Third, while a basic assumption of a prisoner's dilemma game is that players cannot communicate with each other during the game, we specifically investigated the effect of continuous free speech during the task on helping behaviour.

While shared group membership and the ability to talk both led to increased costly helping and success during the

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egg hunt game (indicating that the impact of these two factors is strong enough to override any individual differences in cooperation; e.g. [35]), the analysis of players' talk is the key aspect of our findings. Our conversation analysis reveals the crucial psychological process driving most of the observed variation in costly helping during players' interactions: shared intentionality. It seems that sharing group membership alters people's perspective, changing the same hunt from a simultaneous but very much separate task to one in which the two players could perceive their goals as shared. Consequently, people doing the hunt with an in-group member engaged in more shared intentionality than out-group members, who instead framed the task more in terms of individual goals. Our results suggest that entering into shared intentionality is the key to perceiving the hunt as a mutualistic as opposed to individual task and realizing that helping is a viable option in this game. Shared intentionality in turn predicted the degree to which people engaged in costly helping, which then predicted their success on the hunt. Our results also show that the direct effect of group membership on costly helping falls drastically when taking into account the effect of shared intentionality. That is, shared group membership increases the degree to which players enter into shared intentionality (specifically, prior to the hunt or any helping), and it is precisely this increase that has the most immediate effect on people's decisions to help another at a cost to themselves. Some researchers have proposed that the effects of group membership and talking may be the other way around, in that communication may directly enhance group identity [36] or the salience of social norms [37,38], and that this increase in shared identity then leads to increased cooperation [39]. Our results suggest the contrary: it is in fact shared group identity affecting the very nature of communication which then impacts cooperation. That is, shared group membership increases a person's motivation to enter into a state of shared intentionality and to subsequently discuss shared intentions and goals with another, which in turn is what drives the variation we see in cooperation.

This insight has important implications for the fields of cooperation research, comparative and developmental psychology, and inter-group dynamics. For cooperation research, our results go some way to explaining the great variation seen in human cooperative behaviour. Research using economic games has had a hard time providing plausible explanations for why human behaviour varies from model predictions—in essence, why humans are both more cooperative and competitive than game-theory models predict [40]. This is partially because rational decision-making has often been interpreted as individual maximization of rewards, an interpretation that does not readily transfer to interactive social contexts. To date, this process of interactive cooperation has been predominantly investigated using theoretical models [41]. Furthermore, as economic game paradigms are frequently constrained to fit existing models, behaviour that would normally spontaneously arise in a more natural situation is frequently suppressed. Conversely, with the egg hunt allowing free conversation, we were able to study the spontaneous emergence of helping behaviour, which arose from discussing the shared goals during the task rather than individual goals. While communication is known to increase cooperation [42], to our knowledge our results are the first to identify the primary psychological process via which communication can drive cooperation, namely shared intentionality. However, as we show, communication does not have a uniform effect on cooperation. Instead, group membership affected the type of communication players used, and cooperation rates in the hunt between in-group members increased specifically as a function of the shared intentionality in their discussions. This suggests that shared intentionality is a crucial process driving the variation seen in many cooperative games.

In the fields of comparative and developmental psychology, considerable work has gone into delineating the highly advanced human aspects of shared intentionality in comparison with other species [43,44]. While humans and many apes can understand others as intentional agents, only humans are frequently motivated to actually share in another's goals, with even children as young as 2 years of age being able to enter into shared intentionality [45]. Certain forms of non-verbal communication (eye-contact and smiling) lead children to form shared goals with another person [46,47]. Our results suggest that shared intentionality in adults is in fact triggered by social cues, specifically group membership. So while all 'normal' adults may possess the psychological capacity to engage in shared intentionality, it is apparently not a state entered into automatically but instead selectively used as a function of social context.

For research on inter-group dynamics, shared intentionality provides an explanation in cognitive terms for the maintenance of in-group favouritism documented by a great deal of research in social psychology (e.g. [48]; see [39] for a meta-analysis). While considerable research has shown that, on a physiological level, group bias is probably driven by the hormone oxytocin (e.g. [49]), we speculate that it is shared intentionality that provides the psychological platform for the perpetuation of in-group favouritism in social interactions, defined primarily as an increased willingness to sacrifice individual benefit for the good of one's group [39]. We would suggest that, as per social identity theory, sharing an identity with another person leads people to include fellow group members in their very mental representation of themselves [50,51], it is this inclusion of the other in the definition of the self that not only facilitates shared intentionality but probably makes it a natural next step of such closeness. From this perspective, the mutual in-group helping produced by shared intentionality may have both prosocial and altruistic aspects: while such helping could directly and significantly benefit one's fellow group members, it could also be equally self-serving in terms of how it improves a person's own self-image and/or reputation within a group. This may also explain why interactions between groups who are made to share superordinate goals show less of the typical in-group bias, specifically by allocating more equal amounts to their own and other groups [52]. We would suggest that this process via which shared intentionality produces increased helping within groups at a cost to the individual goes some way to explaining the well-documented increase in cooperation between in-group members (see [39] for a meta-analysis).

A better understanding of how and why humans cooperate in actual social interactions is urgently needed to improve cooperation on a global scale (e.g. for the distribution of public goods and mitigation of climate change [53]). By identifying the human psychological capacity for shared intentionality as a crucial process driving the variation in cooperation in this study, we can begin to synthesize a more complete evolutionary explanation for human hyper-cooperation as we compare mechanisms used by humans and other species [54]. The applications of such a finding are far-reaching: if members of different groups can be primed to perceive goals as shared instead of individual, the resulting

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shared intentionality may overcome the out-group biases that drive many real-world conflicts.

Ethics. The authors declare that this research (i) has not been published previously elsewhere, (ii) was not misconducted, (iii) did not involve animal treatment, and (iv) did not involve plagiarism in any form. The University of Neuchâtel ethics committee approved the study.

Data accessibility. Data are available on the Figshare repository (doi:10.6084/m9.figshare.4294091.v1).

Authors' contributions. All authors designed the experimental paradigm, J.S.M. and S.P. carried out data collection, J.S.M., R.B. and A.B. carried out the analysis, J.S.M. and R.B. wrote the manuscript, with substantial revisions from A.B. and F.C.

Competing interests. We declare no competing interests related to this study.

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