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The Ecological and Civil Mainsprings of Property: An Experimental Economic History of Whalers' Rules of Capture

Bart J. Wilson
Chapman University
Taylor Jaworski
University of Arizona
Karl E. Schurter
University of Chicago
Andrew Smyth
Florida State University

Abstract

This article uses a laboratory experiment to probe the proposition that property emerges anarchically out of social custom. We test the hypothesis that whalers in the 18th and 19th centuries developed rules of conduct that minimized the sum of the transaction and production costs of capturing their prey, the primary implication being that different ecological conditions led to different rules of capture. *Ceteris paribus*, we find that simply

imposing two different types of prey is insufficient to observe two different rules of capture. Another factor is essential, namely, as Samuel Pufendorf theorized over 300 years ago, that the members of the community are civil minded .

[W]e may hence too discover the falsity of that vulgar saying, *Mine* and *Thine* are the cause of all the wars and quarrels in the world. For on the contrary the distinction of *Mine* and *Thine* was rather introduced to prevent all contention.

Samuel Pufendorf (*Of the Law of Nature and Nations*, IV.IV.VII)

1. Introduction

The institution of property solves a fundamental problem in human relations, namely, it defuses costly belligerence. When in direct competition for a resource, people are not outright pugnacious at every turn because there are costs as well as benefits to any fight. These personal costs induce agonists, through a gradual process of feedback and innovation, to adopt individual rules of restraint for orderly engaging their competitors. Little, however, is understood about how these general rules to curb quarrelsome impulses emerge at the level of the individual and subsequently develop into full-blown social institutions modernly recognizable as forms of property.

Calling property an “institution” is somewhat specious, for it evokes notions of something being deliberately instituted by someone. And it is this notion regarding the origins of property that has been the source of considerable philosophical debate since before the enlightenment. Whereas Hobbes (1651/1996), Bentham (1802/1931), and Sened (1997) would argue that an exogenous state is the sole creator and guarantor of rights to property, others such as Pufendorf (1672/2005), Hume (1740/2000), and Demsetz (1967) contend that property endogenously evolves by graduated habit and custom, indeed the result of human action but not the grand product of conscious design.

Ellickson (1989, 1991) attempts to disprove the former “legal-centralist” view of property with a pointed example, the Anglo-American whaling industry in the mid-18th to mid-19th centuries.¹ During its heyday (and still today), whalers competed for prey in the open seas beyond the reach of any state-instituted and -enforced rules of capture, and yet the community of whalers established clear rules of capture.² Not just any rule would do, however. Ellickson builds a case for the hypothesis that members of the whaling community developed norms that were “wealth maximizing,” that is, whalers developed rules of conduct that minimized the sum of the transaction and production costs of capturing their prey. A primary implication of this hypothesis is that different ecological conditions, in this case different types of prey, led to different rules of capture. A further implication is that there also existed a set of counterfactual norms that did *not* emerge. By examining the ecological sensitivity of the rules that whalers did adopt and the nontrivial number of rules that they could have but did *not* develop, Ellickson (1989) concludes that whaling norms were in fact “consistently sensitive to both production incentives and transaction costs and varied in utilitarian fashion with the conditions prevailing in different fisheries” (95).

Our project focuses on two specific rules that emerged from hunting two different types of whales (Ellickson 1989, 1991). British whalers in the 18th century hunted right whales, a type of baleen whale, off the coast of Greenland and developed a rule that has been succinctly summarized as *fast-fish, loose-fish*. If a right whale was held fast to a boat via harpoon or other apparatus, the right to that whale belonged to that boat. If a whale was not attached to a boat or escaped by ineptitude or chance, the loose fish was fair game for any boat.³ This rule worked well because right whales are slow swimmers, not particularly feisty, and not prone to dive (and take an attached boat down with it). On the other hand, sperm whales, the prey of American whalers, swim faster, fight harder, and could drag an attached 19th century whaleboat under water. Hence, the *fast-fish, loose-fish* rule was too costly to be employed to hunt sperm whales. The rule that developed for this prey was called *iron holds*

the whale. The primary difference between the two rules is that with the latter rule, the harpoon did not have to be attached to the boat. As long as the boat remained in pursuit of the harpooned or lanced whale, the whale remained the property of the pursuer. If a boat failed to remain in reasonable proximity and/or could not defend its intention of taking the whale, the next affixer could stake claim to it.

Faced with this historical contravening evidence, how might a (legal-centralist) skeptic respond? By criticizing the empirical method of inquiry, for as Ellickson (1991) anticipates and so politely characterizes it himself, “[a]ny ex post explanation risks being too pat” (205). Such repositioning of the argument is not unique to ex post explanations of questions in economic history and is simply an equivocation on the fundamental Duhem-Quine problem of inquiry. When faced with specific empirical evidence on a question of science, is it the theory that fails or is it the auxiliary assumptions in conducting the particular empirical analysis that we reject? Either is an option, the choice of which is constrained only by our personal intellectual commitments (Polanyi 1958).

This article uses a laboratory experiment to acutely probe, *ex ante*, the proposition that property emerges anarchically out of social custom. Ellickson has only one realization of whaling history on which to support his claim. To that we add 24 independent observations of 144 undergraduates from two universities who are some 85 years removed from 1924—the year the last wooden whaleship left New Bedford harbor (it ingloriously sank).⁴ This article, however, is not just a test of Ellickson’s hypothesis of wealth-maximizing norms with participants who are unfamiliar, if not completely ignorant, of 19th century whaler norms. Ellickson’s seminal contribution is highlighting the crucial role that specific ecological conditions play in the emergence of property norms. Our experiment directly investigates this hypothesis by creating two virtual ecological conditions of prey that differ in an arguably subtle way. Yet differences in prey are not the only ecological factors that shape rules of capture. Any rule that emerges must also operate in combination with the diverse dispositions and impulses of the whalers themselves. Our experimental design allows us, like Ellickson, to assess which rules do *not* emerge, but, crucially, it also enables us to observe how anarchically unstable and hence inefficient groups respond to different types of prey vis-à-vis stable, wealth-maximizing groups, both of whom experience precisely the same change in ecological conditions. In other words, in addition to observing how wealth-maximizing groups react to changes in prey, we will also observe the interaction of counter-social groups with directly comparable changes in ecology.

Our article is organized as follows. In Section 2, we present our original between-group experimental design, procedures, and hypotheses. Section 3 then reports the results from our first two treatments. Based upon what we observed from the initial treatments, we introduce in Section 4 the design and results for a final within-group treatment. This treatment pins down what we can learn from this experiment. The article concludes with a discussion and closing remarks in Section 5.

2. Experiment Design, Procedures, and Hypotheses

2.1 Preliminaries

Although Ellickson’s observations on informal whaling rules serve as the inspiration for the basic structure of our experimental design, we are under no illusion that we are capturing in toto the conditions that naturally occurred over 150 years ago. (Our Internal Review Board vetoed bringing any whales to campus for our subjects to hunt.) The guiding principle behind the choices of our numerous abstractions is parsimonious control. Thus, our virtual whale hunts differ in many ways, both intentionally and unintentionally, from those that occurred historically. Our objective is to observe how differences in an exogenously imposed ecology affect the rules that emerge for extracting a prey that lies open to any and every person in a randomly assigned community. Given the large number of detailed parameters that are not expressly presented to the subjects, we recommend reading the experiment instructions in Appendix A before reading the rest of this section.

2.2 Environment

Each subject is given control over a colored stick figure that identifies him or her by his or her color name to the other subjects in the session (see Figure 1a). Each experimental session consists of 26 periods of 3 minutes each. Each period is further subdivided into two 90-s phases. In phase A, which is called the “gathering” phase in the instructions, subjects can move around an open “gathering” area shown in the middle portion of Figure 1a by left clicking anywhere in the gathering area. Left clicking at anytime will immediately change their direction and distance of travel by taking the stick figure to that spot in the coordinate plane.⁵ Subjects have limited vision of the gathering area, as indicated by the gray 325-pixel diameter that surrounds each stick figure.

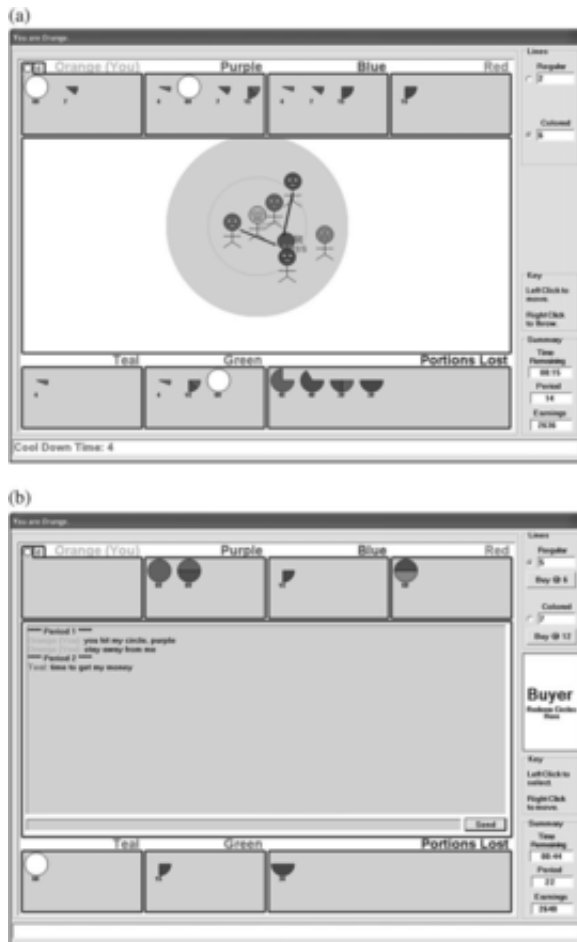


Figure 1. Screenshots for the Gathering and Interim Phases. (a) Gathering Phase. (b) Interim Phase.

Each session is composed of six subjects. To allow the subjects time to familiarize themselves with their task and forge a potential relationship, we use a “build” design similar to the previous experiments that gradually increases the group size (Weber 2006; Crockett et al. 2009). Subjects begin the experiment in three paired groups; after period 13, all three pairs merge into one group of six, which remains intact for the duration of the session.

During the first 60 s of phase A, the computer software randomly spawns white circles for the subjects to gather. A total of four circles randomly appear in the gathering area when the subjects are in pairs. Thus, if divided equally within the pair, each subject would receive two circles. After the subjects merge to a single group of six in period 14, a total of 10 circles appear so as to introduce some distributional tension into the problem (two circles can no longer be evenly distributed to each person within a period). In what we will call the *Right* treatment, circles move at a pace of 50 pixels/s; stick figures only move at a speed of 25 pixels/s. The circles are always moving in a straight line to a randomly chosen location unbeknownst to the subjects. After the

circle reaches its destination, it chooses another immediately and moves toward it. The circles also dive and surface.⁶ To get a sense of the cumulative effect of these parameters, imagine that you control a stick figure that you can move around an environment populated by other stick figures and also white circles that *either* travel in and out of your limited field of vision at a pace that is faster than you move *or* occasionally simply fade (dive) out of sight.

Each participant's task is to earn money by "gathering" circles. We first discuss the simplest case for gathering circles and then move on to more involved cases. Throughout the experiment, subjects can purchase "lines" in the previous period's phase B. A subject can attach a line to a circle by right clicking on a circle within a 175-pixel diameter of their stick figure. A colored line encircles each stick figure and denotes their "line-throwing" range. If the subject misses the circle (remember that the circles are constantly moving), the word "Miss" appears where the line failed to attach to a circle. After a subject "attaches" a line to a circle, it takes 5 s to pull in the circle, during which time the circle no longer moves and the line continues to connect the stick figure to the circle. After 5 s, the computer determines with a 75% probability whether the circle will be successfully "pulled in" by the subject. If the subject is successful, the circle appears in the designated cargo boxes that surround the gathering area. A whole circle is worth 100 US cents and can be redeemed in phase B of the experiment. Thus, in the first 39 min of the experiment, a pair of subjects can earn a total of \$52 between them. In the last half of the experiment, there is \$130 of prey roaming the gathering area.

If by a 25% chance a circle is not caught, then the stick figure and circle are free to move around. At that instant, there is an independent 25% chance that the circle will stop moving altogether. This "dead" circle can be caught with a 100% probability by the next line or lines that attach to it for the same value of a "live" moving circle. After each successful or unsuccessful throw, a stick figure must "cool down" for 5 s before it can throw another line. If a circle survives an initial strike and does not die, any subsequent strike on this moving circle will be successful with a 90% probability. After the first strike, the circle also slows down to roaming at 37.5 pixels/s, or 75% its original speed. If a circle survives a second and any subsequent strikes, it permanently slows down to 25 pixels/s, the speed of the stick figures. Finally, circles die at a rate of 50% the instant after all second and subsequent strikes are unsuccessful.

The more involved cases arise when one subject is attached to a circle and additional subjects also right click and attach a line to the same circle. The result of this process is that any or all of n attached subjects can successfully catch a circle. As mentioned above, when only one subject catches a circle, only that subject can redeem it for 100 cents. However, when $m \leq n$ subjects successfully catch a circle (each person has its own independent probability of being successful), each successful subject only receives a pie-sized piece of the circle worth $1/m^2$ of the total value of the circle. The remaining amount of the circle, $(m - 1)/m$, is lost as waste from the fight for the circle. For example, if two subjects successfully catch the same circle, each receives a quarter of a circle worth 25 cents, and 50 cents is lost to the ether. If three subjects catch a circle, each receives 11 cents and 67 cents is lost. The fractions lost are displayed in the box in the bottom right portion of Figure 1a under the heading, "portions lost." The salient monetary losses are important to keep in mind when evaluating the observed amount of double, triple, quadruple, and even occasionally quintuple strikes that are made on attached circles in Section 3.7

In phase B, which is called the "interim" phase in the instructions, subjects can redeem caught circles and any portions thereof for money by right clicking and dragging the circle to the "Buyer" on the right side of the screen (see Figure 1b). They can also transfer circles or money to any other subject, and they can use the chat room in the center of screen to communicate with each other. To transfer money, subjects click on the ¢-tab in the cargo box, left click the amount to add to the total to send, and drag the amount indicated to another subject's cargo area. All transfers of circles and money are publicly recorded in the chat room. Finally, during the interim phase

subjects can purchase new lines for use in later periods. All transfers of circles and whales are publicly recorded in the chat room.

There are two types of lines, regular and colored, which cost 10 and 20 cents, respectively. The lines have exactly the same capabilities in catching a circle, the only difference, apart from the cost, is that a colored line will change the color of the circle to the color of the thrower, regardless of whether the line is successful or not. If another stick figure attempts to attach a colored line to a colored circle, then both colors are displayed in equal proportion on the circle. So, for example, if *Red* throws a colored line at a white circle and with a 25% chance it gets away, one red circle will roam the gathering area among the other white circles.

If *Blue* subsequently attaches a colored line to the red-colored circle, half of the circle will become blue and half remains red. If while *Blue* is attached to the half-red, half-blue circle, *Green* comes along and attaches a colored line to the same circle, it becomes one-third red, one-third blue, and one-third green, and so forth. Regular lines have no coloring effect on white or colored circles. We will discuss the reasoning behind this aspect of the design in the hypothesis subsection below.

Importantly, subjects are only told that circles must be redeemed in order to accumulate earnings to be paid in cash at the end of the experiment; otherwise they are not told why transferring, chatting, or using one type of line or another might be advantageous or adventitious. The reader will also note that the minutiae of the circle movements and probabilities are not explained to the subjects in the instructions. These are aspects of this novel environment that they must learn from trial and error. We note that although the plethora of written details may leave the reader with the impression that this is a difficult task for a subject to comprehend, the challenging part of this “video game,” as our subjects have called it, is not navigating the software interface with left and right mouse clicks but solving the problem of forming a social order with the other participants.⁸ After the first three periods, rare is the circle that is not captured by at least one person. A 3-min video demonstration of the software is available for viewing at <http://www.youtube.com/watch?v=26eHNShfMGI>.⁹

Although our experiment does involve a resource that lies free to anyone who would capture it in an open area, this superficial similarity to fishing does not mean that this is an experiment on the common pool resource problem. The central problem of a common pool resource is overuse, that is, a problem associated with *how much* of a resource is extracted from a common pool. By design, our resource fully replenishes each period because we are interested in *how people go about* extracting a resource, that is, we are investigating the more limited but fundamental question of what system of rules, if any, emerges to delineate what is yours from what is mine while extracting a constantly renewing resource.¹⁰

2.3 Treatments and Hypotheses

As mentioned above, our objective is to exogenously vary the ecological conditions of the prey to observe how this affects which rules, if any, predominantly emerge to minimize losses from the whalers’ conflicting interests. The parameters described in the previous subsection refer to what we will call the *Right* (whale) treatment. In the second treatment, which we call the *Sperm* treatment, the prey is more difficult to catch. Our sperm whales move 50% faster than right whales, or three times the speed of the whalers.¹¹ Once first harpooned, a sperm whale is successfully pulled in only 25% of the time, which is one-third the probability of a right whale being pulled in, and sperm whales only die with 10% probability after the first strike. In both treatments, each whole whale is worth 100 cents; the same number of whales appears in the gathering area each comparable period; and all harpoons cost and function the same. Table 1 summarizes the parameters for both treatments.

Table 1. Summary of Parameters for *Right* and *Sperm* Treatments

Parameter	<i>Right</i>	<i>Sperm</i>
Probability of successful first strike (q)	0.75	0.25
Probability of successful subsequent strike (θ)	0.90	0.75

Probability of death after first strike (d)	0.25	0.10
Probability of death after subsequent strike (δ)	0.50	0.25
Expected number of harpoons (h) to pull in a whale ^a	≈ 1.2697	≈ 1.9577
Whale speed, pixels/s	50	75
Whale speed reduction after first strike	0.75	0.75
Whale speed reduction after second strike	0.50	0.50
Whaler speed, pixels/s	25	25
Value of whole whale	100¢	100¢
Portion allocated to m successful whalers	$1/m^2$	$1/m^2$
Cost of regular harpoon	10¢	10¢
Cost of colored harpoon	20¢	20¢
Diameter of harpoon range, pixels	175	175
Diameter of sight, pixels	325	325
Number of whales per pair (periods 1–13)	4	4
Number of whales per sextuplet (periods 14–26)	10	10
Cash endowment (to buy harpoons for period 1)	150¢	150¢
Length of gathering (phase A), s	90	90
Length of interim (phase B), s	90	90
Time to pull in, s	5	5
Time to cool down, s	5	5

$$E(h) = 1 \cdot q + 2 \cdot [d(1 - q) + (1 - q)(1 - d)\theta] + (1 - q)(1 - d)(1 - \theta) \sum_{n=3}^{\infty} n[\delta(1 - \delta)^{n-3}(1 - \theta)^{n-3} + (1 - \delta)^{n-2}(1 - \theta)^{n-3}\theta].$$

We designed the two types of harpoons described to allow our subjects to more clearly express the two different rules of capture that Ellickson studied in whalers over 150–250 years ago: *fast-fish*, *loose-fish* and *iron holds the whale*. If our subjects adopt a *fast-fish*, *loose-fish* rule (we think it is safe to say that 99% were unaware that their computerized task crudely models Anglo-American whaling), there is no need to pay twice as much for colored harpoons; a colored line simply leaves money on the table. In contrast, a subject who adopts the *iron holds the whale* rule may believe that there is at least a value of 10 cents to marking a whale as his, which is 10% of the redemption value of a whole whale and 40% of the redemption value of a whale split two ways.¹² A bright, fully colored circle provides stark evidence to back up any claim that a particular whaler affixed the first harpoon. This rule rewards the investment of the first harpoon that slows a whale down and makes it more likely that subsequent harpoons will successfully pull in the whale. Recall from Table 1 that the first harpoon in a sperm whale is only successful 25% of the time, whereas any subsequent harpoon is 75% successful. Although regular lines also equally reduce the speed and increase the probability of taking a whale with a future strike, there is no evidence of who bore the cost of affixing the first harpoon. We chose to conclude the second half of a session with a group of six subjects to make it difficult for the subjects to keep track of who threw which regular harpoons into which whale.

Of course, it is possible that our subjects do not adopt either of these rules, nor for that matter any rule of capture. A free-for-all is feasible and not at all unanticipated given the rampant disorder that Kimbrough et al. (2010) report in their virtual communities. We can determine whether any rules of capture are present by the number of harpoons affixed to a whale that is attached to a whaler. After an initial harpoon strike, every subsequent strike on an attached whale risks wasting $100(m - 1)/m$ cents.¹³ Thus, subsequent strikes can “take” $100 - 100/m^2$ cents from a successful first harpooner. We fully expect this costly behavior. The question is

whether we will observe a spontaneous order emerge out of the initially unruly and thus inefficient environment. Based upon the random assignment of subjects to treatments, our aim is to identify and characterize any spontaneous orders. At this point, it is not clear whether the delicate differences between the *Sperm* and *Right* treatments in Table 1 will lead to similar social orders, different social orders, or no social order at all.

However, we do have an *ex ante* hypothesis that ecology matters, that is, that we will observe different social orders in the two different treatments. Specifically, we predict that we will observe more *fast-fish, loose-fish* behavior in the *Right* treatment than in the *Sperm* treatment and, complementarily, more *iron holds the whale* behavior in the *Sperm* treatment than in the *Right* treatment. Within the *Right* treatment, we also predict more *fast-fish, loose-fish* behavior than *iron holds the whale* behavior and, vice versa, more *iron holds the whale* behavior than *fast-fish, loose-fish* behavior in the *Sperm* treatment. Finally, we do not expect widespread use of a third rule that is feasible in our experiment, namely, *split ownership*, a rule whereby everyone gets an equal share of the total earnings from a whale hunt. This potential rule of capture is why our design allows subjects to transfer whole whales or cash to other subjects during the interim phase. However, we anticipate that this rule will be too costly for subjects to use widely without the complementary formal institutions that Ellickson (1989:92–4) suggests were instrumental to its adoption. To reiterate:

Ex ante Hypothesis 1a. Ecology matters for forming a social order.

Ex ante Hypothesis 1b. *Fast-fish, loose-fish* will be more prevalent in the *Right* sessions than in the *Sperm* sessions, and *iron holds the whale* will be more prevalent in the *Sperm* sessions than in the *Right* sessions.

Ex ante Hypothesis 1c. In the *Right* sessions, there will be more *fast-fish, loose-fish* than *iron holds the whale*. In the *Sperm* sessions, there will be more *iron holds the whale* than *fast-fish, loose-fish*.

Ex ante Hypothesis 2. Split ownership will not be widely employed in either treatment.

2.4 Procedures

We conducted six replicates of each of the *Right* and *Sperm* treatments. These 72 subjects were recruited from the general student body of George Mason University. We discuss a third treatment in Section 4 for which we recruited another 72 subjects at Chapman University. (In Section 4, we also report that the change in subject pools has no statistical effect for the first 13 periods in which the parameters of the third treatment very nearly match those in the *Right* treatment.) No subject participated twice, and all subjects were randomly recruited via an electronic email system and were paid \$7 for showing up on time. When subjects arrived in the laboratory, they were seated at visually isolated computer terminals where they privately read through self-paced instructions. Subjects were free to ask questions during the instructions and throughout the experiment. Not including the show-up payment, mean earnings for all 144 subjects were \$27.59 and paid privately at the conclusion of the session that lasted less than the 2 h for which they were recruited.

3. Results from the *Right* and *Sperm* Treatments

Each harpoon thrown suggests which rules might be guiding the actions of the player who threw the harpoon. Although no social scientist can peer into the minds of his or her subjects to ascertain whether a given rule governs their behavior, or even to determine whether their actions simply do not contradict the rule, we can use trends in the observed proportion of harpoon throws that appear to follow a specific rule as tethered evidence that the rule is used relatively more than other potential rules. Specifically, we classify each harpoon thrown into one of four categories according to the rule that it suggests: *fast-fish, loose-fish*; *iron holds the whale*; *deadweight loss*; and *unknowable*. The categories are mutually exclusive and exhaustive. In the following explanation of these categories, we use feminine pronouns in reference to the first person to strike a whale and masculine pronouns for subsequent strikers.

First, while anyone is attached to a whale, regardless of the type of line she is using, a subsequent strike on the whale clearly does not demonstrate wealth maximization as this behavior may waste portions of the whale depending upon the random probability that both parties are successful in pulling it in. Thus, any of these interloping harpoons are counted as *deadweight loss*.

If a subject finds an uncolored whale and strikes it with a colored line, we classify it as *iron holds the whale*. This harpoon suggests that she is attempting to convey to the other whalers that she struck the whale. If she is behaving according to *fast-fish, loose-fish*, then she could have used the cheaper but equally effective regular lines since she would have no incentive to mark the whale under *fast-fish, loose-fish*.

Suppose that a first striker who used a colored line and any interlopers are all unsuccessful in capturing a whale. Now there is a free-roaming colored whale. If the first striker harpoons it again, then this suggests that she is behaving according to *iron holds the whale*. In this case, the type of line used does not matter because she already marked the whale with her initial strike. On the other hand, if someone else finds this colored whale before the first striker does and harpoons it with a *regular* line, then it is unclear which norm he is following unless the whale is captured by him. If the second striker respects the property right claimed by the first striker when she colored the whale, he will transfer the whale or some amount of money to her, perhaps keeping a "finder's" fee for himself. This harpoon is then coded as *iron holds the whale*. If he does not transfer anything to the first striker, then the harpoon is classified as *fast-fish, loose-fish*. If he is unsuccessful in pulling in the whale, then we cannot predict what his intentions were and must categorize the strike as *unknowable*.

If a second striker of a colored whale uses a colored line on the already colored free-roaming whale, then this does not immediately suggest either *fast-fish, loose-fish* or *iron holds the whale*. The second striker should not use a colored line if he is following *fast-fish, loose-fish* because a regular line is an equally effective but less expensive alternative. Thus, the strike is classified as *unknowable* if he captures it with a colored line and does not transfer wealth to the first striker.¹⁴ Likewise, the second striker should not use a colored line if he is following *iron holds the whale* because it is now unclear who the original claimant is in the event that he is unsuccessful and a third whaler then finds and successfully captures this multicolored whale. However, if the second striker captures the whale and transfers money or the whale to the first striker, then that strike is classified as *iron holds the whale* because the transfer of wealth indicates that he rightfully acknowledges the first striker's property.

In comparing across treatments, we normalize the number of harpoons in the *Sperm* treatment based upon the expected number of harpoons it takes to successfully pull in a whale.¹⁵ Table 1 reports that the expected number of harpoons per whale in the *Right* and *Sperm* treatments is approximately 1.2697 and 1.9577, respectively. Thus, for the purposes of directly comparing the two treatments, we scale down the number of *Sperm* harpoons by dividing the totals by the ratio $\frac{1.9577}{1.2697} = 1.549$. Likewise, for all data presented for periods 1–13, unless noted to the contrary, we scale the total number of harpoons by the relative number of whales available; specifically, we divide pair data by $\frac{1}{2}$.¹⁰ We focus our analysis on data from the last six periods of the session, which is (approximately) the last half of the session for which the subjects were in one group of six.¹⁶

Before we present our quantitative findings, we first discuss a qualitative organization of the data. Figures 2 and 3 report the scaled number of harpoons thrown in the *Right* and *Sperm* treatments, respectively. The vertical line separates the pair data from the sextuplet data within a session. This change clearly and permanently increases the number of *deadweight loss* harpoons in the *Sperm* treatment and in three of the six *Right* sessions. In the three other *Right* sessions (2, 3, and 4), the number of *deadweight loss* harpoons spikes in periods 14–16 but then drops off substantially for the final quarter of the session. Of those, some are

reported in the interim phase to be accidents, for which they explicitly apologize, lest they be misunderstood as blatantly violating their customary rules of capture.¹⁷

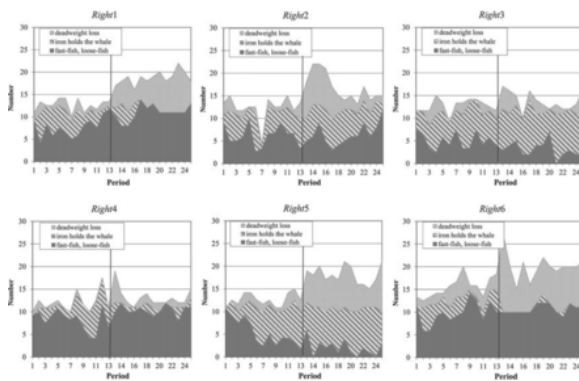


Figure 2. Stacked Area Plot of Harpoon Types by Session for the *Right* Treatment.

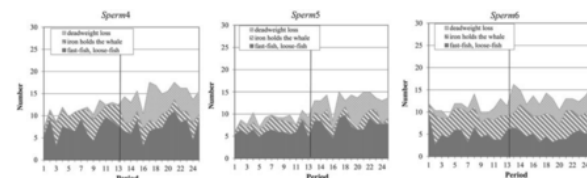


Figure 3. Stacked Area Plot of Harpoon Types by Session for the *Sperm* Treatment.

Figure 4 summarizes the data from all 12 sessions for periods 21–26. The height of the bar is the total number of *deadweight loss* harpoons in the session.¹⁸ The colors of the bar represent the relative proportion of non-*deadweight loss* harpoons that are classified as *fast-fish*, *loose-fish* and *iron holds the whale*. First, note that there are only three sessions with a rather low number of *deadweight loss* harpoons. These sessions, all from the *Right* treatment, average 1.8 *deadweight loss* harpoons per period. The remaining three *Right* sessions average 8.0 *deadweight loss* harpoons per period. In other words, a *Right* session either clearly establishes customary rules of capture or is a chaotic free-for-all; there are none in between. Lying between this gulf is the scaled number of *deadweight loss* harpoons in the *Sperm* treatment, the average of which is 4.3 harpoons per period. The *Sperm* sessions do not establish wealth-maximizing norms like the best sessions in the *Right* treatment do (though *Sperm6* comes close). But they also do not double-hit attached whales as frequently as the worst *Right* sessions do, perhaps because sperm whales move 50% faster than right whales.

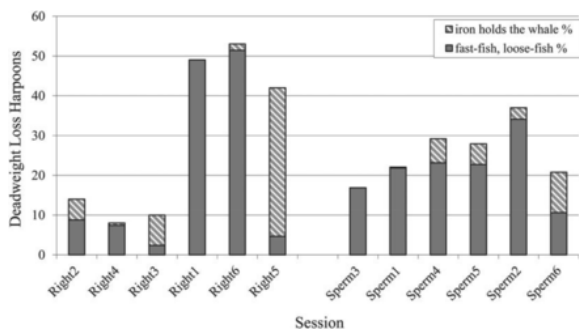


Figure 4. Summary of *Right* and *Sperm* Treatments. Note: The total height of the bar is the number of *deadweight loss* harpoons thrown over periods 21–26, and the solid and hatched areas report the relative percentage of non-*deadweight loss* harpoons for periods 21–26.

The second summary observation of note is the predominance of *fast-fish*, *loose-fish* in *both* treatments.¹⁹ In the *Right* treatment, two of the three more efficient sessions and two of the three less efficient sessions chiefly throw *fast-fish*, *loose-fish* harpoons. On the other hand, all six *Sperm* sessions throw more *fast-fish*, *loose-fish* harpoons than *iron holds the whale* harpoons, though the proportion is close in *Sperm6*, 51%–49%. So when

a session does not clearly establish wealth-maximizing rules of capture, the whalers respond quite economically by buying the cheaper regular harpoons. This, however, leaves us with a total of three sessions that conform to our predictions, split 2 to 1 between the two rules, and thus the need for the new hypotheses and concomitant treatment in Section 4. This brings us to our first formal finding.

Finding 1a. Ecology indeed matters in forming a wealth-maximizing social order.

Evidence: In Figure 4, no-*Sperm* session achieves an efficient social order similar to *Right*2, -3, and -4, as measured by the number of *deadweight loss* harpoons. However, in no-*Sperm* session does anarchy so utterly break down into “amorphous,” as Hirshleifer (1995) calls it, as it so clearly does in *Right*1, -5, and -6. Individual temperaments within a group also appear to matter eminently in the *Right* treatment but not in the *Sperm* treatment.

Finding 1b. There is no statistical difference in the scaled number of fast-fish, loose-fish harpoons thrown in the *Right* and *Sperm* treatments. There is also no statistical difference in the usage of iron holds the whale harpoons across treatments.

Evidence: Using a Wilcoxon rank sum test comparing each independent session, we fail to reject the null hypothesis of equal number of *fast-fish, loose-fish* harpoons ($U_{6,6} = 19$, p -value = 0.5319, one-sided test). As the p -value greater than 0.5 indicates, contrary to our *Ex ante Hypothesis*, the mean number of *fast-fish, loose-fish* harpoons is higher in the *Sperm* treatment than in the *Right* treatment. Out of an average of 97.5 harpoons thrown in the *Right* treatment in periods 21–26, 44.3 are consistent with *fast-fish, loose-fish*. In contrast, in the *Sperm* treatment 52.0 of an average of 87.1 harpoons thrown in periods 21–26 are *fast-fish, loose-fish* compatible. Likewise, we fail to reject the null hypothesis of an equal number of *iron holds the whale* harpoons ($U_{6,6} = 23.5$, p -value = 0.8030, one-sided test). Whereas the average *Sperm* session uses only 9.5 *iron holds the whale* harpoons over periods 21–26, the average *Right* session uses 23.8. The means are again in the opposite direction of our *Ex ante Hypothesis*.

Finding 1c. For the *Sperm* treatment, contra our *Ex ante Hypothesis* every single session uses more *fast-fish, loose-fish* harpoons than *iron holds the whale* harpoons. Within the *Right* treatment, whalers use as many *iron holds the whale* harpoons as they do *fast-fish, loose-fish* harpoons.

Evidence: Using a Wilcoxon signed rank test comparing the paired number of *fast-fish, loose-fish* and *iron holds the whale* harpoons in each session, we fail to reject the null hypothesis of an equal number of harpoons of each type against the alternative of more *iron holds the whale* in the *Sperm* treatment ($W_6 = 0$, p -value = 1.000, one-sided test). The average *Sperm* session uses 42.5 more *fast-fish, loose-fish* than *iron holds the whale* harpoons, ranging from a low of 1.3 more to a high of 68.8 more. In the *Right* treatment, there is no statistical difference ($W_6 = 16$, p -value = 0.1562, one-sided). One *Right* session uses 49 more *iron holds the whale* than *fast-fish, loose-fish* harpoons and another uses 68 more *fast-fish, loose-fish* than *iron holds the whale* harpoons.

Before taking stock of what we have learned thus far, we assess in our second finding the degree to which *split ownership* rule is utilized.

Finding 2. Very little cash and very few whales are redistributed among the whalers in the interim period.

Evidence: To examine the *split ownership* rule, we count the total value of the whales (w_t) and cash (c_t) transferred in period t . Table 2 reports the total amounts transferred in periods 14–26 by session. Very little is

transferred. Using a Wilcoxon rank sum test, we fail to reject the null hypothesis of equal amounts transferred in the *Right* and *Sperm* treatments ($U_{6,6} = 26$, p -value = 0.2403, two-sided test). Whereas one *Sperm* session engages in considerable redistribution during the interim phase, none of the three wealth-maximizing *Right* sessions (2, 3, and 4) transfer a single penny of earnings among each other. It is not difficult to conclude that the *split ownership* norm is not our subjects' solution to their environment and the hunting task they confront.20

Table 2. Transfers of Whales and Cash by Session for Periods 14–26

	Right treatment			Sperm treatment	
	Total revenue	$\sum_{t=14}^{26} w_t + c_t$		Total revenue	$\sum_{t=14}^{26} w_t + c_t$
<i>Right</i> 1	10,364¢	463¢	<i>Sperm</i> 1	11,316¢	1061¢
<i>Right</i> 2	10,772¢	0¢	<i>Sperm</i> 2	9631¢	2¢
<i>Right</i> 3	12,133¢	0¢	<i>Sperm</i> 3	10,723¢	0¢
<i>Right</i> 4	12,133¢	0¢	<i>Sperm</i> 4	10,205¢	562¢
<i>Right</i> 5	10,670¢	38¢	<i>Sperm</i> 5	9748¢	0¢
<i>Right</i> 6	9239¢	0¢	<i>Sperm</i> 6	10,040¢	2770¢
Average	10,885¢	83.5¢	Average	10,277¢	732.5¢

Before moving on to the next section and a new explicating treatment, it is worth spending a few sentences reflecting on what we have learned with these first two treatments. An advantage of an experiment in the laboratory vis-à-vis the naturally occurring world is its scale. Because we can create a further treatment to explore the clues in Figure 4 that hint at the emergence of social orders, we can learn from what we fail to observe in a way that is not possible outside the laboratory. And what are these clues? With slower, easier to capture prey, a community of six is either wealth maximizing or is clearly not. Moreover, groups hunting faster, harder to capture prey split this difference. This is a nontrivial systematic result considering how subtle the changes are between the *Right* and *Sperm* treatments. So although the medians do not statistically differ in terms of the number of *deadweight loss* harpoons thrown ($U_{6,6} = 18$, p -value = 1.000, two-sided test), we see potential; there are the outlines of social orders leading us to probe further and test our conjectured learning.

Finally, the chat room transcripts provide evidence that is consistent with such orders. In each transcript from *Right*2, -3, and -4, someone makes an explicit appeal to a *fast-fish, loose-fish* rule. 21 Immediately after the first period hunting as a sextuplet, *Orange* in *Right*2 proposes a *fast-fish* agreement:

Orange: lets agree to not hit once someone is on it alot of money is lost
 Green: hahah
 Blue: true
 Orange: my partner and i did and it worked well
 Purple: yup
 Orange: agreed??
 Blue: agreed
 Orange: green??
 Orange: teal??
 Blue: lol
 Purple: haha
 Blue: guess not
 Teal: yea that sounds like a plan

The subjects in *Right3* also have a conversation in period 15 with explicit *fast-fish* and *loose-fish* provisions:

Orange: if you steal another person's hit we all lose 50
Blue: the pies getting smaller nam saying
Blue: lets spread out and not steal then cuz
Orange: so if somebody gets one it would be more advantageous to let them have it
Blue: yeah
Red: sounds good
Orange: and then it can be free game if they dsont catch it

This is similarly the case in period 14 of *Right4*, and everyone joins the conversation:

Purple: we missed a bunch
Green: i think its first tagged first served
Orange: yeah
Red: agreed!
Green: anything else is a hyge waste
Green: huge*
Blue: that would be better
Orange: we wont get any money if it splits
Orange: okay
Orange: first tag first serve!
Orange: good idea
Green: so everyone play nice? no pirates?
Purple: boo
Red: anyone know the purpose of the color?
Purple: yeah
Blue: what is it?
Orange: its pointless
Teal: yhoutght so
Green: anyone not for that?
Red: just more expensive
Teal: so first grab first get
Purple: sounds good
Orange: yup
Red: great
Teal: no fighting!
Orange: its really not worth it otherwise

Figure 5 is a snapshot of the *fast-fish, loose-fish* rule at work late in the *Right4* session. This particular whale escaped from *Purple* and now *Blue* is attached to it. Even though it is within *Purple's* range, her cool down time has expired, and she has yet to catch a whale this period, she acknowledges *Blue's* right to it, as does *Red*. Also notice that all the six previously caught whales are whole and uncolored.

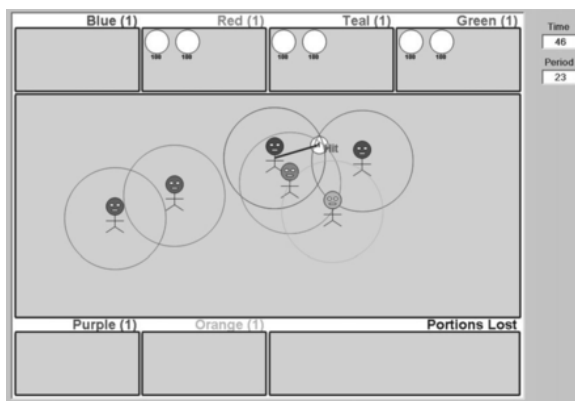


Figure 5. Snapshot of *Fast-fish, Loose-fish* at Work in *Right4*.

To summarize, we have found that ecology does matter in whether a social order forms, but we have too little data from the successful economies (3 of 12) to conclude anything about the content of the rules that govern the social order. For that we design a new treatment.

4. *Sort*: A Within- and Between-Group Design

4.1 Design and Hypothesis

At this juncture, our project exemplifies what Latour (1999) pithily contends is subsidiarily true of all scientific hypothesizing, namely, that “[s]cientists’ predictions or previsions are always postdictions or repetitions” (272). We now present a hypothesis that is unrepentantly grounded in postdictions of the *Sperm* and *Right* treatments. A rereading of Ellickson in light of our results reveals an understated but potentially important design consideration (emphasis added):

“[A]ccording to the hypothesis, whalers *switched* to iron holds the whale because that rule’s advantages in reducing deadweight losses outweighed its transaction-cost disadvantages” (1991: 201).

“[W]halers succeeded in [settling disputes without any guidance from American courts] during a time period in which all British decisions on whale ownership supported norms other than the iron-holds-the-whale rule [chiefly, *fast-fish, loose-fish*] that the Americans were *increasingly adopting*” (1991: 204).

“The critic might challenge the offered utilitarian interpretation on a number of grounds. First, the evidence suggests that whalers might have been wise to use the first-iron rule for sperm whales and the *fast-fish* rule for right whales. *They did not, and instead varied their rules according to the location of the fishery, not according to species*” (1991: 205).

The first two quotations highlight that history matters. Among American whalers, *iron holds the whale* emerged spontaneously on the heel of another established rule, principally *fast-fish, loose-fish*. Moreover, this was a gradual process of change in response to increases in *deadweight loss* when the old rule no longer fit the ecology of the prey within a particular geographic community, as the third quotation specifies.

Our new treatment incorporates these observations. Our first aim for the new treatment is a feature that regularly predicts for our sextuplet communities the stable adoption of a wealth-maximizing rule of capture, whether *fast-fish, loose-fish* or *iron holds the whale* or neither. The second aim is to change our between-group comparison to a within-group comparison, that is, change the type of whale from right to sperm within a session to reflect the historical chronology of the emergent norms. The former feature provides the important empirical foundation for investigating the latter feature of how established wealth-maximizing rules evolve to fit the ecological circumstances.

An implicit assumption of Ellickson’s hypothesis is that whale boat captains were part of a process of trial and error that selected “whalers” who respected a community’s rules of capture, whatever the rules may be or however they evolved. Although 19th-century whaling was not without its conflicts, disputes were not rampant. Ellickson (1991) writes that “[t]he international whaling community was a tight one ... primarily because whaling ships commonly encountered one another at sea, and because whalers’ home and layover ports were few, intimate, and socially interlinked. The scant evidence available suggests that whalers’ norms of capture were internationally binding” (193).

Within the framework of our original design, we looked for an observable metric from the first 13 periods with which we could prevision (and replicate from past experience) a community-minded sextuplet for periods 14–26. In the *Right* and *Sperm* treatments, we recruit six random people for a session and force them to interact in a community in which no one can be excluded, nor can anyone exclude themselves no matter their individual dispositions. For our last treatment, which we will call *Sort*, we invite 12 participants for each of six sessions and then divide them into two groups of six after period 13: *Civil* and *Rude*.²² Unbeknownst to the subjects, the *Civil (Rude)* group is composed of the top (bottom) three pairs from periods 8–13 that have the fewest (highest) total number of strikes on attached whales. The idea is that this early behavior predicts whether or not the sextuplet will develop and abide by a rule of capture.²³ In a civil community, *no single person sets himself above the others* by striking an attached whale; there is a mutual, or better, reciprocal, respect for evolved rules of capture. In contrast, rude members of a group *put their own material interests above the interests of others* by striking attached whales.

For the second aim of this final treatment, we add an additional 13 periods to the end of the session. For the first 26 periods, right whales are the prey, but for the last 13 periods, the prey switches without announcement to sperm whales in both the *Civil* and the *Rude* groups. Because we have increased the number of periods by 50%, we decrease the value of a whale and the cost of harpoons by 40%. Table 3 compares the parameters of the *Sort* treatment with the *Right* treatment. The only other difference is that we trim the interim phase from 90 to 60 s so that we can continue to complete the sessions within 2 h. In the first two treatments, the interim phase appeared to have about half a minute’s worth a slack.

Table 3. Summary of Parameters for *Right* and *Sort* Treatments

	Right	Sort (right whales)	Sort (sperm whales)
Parameter	Periods 1–26	Periods 1–26	Periods 27–39
Probability of successful first strike	0.75	0.75	0.25
Probability of successful subsequent strike	0.90	0.90	0.75
Probability of death after first strike	0.25	0.25	0.10
Probability of death after subsequent strike	0.50	0.50	0.25
Expected number of harpoons to pull in a whale	≈1.2697	≈1.2697	≈1.9577
Whale speed, pixels/s	50	50	75
Whale speed reduction after first strike	0.75	0.75	0.75
Whale speed reduction after second strike	0.50	0.50	0.50
Whaler speed, pixels/s	25	25	25
Value of whole whale	100¢	60¢	60¢
Portion allocated to <i>m</i> successful whalers	$1/m^2$	$1/m^2$	$1/m^2$
Cost of regular harpoon	10¢	6¢	6¢
Cost of colored harpoon	20¢	12¢	12¢
Diameter of harpoon range, pixels	175	175	175
Diameter of sight, pixels	325	325	325
Number of whales per pair (periods 1–13)	4	4	NA

Number of whales per sextuplet	10	10	10
Cash endowment (to buy harpoons for period 1)	150¢	90¢	NA
Length of gathering (phase A), s	90	90	90
Length of interim (phase B), s	90	60	60
Time to pull in, s	5	5	5
Time to cool down, s	5	5	5

In general terms, we hypothesize that *Civil* sextuplets will respond to the ecological change in whale type in a wealth-maximizing manner and that *Rude* sextuplets will not respond to the change or will respond in a way that is not wealth maximizing. More specifically, the *Sort* treatment generates eight hypotheses, the findings for which we examine in detail in the next subsection:

Baseline hypothesis: For periods 1–13, there is no difference in the number of *fast-fish*, *loose-fish*, *iron holds the whale*, and *deadweight loss* harpoons in the *Sort* (in aggregate) and *Right* treatments.

Civil pair hypothesis: For periods 8–13, *Civil* pairs throw fewer *deadweight loss* harpoons than *Right* pairs.²⁴

Civil sextuplet hypothesis: For periods 21–26, *Civil* sextuplets throw fewer *deadweight loss* harpoons than *Right* and *Rude* sextuplets.

Civil fast-fish, loose-fish hypothesis: For periods 21–26, *Civil* sextuplets throw more *fast-fish*, *loose-fish* than *iron holds the whale* harpoons.

Ellickson hypothesis: For *Civil* sextuplets, there is a structural break in the number of *deadweight loss* harpoons thrown when the prey changes from right to sperm whales in period 27.

Ellickson counterhypothesis: For *Rude* sextuplets, there is no structural break in the number of *deadweight loss* harpoons thrown when the prey changes from right to sperm whales in period 27.

Auxiliary Ellickson hypothesis: The usage of *iron holds the whale* harpoons is nondecreasing in *Civil* sextuplets.

Auxiliary Ellickson counterhypothesis: The usage of *iron holds the whale* harpoons decreases in *Rude* sextuplets.

4.2 Results

Given that we have changed a couple minor parameters and the subject pool with the new *Sort* treatment, our first finding is important to establish that we have the same baseline in periods 1–13.

Finding 3 (Baseline hypothesis). There is no difference in the number of *fast-fish*, *loose-fish*, *iron holds the whale*, and *deadweight loss* harpoons in the *Sort* and *Right* treatments summed over periods 1–13.²⁵

Evidence: Using a Wilcoxon rank sum test on the 36 independent pairs in the *Sort* treatment and the 18 independent pairs in the *Right* treatment, we fail to reject the null hypothesis of equal number of harpoons in each of the three categories with two-sided tests (*fast-fish, loose-fish*: $U_{36,18} = 393.5$, p -value = 0.2047; *iron holds the whale*: $U_{36,18} = 367$, p -value = 0.4387; *deadweight loss*: $U_{36,18} = 334.5$, p -value = 0.8495).

Having established that we have the same baseline in *Sort* and *Right* for the first 13 periods, we check that our metric separates out civil-minded pairs in *Sort* relative to *Right* where both civil and rude subjects are “lumped” together.

Finding 4 (Civil pair hypothesis). *Civil* pairs throw fewer *deadweight loss* harpoons than *Right* pairs for periods 8–13.

Evidence: Using a Wilcoxon rank sum test on the 18 independent *Civil* pairs and the 18 independent *Right* pairs, we reject the null hypothesis of equal number of *deadweight loss* harpoons in favor of the alternative of

fewer *deadweight loss* harpoons in *Civil* ($U_{18,18} = 240$, p -value = 0.0066, one-sided test). On average, a *Civil* pair throws 1.1 *deadweight loss* harpoons as opposed to 3.8 such harpoons for the average *Right* pair.

Finding 4 is only useful if it serves as the predictor for wealth-maximizing, rule-following behavior among *Civil* sextuplets, which is our next finding.

Finding 5 (Civil sextuplet hypothesis). Civil sextuplets throw fewer deadweight loss harpoons than Right and Rude sextuplets for periods 21–26.

Evidence: Using a Wilcoxon rank sum test, we reject the null hypothesis of an equal number of *deadweight loss* harpoons in favor of the alternative of fewer *deadweight loss* harpoons in *Civil* than in *Right* ($U_{6,6} = 29$, p -value = 0.0465, one-sided test) and in *Rude* ($U_{6,6} = 27.5$, p -value = 0.0660, one-sided test). On average, a *Civil* sextuplet throws 9.3 *deadweight loss* harpoons per session over the last six periods with right whales, whereas *Right* and *Rude* sextuplets each throw 29.3 such harpoons over the same time period.²⁷

Finding 1c reports no significant difference in the number of *fast-fish*, *loose-fish* and *iron holds the whale* harpoon throws in the *Right* treatment. But as Figure 4 suggests, *Right* sessions are either wealth maximizing or not. *Right* whalers who are not wealth maximizing may throw costly *iron holds the whale* harpoons, but what about *Civil* whalers who we know from Finding 5 are wealth maximizing? Naturally, we ask whether *Civil* whalers in the *Sort* treatment throw more *fast-fish*, *loose-fish* than *iron holds the whale* harpoons at right whales. Our next result strongly finds this to be the case.

Finding 6 (Civil fast-fish, loose-fish hypothesis). With right whale prey Civil sextuplets throw more fast-fish, loose-fish than iron holds the whale harpoons.

Evidence: Using a Wilcoxon signed rank test, we reject the null hypothesis of equal number of *fast-fish*, *loose-fish* and *iron holds the whale* harpoons in favor of the alternative of more *fast-fish*, *loose-fish* harpoons in *Civil* ($W_6 = 20$, p -value = 0.0312, one-sided). Of all the non-*deadweight loss* harpoons that are thrown for periods 21–26, the *Civil* sessions, respectively, throw *fast-fish*, *loose-fish* harpoons 84.5%, 82.4%, 33.8%, 81.3%, 88.2%, and 94.4% of the time.

Taken together, Findings 1c and 6 support Ellickson's hypothesis on the adoption of wealth-maximizing norms plus they highlight the importance of group selection. So although we could only conclude from Finding 1 that the ecology matters in whether a social order forms, we could not conclude what the content of the rule system is that the three wealth-maximizing groups implemented. *Finding 6 reports that civil-minded subjects rather convincingly adopt, as hypothesized, the rule of fast-fish, loose-fish.*

Although we did not initially recognize the importance of Ellickson's implicit assumption that whalers were survivors of a process that selected for people who abided by customary rules of behavior, our laboratory experiment demonstrates that some groups of individuals may be, at least as a group, simply ill-suited to hunt whales. If the subjects in the three inefficient *Right* sessions had been actual 18th or 19th century whalers, their "rude" behavior would have put them out of business. Or they would have realized that whaling was for them an inferior means of earning a living, and they would have self-selected into an occupation more suited to their temperament.

Our sorting mechanism, unbeknownst to the subjects, mimics this process in our laboratory. As in nearly every economic experiment, they have no outside option in the experiment for earning money, nor any enforcement mechanism to minimize *deadweight losses* except the threat of retaliation (which only causes further *deadweight loss*). Indeed, a whaling community following *fast-fish*, *loose-fish* or *iron holds the whale* is

unstable under defection or invasion by unruly outsiders. Hence, the importance of cultivating order via the composition of a community. Jaworski and Wilson (2011) illustrate the importance of endogenous group selection for the emergence of a respect for property. In our *Sort* treatment, we draw upon the lessons from Jaworski and Wilson, Ellickson, and our first two treatments by incorporating an endogenous group selection mechanism. Consequently, we find statistically significant support for the hypothesis that *Right* whalers predominantly adopt a rule of *fast-fish, loose-fish* rather than *iron holds the whale*.²⁸

Having established a wealth-maximizing metric that sorts subjects into *Civil* and *Rude* groups, we now examine the responses of these groups to an ecological change in prey and assess the implications of the general wealth-maximizing hypothesis.

Finding 7a (Ellickson hypothesis). For *Civil* sextuplets, there is a structural break in the number of *deadweight loss* harpoons thrown when the prey changes from right to sperm whales.

Evidence: For our quantitative evidence, we employ a Chow (1960) test on an ordinary least squares (OLS) regression of the average number of *deadweight loss* harpoons (across the six sessions) on a constant and the period. The results are reported in Table 4. For the *Civil* treatment average as a whole, we reject the null hypothesis of no structural break in period 27 in favor of the alternative of a structural break at the 99% level of confidence ($F_{2,22} = 19.20 > F_{0.012,22} = 5.72$). We also conduct this test for each individual session. *Civil3*, -5 and -6 all have statistically significant structural breaks at the 99% and 95% levels of confidence, respectively. The remaining three sessions are insignificant. Figure 6 plots the number of *deadweight loss* harpoons for the treatment as a whole and for the two subsets of sessions that do and do not have structural breaks at the session level. In the top two panels, there is a statistically significant *negative* slope with right whales followed by a statistically significant and *positive* slope with sperm whales. Notice also that the variance starts low in the early periods with sperm whales but then increases strikingly toward the end of the sessions. Although the three other sessions do not have upward trends with sperm whales, the variance is increasing, which is perhaps an indicator that a (statistically significant) breakdown may be coming later for these sessions (see panel (c) in Figure 6).

Table 4. Estimated Linear Regressions for *Civil* *Deadweight Loss* Harpoons

Coefficient	Periods 14–39	p-value	Periods 14–26	p-value	Periods 26–39	p-value
<i>Civil</i> (all)						
Constant	20.36	<0.0001	44.16	<0.0001	-16.16	0.0287
Period	-0.33	0.0334	-1.53	0.0006	0.78	0.0020
$F_{2,22}$	19.20					
<i>Civil1</i>						
Constant	2.45	0.0090	4.77	0.0575	0.81	0.6783
Period	-0.03	0.2873	-0.15	0.1915	0.02	0.7611
$F_{2,22}$	1.15					
<i>Civil2</i>						
Constant	0.86	0.3437	1.04	0.5598	-3.63	0.2766
Period	0.05	0.1646	0.04	0.6166	0.18	0.0892
$F_{2,22}$	1.23					
<i>Civil3</i>						
Constant	6.10	0.0042	16.18	0.0043	-3.22	0.1721
Period	-0.15	0.0374	-0.67	0.0116	0.14	0.0662
$F_{2,22}$	6.69					
<i>Civil4</i>						
Constant	2.61	0.0240	5.89	0.0478	5.18	0.0670

Period	-0.05	0.2360	-0.23	0.1111	-0.12	0.1536
$F_{2,22}$	2.01					
<i>Civil5</i>						
Constant	9.86	0.0000	16.69	0.0016	-2.83	0.1695
Period	-0.28	0.0002	-0.62	0.0098	0.11	0.0921
$F_{2,22}$	6.18					
<i>Civil6</i>						
Constant	-1.52	0.2435	-0.41	0.8575	-12.46	0.0102
Period	0.13	0.0078	0.09	0.4084	0.46	0.0031
$F_{2,22}$	4.48					

Bolded entries are significant at the 95% level of confidence.

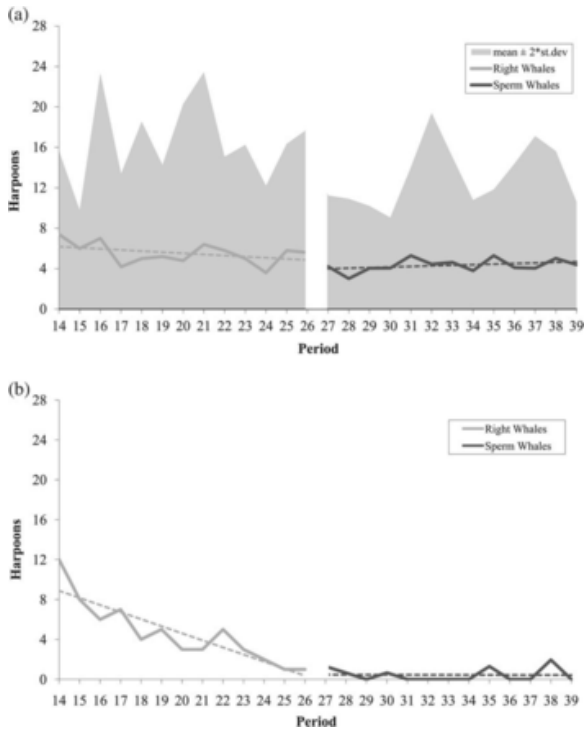


Figure 6. *CivilDeadweight Loss Harpoons.* (a) Average of All Sessions. (b) Average of *Civil3*, -5, -6. (c) Average of *Civil1*, -2, -4. Note: The portion of $\mu-2\sigma$ that falls below zero is added to $\mu+2\sigma$.

The chat transcripts for the final two periods of *Civil6* exemplify the breakdown in the social order and a yearning for the order of periods past:

Orchid: what happended to the pack olive?

Brown: olive how do you theif?

Pink: why is brown really red

Olive: the rules of the game seemed to have changed, as I noticed from pink

Orchid: how so?

Brown: OUCH

Khaki: yeah i notived that too

Olive: it seems the last person (usually) to touch gets the ball

Brown: i am not commie

Khaki: lol

Olive: well maybe not, I'm not so sure.

Pink: it seems as if i have started an all out war
 Orchid: just keep to the old rules
 Brown: i think it was better before
 Pink: my bad
 Olive: okay
 Orchid: k
 Khaki: yeah i liked it when it was just 2 ppl
 Olive: haha
 Orchid: true
 Gray: the good ol' days

If, given the particular circumstances of time and place, rules form endogenously to maximize wealth, then the rules of capture for right whales will be ill-suited for sperm whales. Finding 7a supports this hypothesis with *Civil* sextuplets. Finding 7b assesses the implications of the hypothesis for the counterfactual circumstances of counter-social groups.

Finding 7b (Ellickson counterhypothesis). For five of six of the *Rude* sextuplets, there are no structural breaks in the number of *deadweight loss* harpoons thrown when the prey changes from right to sperm whales.

Evidence: Table 5 reports the *F*-statistics for a Chow tests by session of an OLS regression of the average number of *deadweight loss* harpoons on a constant and the period. Save *Rude3*, all are highly insignificant. Panel (a) in Figure 7 plots the average number of *deadweight loss* harpoons for these five sessions. There is no structural break in their wealth-maximizing behavior because there is no such behavior to begin with. As their treatment name suggests, they are as Ferguson (1767/2007) might describe them, “a band of robbers, who prey without restraint, or remorse, on their neighbors” (83). An implicit assumption of the counterhypothesis is that preying without restraint or remorse will not lead to the emergence of wealth-maximizing rules of capture within periods 14–26. *Rude3* demonstrates that this assumption is not uniformly true. Despite starting period 14 with 12 *deadweight loss* harpoons thrown, that number steadily falls to just one *deadweight loss* harpoon in periods 25 and 26 (see Figure 7). When the prey switches to sperm whales, they remain well-behaved with no *deadweight loss* harpoons for several periods, which is a structural break because they cannot improve any more until the end of the session when their number of *deadweight loss* harpoons slightly increases. *Rude3* is the proverbial exception that proves the rule; it looks more like *Civil*1, -2, and -4 with sperm whales than its treatment counterparts.

Table 5. Chow Test Statistics for *Deadweight Loss* Harpoons by *Rude* Session

	$F_{2,22}$
<i>Rude1</i>	1.78
<i>Rude2</i>	1.53
<i>Rude3</i>	17.29
<i>Rude4</i>	1.46
<i>Rude5</i>	1.80
<i>Rude6</i>	1.60
F _{0.052,22}	3.44

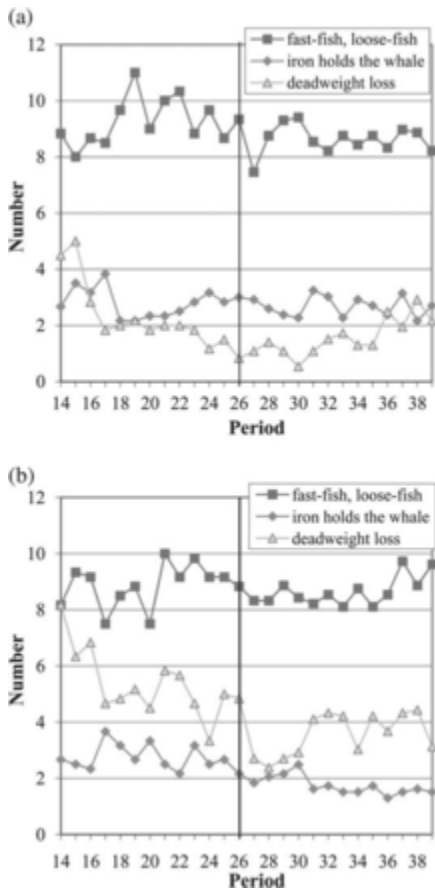


Figure 7. *RudeDeadweight Loss Harpoons*. (a) Average of *Rude1*, -2, -4, -5, -6. (b) *Rude3*. Note: The portion of $\mu-2\sigma$ that falls below zero is added to $\mu+2\sigma$.

Having found striking direct and indirect evidence that *Civil groups*, unlike their *Rude* counterparts, exhibit wealth-maximizing behavior and respond to changes in their environment, we conclude this section with our final finding.

Finding 8 (Auxiliary Ellickson hypothesis and counterhypothesis). The usage of *iron holds the whale* harpoons is constant in *Civil* sextuplets and decreases in *Rude* sextuplets.

Evidence: We employ a simple OLS regression of average number of *iron holds the whale* harpoons in the *Civil* and *Rude* subtreatments on a constant and the period, for periods 14–39. The results are reported in Table 6. There is no significant trend in the *Civil* regression across the whale types (p -value = 0.1723), and hence the regression explains almost nothing ($R^2 = 7.6\%$). In contrast, in the *Rude* regression, the period covariate is highly significant (p -value < 0.0001) and explains 58.3% of the variance of the dependent variable. Figure 8 plots the average (scaled) number of harpoons thrown in the *Civil* and *Rude* subtreatments, and Figures 9 and 10 report the same at the session level. Although the number of *iron holds the whale* harpoons is increasing in some *Civil* sessions, decreasing in others, and constant in others still, the strength of this finding rests in the *Rude* sextuplets, save for *Rude1* that looks more like *Civil1*, -2, and -4.

Table 6. Estimated Linear Regressions for *Iron Holds the Whale* Harpoons for Periods 14–39

	<i>Civil</i>		<i>Rude</i>	
Coefficient	Estimate	p -value	Estimate	p -value
Constant	4.33	<0.0001	4.98	<0.0001
Period	-0.03	0.1723	-0.08	<0.0001

$R^2, \%$	7.6		58.3	
Observations	26		26	

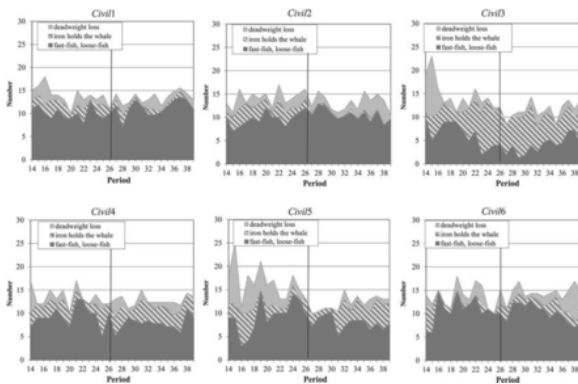


Figure 8. Average Number of Harpoons by Type for the *Sort* Sextuplets. (a) *Civil* Sextuplets. (b) *Rude* Sextuplets.

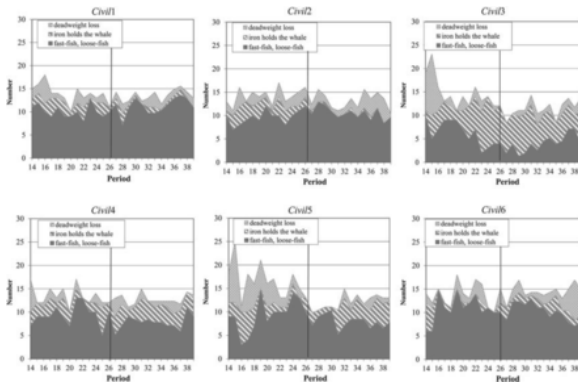


Figure 9. Stacked Area Plot of Harpoon Types by Session for the *Civil* Sextuplets.

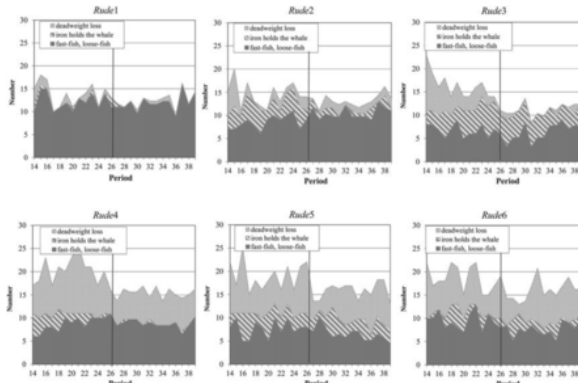


Figure 10. Stacked Area Plot of Harpoon Types by Session for the *Rude* Sextuplets.

Although the usage of *iron holds the whale* harpoons is not increasing in the *Civil* sessions, it is also not decreasing as it is in the *Rude* sessions. This suggests that *Civil* whalers may be on the path to adopting a new wealth-maximizing rule of capture to fit their new ecological environment. *Rude* whalers, on the other hand, do not appear headed toward any rule of capture, much less a wealth-maximizing one involving *iron holds the whale*. The process by which norms of behavior change is undoubtedly long and tedious. Yet the *Civil* whalers, unlike their *Rude* counterparts, appear not to be headed in the wrong direction.

5. Discussion and Conclusion

Economists, like ordinary people, tend to think of property as a relationship between things and people, when instead property is a system of relational rules between people involving things (Stake 2004). This subtle change in focus obscures the ultimate impetus for developing rules of property: minimizing the negative sum costs of conflict over competition for resources. Moreover, when the focus shifts away from rules of good and proper behavior among people to rules that assign things to people, the idea of the legal centralism follows quite readily. Rules, it seems, must be deliberately created to determine what is right regarding an individual and his or her things, and the state appears to be the sole available option to do the instituting and enforcing of such rules. Legal centralism assumes away conflict as the impetus for property because the state has a monopoly on the use of violence.

But this gets things the wrong way.²⁹ When people have a common understanding of the right and wrong ways to behave, rules governing behavior can emerge by agreement to avoid particular conflicts of time and place. This approach to understanding property has a rich and long intellectual tradition that predates the enlightenment (Buckle 1991). Samuel Pufendorf, a 17th century German jurist-philosopher, is one such precursor who laid out the foundations for the origins of property that we explore in our experiment. His theory begins with the antecedent circumstance of “communion,” which is

taken either negatively, or positively. In the former manner things are said to be common, as considered before any human act or agreement had declared them to belong to one rather than to another. In the same sense, things thus considered are said to be *No Body's*, rather negatively, than privatively, i.e., that they are not yet assigned to any particular person, not that they are incapable of being so assigned. They are likewise termed *res in medio quibusvis exposita*, things that lie free for any taker (1672/2005: IV.IV.II).

Whales are such things that “lay free to any that would use, and do not belong to one more than another,” and moreover, whalers are members of a negative as opposed to a positive community in that no one can be excluded from taking a whale (IV.IV.V). The problem is that even though man is capable of “kindness by the furtherance of mutual good,” he is also “often malicious, insolent, and easily provoked, and as powerful in effecting mischief, as he is ready in designing it” (II.III.XV).

In this article, we present an experiment that explores Pufendorf’s ecological preconditions for property, namely, a negative community without any exogenously enforced rules of capture populated with agonists with a propensity for mischief and petulance.³⁰ As Pufendorf explains, “it was left to the reason of men to determine what measures should be taken to prevent discord that might arise amongst them” (IV.IV.III). Likewise, we find in our virtual communities that many of our participants desire rules to prevent discord:

Rude2, Periods 14–15

Green: should we be trying to help each other?

Green: or is selfishness the way to go?

Pink: that’s a super good plan

...

Pink: if everyone just agrees to not steal other peoples then we will get more

Blue: that is very true

Green: I think so too

Brown: true

Green: I'm down

Pink: so just do that

Civil4, Period 14

Brown: hey guys

Green: hey

Brown: if we dont steal from each other

Brown: we make more money

Orange: yeah

Brown: i dont know how you guys feel about that

Brown: we lost 2 full circles

Brown: from competing

But what exactly does the generic rule "don't steal" mean in practice, and how does a community come to agree on the rules? Agreement cannot be assumed, for different people may have different ideas of what the rule "don't steal" means, as the following conversation in Civil4 plainly indicates:

Green: omg teal31

Green: u saw i had that one

...

Green: teal

Green: give me half

Green: that was mine

Green: it was green

...

Teal: u lost it so i have to get it

(Teal does not transfer any money to Green.)

Green is following *iron holds the whale* and expecting at least half of the whale for striking it with a colored harpoon, but *Teal* is following *fast-fish, loose-fish* and will have nothing of it.

Ellickson's hypothesis is that the ecological conditions of the community shape the content of rules so as to maximize wealth, and this shaping process is what this article examines. "Vulture-like," "greedy," or "selfish" (as undesirable attributes) are defined only with respect to the emergence of rules by consent that are appropriate to the circumstances. We find that simply imposing two different ecological conditions and randomly allocating participants to them is insufficient to observe the two different rules of capture for right and sperm whales that Ellickson postdicts. Another factor is essential, namely, that the members of the community are civil-minded from the outset. *In a civil as opposed to a rude community, no one considers his or her own interest superior to another.* Harmony in a civil community is then possible, not by agreement on outcomes but by agreement on the rules for pursuing one's own interest. By typecasting early actions as civil and rude and sorting people accordingly into *Civil* and *Rude* communities, we observe some 200 years after the glory days of Anglo-American whaling that civil-minded communities more broadly employ a *fast-fish, loose-fish* rule than their insolent mischievous counterparts. Moreover, for prey that moves faster and fights harder, we find that (a) changing the ecological conditions of a *Civil* community leads to a breakdown in the usefulness of the *fast-fish, loose-fish* rule and (b) the rule of *iron holds the whale* decreases in usage in our counterfactual *Rude* communities.

Pufendorf brilliantly anticipates by more than three centuries that which Ellickson explains ex post and we explore ex ante on the origins of property:

in affirming that men left this [negative] communion upon the advice and direction of reason, we pretend not that it was necessary all things should be appropriated in the same moment; but *according as the temper or condition of men, the nature of the things themselves, and the difference of place required; and as was judged most convenient for the cutting off all manner of quarrel or dissension* (1672/2005: IV.IV.XIII, emphasis added).

The implications for economics and jurisprudence are far reaching. For if property evolves in stages through a process circumscribed by the current ecological circumstances of time and place and the particular civil mindset of the people in question, then the history of property is necessarily path dependent. Modern discussions of property by economists tend to focus on the benefits of property rights and wrongs once they are established, but what Pufendorf clearly articulates about the origins of property and what we too hence *rediscover* in our experiment is that there is a necessary precondition that people are predisposed toward cutting off all manner of quarrel or dissension. *Both ecology and civility are mainsprings of property.* This article lays the foundation for exploring the steps of moving from resource extraction in a negative community, to resource cultivation in a positive community in which those outside the group are excluded by right from the goods in question, and then finally to a system of private property that further increases the industry of people with the strongest of all incentives—reaping the rewards of one’s own efforts.

We gratefully acknowledge the financial support of the International Foundation for Research in Experimental Economics and Chapman University. We also thank Jeffrey Kirchner for his software programming sans pareil, Elliott Kashner for his initial work on this project as part of his undergraduate independent study at George Mason University, and Pete Abbate, Joy Buchanan, Michael Gamboa, Matt McMahon, Maciej Pisarek, Matt Simpson, and Jake Troesh for their competent research assistance. Finally, we thank Doug Davis, Robert Ellickson, Erik Kimbrough, Deirdre McCloskey, and Vernon Smith for comments that have improved the article as well as seminar and conference participants at the 2010 Southern Economic Association Meetings, the Property and Environment Research Center, Baruch College, Cal Poly State University, CERGE-EI, Florida State University, Georgia State University, and the University of Southern California. The data and source code are available upon request.

Appendix A

Experiment Instructions

Welcome

You will be participating in an economics experiment. The choices you make while in this experiment can earn you money, which will be paid to you in cash at the conclusion of the experiment.

In this experiment, you will be a **Red/Blue/Green/Teal/Orange/Purple** person. You and 5 other people will be gathering circles over the course of several periods. Each period consists of two phases: the gathering phase and the interim phase.

Gathering Phase

During the **90-second** gathering phase, the middle of the screen will display a gathering area, where each person is represented by a stick figure. Circles will randomly appear and move around this area. To move your stick figure around, **left click** anywhere in the gathering area and your figure will move to that spot. Do this now.

To gather circles, you must throw out a line from your stick figure to a moving circle. To do this, **right click** anywhere in the gathering area. If you **right click** on a circle, your figure will throw a line to that circle and attempt to catch it. You cannot throw out a line beyond the colored circle surrounding you stick figure. (You cannot do this until the experiment begins.)

After successfully striking a circle with a line, it will take 5 seconds for you to attempt to catch it. The computer will determine randomly whether you were successful in catching the circle. If you are successful, it will appear in your cargo area located around the border of the gathering area. The cargo boxes of the other people in the experiment are also displayed here.

After you use a line, you will have to wait 5 seconds before you can throw another one. During this time you will still be able to move around but you will be unable to throw lines.

The Status Bar along the bottom of the screen will keep you updated with the events of the gathering phase.

On the top right side, you will see the number of lines that you have left. There are two types of lines, *regular* and *colored* which can be selected by using the appropriate radio button next to them. Both lines work in the same way with one exception. If you hit a circle with a *colored* line, the circle will turn your color whether or not the computer determines you are successful in catching it.

More than one person may attempt to catch a circle at the same time. If more than one person is successful in catching a circle, each successful person will receive only fraction of the circle, where the sum of the individual fractions is less than the whole circle. Each person receives $1/n^2$, where n is the number of people successful in catching the circle. The remaining portions of a circle that no one receives are displayed in the "Portions Lost" area at the bottom of the screen.

The value of a circle is displayed under the circle in the cargo area. All whole circles will have a starting value of **100¢**.

If your line hits a circle, but you are not successful in catching it, the circle will move away from you, but at a slower pace. Others can attempt to catch the circle as it moves away from you.

Interim Phase

Between gathering phases is a **90-second** an interim phase. During the interim phase you are free to talk with the other people in the experiment. Type your message in the bottom of the chat area, and then press ENTER or click the SEND button. (You cannot do this until the experiment begins.)

You are free to discuss any and all aspects of the experiment, with the following exceptions: you may not reveal your name, discuss side payments outside the laboratory, make threats, or engage in inappropriate language (including such shorthand as "WTF"). If you do, you will be excused and you will forfeit your earnings.

To convert your gathered circles into earnings you must move them to the Buyer on the right side of the screen. Your cumulative earnings are displayed in the lower right.

To move a circle, first **Left click** to select a circle (it will become highlighted in yellow). Then with the **Right mouse button depressed**, drag the circle to move it. Do this now. If you have a question, please raise your hand.

If you move a circle to another person's cargo area, the circle will be transferred to them. (You cannot do this until the experiment begins.)

At the end each interim phase any circles remaining in the cargo box will disappear.

Money can also be moved in the same way as circles. First click on the ¢ tab in your cargo area and then left click on the desired amounts to add them to your selected total. Then right click and drag your selected total to another cargo area. That money will be transferred from you to the other player.

You may also purchase additional lines by clicking on the BUY button next to the type of line you would like to purchase. The cost of the lines is taken out of your earnings. You will be given an initial allotment of lines. After that you will be able to purchase *colored* lines for 20¢ and *regular* lines for 10¢.

Buy 5 *colored* and 5 *regular* lines now. If you have a question, please raise your hand.

This is the end of the instructions. If you have any questions or if you have not purchased any lines or if you have not redeemed a circle, please raise your hand and a monitor will come by.

If you are finished with the instructions please press Start. The instructions will remain on your screen until the experiment starts.

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- 1 Galanter (1981) credits J. Griffiths with coining the term "legal centralism" in a 1979 working paper to be published and notes that "[t]he view that the justice to which we seek access is a product that is produced—or at least distributed—exclusively by the state, a view which I shall for convenience label 'legal centralism,' is not an uncommon one among legal professionals," nor, we might add, among economists some 30 years later (1).
- 2 Another example of the emergence of a system of property in the absence of a legal authority is the mining districts of the California gold rush (Umbeck 1977). Clay and Wright (2005) show that the content of the rules of property during the gold rush critically depends upon how the nonrenewable resource is distributed in concentrated areas.
- 3 Or, as one of our subjects says, it is "free game" when the prey escapes.
- 4 See Dolin (2007) for a fascinating history of American whaling from 1614 to 1924. The cast of characters includes John Hancock, James Fennimore Cooper, and John Adams. Davis et al. (1997) document a detailed economic history of whaling for the period of 1816–1906.
- 5 Each pixel is one unit on a coordinate plane that comprises the gathering area.

- 6 More specifically, there are four status phases of circles: On-the-surface, Diving, Surfacing, and On-the-bottom. If a circle is not On-the-bottom, then a line can be attached to it. A circle takes 5 s to dive or to surface and continue to move and pick new destinations when On-the-bottom. Each second a circle is On-the-surface, there is a 10% probability it will dive. There is also a 25% probability each second a circle is On-the-bottom that it will surface.
- 7 A reader asks, “Is there any evidence of this particular loss function (I find it hard to believe that on average the introduction of a second whaler reduces output by a half)?” As we state in opening this section, some of our design choices do not have direct historical parallels to whaling in the 18th and 19th centuries, and the particular form of the loss function is one of those choices. The pertinent question is not about historical parallels of the loss function, but how well does it serve its purpose in the experiment? Our goal is to make conflict costly so as to provide a salient motivation for solving the problem. By design, failing to form a social order comes at a nontrivial monetary cost. This is decidedly important for when we observe rampant waste from conflict in some economies and very little in others, lest someone raise the question of insufficient monetary motivation for solving the social problem. Our loss function does appear to have succeeded in grabbing the attention of our subjects. The transcripts are filled with comments like “we wont get any money if it splits” and “its really not worth it otherwise [to split the circles].”
- 8 One subject from the Sony PlayStation generation offers this implied comment on the complexity of their task: “i guess the money isn’t bad considering were just playing a lame video game.”
- 9 Please note that in the actual sessions, six subjects do not appear together until period 14.
- 10 Ellickson (1991) specifically rejoins the critic who “assert[s] that the whalers’ norms were too short-sighted to be welfare maximizing” when pointing out that whalers overfished the seas (205–6). First, it would require a “sophisticated scientific understanding of whale breeding and also an international system for monitoring worldwide catches ... Whalers who recognized the risk of overfishing thus could rationally ignore that risk when making norms on the ground that the norm-makers could make no cost-justified contribution to its solution.” Second, “[e]ven though overwhaling may not have been welfare maximizing from a global perspective, the rapid depletion of whaling stocks may well have been in the interest of the club of whalers centered in southern New England. From their parochial perspective, grabbing as many of the world’s whales as quickly as possible was a plausibly welfare-maximizing strategy ... [due to] entry into whaling by mariners in ... other ports that could prove to be beyond their control.”
- 11 Henceforth we shall often refer to circles as “whales,” subjects as “whalers,” etc. We proceed in this manner purely for convenience and not because we have forgotten our remarks at the beginning of Section 2.1. Though one subject refers to the circles as “whales” in the chat room, the majority of subjects simply refer to them as “circles”; others call them “balls,” “bubbles,” “eggs,” or “fish.” Subjects also refer to the task confronting them in several ways, variously likening it to fishing, butterfly catching, and participating in an Easter egg hunt. This demonstrates that even though experimenters may implement what they consider to be neutral instructions, subjects provide their own context based upon their personal life experiences.
- 12 If a colored harpoon cost the same as regular harpoon, we could not use the choice of harpoons to distinguish between the rules of fast-fish, loose-fish and iron holds the whale. To determine the maximum amount that a colored line could cost consider that the expected number of harpoons to secure a Sperm whale is 1.96. If a whaler used a color line for the first strike and regular lines for any subsequent strikes on a whale that gets away, then the most a colored line could cost before it equaled the value of a whole whale would be 80.4¢. If the whaler only used colored lines, then the most a colored line could cost before it equaled the value of a whole whale would be 41¢. For Right whales, the expected number of harpoons to secure a whale is 1.27. Thus, a colored line would have to cost a lot

more in order to equal the value of a whole whale: 87.3¢ if regular lines are used in subsequent strikes and 68.7¢ if colored lines are only used. We thank an anonymous referee for raising this clarifying question.

13 Such waste is not guaranteed since there is a 10% (25%) probability that the subsequent strikers will be unsuccessful in pulling in a share of the whale for themselves in the Right (Sperm) treatment.

14 Of the 3,091 harpoons thrown in the Right and Sperm treatments combined, only 42 are classified as unknowable and hence we do not consider this category in any of our analysis.

15 After the first three periods, rare is the whale in either treatment that is not captured by at least one person.

16 There are no tests for which we find a significant result using the same test on all data for periods 14–26 but which is insignificant using the subsample of periods 21–26.

17 As Purple in Right4 explains, “sometimes its a mistake that we nab eachothers ... we see('e)m at the same time and we(')re like the seagulls from finding nemo, MINE!”

18 Total profits by session inversely rank order the sessions with respect to the number of deadweight loss harpoons. In terms of profits, the difference between Right2, -3, and -4 and Right1, -5, and -6 is as stark as it is for the number of deadweight loss harpoons. Likewise, profits in the Sperm sessions fall in between this gap.

19 Pooling the Right and Sperm treatments, we reject the null hypothesis of equal fast-fish, loose-fish and iron holds the whale harpoons using a Wilcoxon signed rank test ($W_{12} = 68$, $p\text{-value} = 0.0210$, two-sided).

20 Because people can transfer money to each other, our experiment allows for positive rewards for good behavior. Negative sanctions are also possible by deliberately following a deviant around in order to harpoon the deviant’s harpooned whales. The subjects in Right2 talk explicitly about this in period 15 and agree to target Green for his unruly behavior:

Red: green you took mine! haha

Orange: what ever happen to our deal??

Green: hhahah im the best

Green: im the master

Teal: i know right

Blue: green u suck\

Green: i leraned the best from teal

Orange: ok everybody only steal from green

Teal: LOL

Blue: k

Red: haha

Green: hahah hey no fair

Orange: deal

Teal: deal

Purple: haha

Orange: blue??

Orange: dude come on

Blue: sorry ...

Purple: hahahaha

Orange: or dudet u in??

Orange: steal from green no one else

Orange: ??

Blue: i will

Purple: me 2

Orange: sweet

Eventually Green reforms. As Figure 2 shows, Right2 whalers threw many deadweight loss harpoons shortly after the sextuplet forms, but the number of double-hits falls precipitously until the end of the session. We thank Robert Ellickson for his questions about the possibilities for negative informal sanctions.

21 More so than the average person, economists are chary if not openly hostile to accepting at face value what people say, for as McCloskey (2010) notes, “[s]ometimes people mean what they say, or at least say by accident their meaning. Words are data for a social science, too” (43). The burden rests with the skeptic for offering a theory and evidence that the participants in the three sessions that have successfully formed a working social order do not in fact mean what they say when they agree to abide by a rule recognizable as fast-fish, loose-fish.

22 We are using civil and rude in the common 18th century meaning of the words. Our modern lexicon does not have a better pair of mutual antonyms for our purposes. As opposed to the modern meaning connoting a citizen of a state, civil in the 18th century also meant “relating to a community of men, or to a man as a member of community” (Johnson, 1755/2005). Rude also conveyed a much harsher sense than it does now, connoting “rough, savage, coarse of manners, uncivil, brutal” (Johnson, 1755/2005). Adam Ferguson in his *An Essay on the History of Civil Society* distinguishes rude societies from civil ones based upon the establishment of property. He describes people “[o]f rude nations, under the impressions of Property and Interest,” as a “band of robbers, who prey without restraint, or remorse, on their neighbors” (1767/2007: 82–3). That aptly describes the whalers of Right1, -5, and -6. We could have used communital instead of civil, but the latter additionally conveys, just as rude does, how the community goes about their business in way that the former does not.

23 Following Gunnthorsdottir et al. (2007) and Rigdon et al. (2007), we do not reveal to our subjects how their group is formed because our hypothesis is not about the rules of capture that people develop when they know they are combined with two other pairs who have the fewest or highest total number of strikes on attached whales in the previous six periods. Rather, the question is what rules, if any, spontaneously emerge among six similarly disposed people who happen to find themselves suddenly interacting with four other like-minded people.

24 Except where noted, there are no tests for which we find a significant result using the same test on all data for periods 1–13 or 14–26, but which is insignificant using the subsample of periods 8–13 or 21–26.

25 To illustrate that the participants are in fact exploring different rules early in the session and weighing the costs and benefits of the colored lines, the following is a conversation of one pair in periods 3 and 4 of Sort5:

Orchid: use the colored ones ... then we know who's is whos

Orchid: white are up for grabs

Olive: hm

Olive: We can see who is hitting whose just by the lines

Olive: don't need the colored

Orchid: can we agree that if it's my color you wont go for it? that justifies the higher cost for the colored line

Orchid: we're not always next to eachother

Civil4 has a similar conversation in period 19:

Green: ok so when its not ur color dont grab itt

Brown: haha

Brown: and if you see the word 'hit dont go after it"

Green: yeah

Brown: you guys are balla ... using colored lines

(For those readers unfamiliar with urban vernacular, “balla” is a suburban variant of “baller,” which means a person ostentatiously displaying wealth and a cocky attitude. Think LeBron James.)

We also conducted a rigorous content analysis on the chat transcripts involving 200 h of work by seven research assistants. An appendix available upon request discusses the procedures and results. Of the 21 different

codes that the research assistants could assign to each line of chat, there was only one significant treatment difference: Civil sextuplets discuss the change in circle movements more than the Rude sextuplets. One of 21 is too close to $\alpha = 0.05$ to draw any conclusions.

26 In the sole exception to footnote 24, for periods 8–13 we can reject the null hypothesis in favor of the alternative that there are more iron holds the whale harpoons in the Right treatment than in the Sort treatment ($U_{36,18} = 424.5$, $p\text{-value} = 0.0648$).

27 Yes, the total number of deadweight loss harpoons is exactly the same in Right and Rude over these six periods. This observation together with Finding 5 suggests the strong degree to which a few bad apples can spoil the whole barrel and confirms that our choice of six subjects per sessions is successful in generating conditions for amorphy.

28 We are using the term “group selection” in the cultural, not biological sense of the term.

29 Julius Paulus, the third-century Roman jurist, astutely put it this way: “What is right is not derived from the rule, but the rule arises from our knowledge of what is right” (quoted in Hayek 1973: 72, 162).

30 The following representative exclamations attest that we have replicated such mischievousness in our experiment: “you’re all a bunch of crooks,” “o! damn the heathen,” “we(’)re turning into vultures,” “It’s a madhouse! A madhouse!,” “this is madness,” “I’m gonna have nightmares about this tonight,” and “This is like lord of the flies, they leave us to fend for ourselves, lol.”

31 For those unfamiliar with instant messaging shorthand, “omg” means “oh my god!”.