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Children and the Commons Dilemma[1]

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The management of a commons dilemma analog by same-age, same-sex groups of children from age 3 to age 16 was examined. The effectiveness of commons dilemma management by the groups was greater than expected. Effectiveness increased with age and from one period to another. There were no sex differences, but a significant age x sex interaction indicated that girls manage the commons better in the younger groups and boys manage it better in the older groups.

When a number of consumers draw from a finite but slowly regenerating resource pool (e.g., fresh water, whales, oil, grass for grazing), each of them faces a dilemma. If individuals have the capacity to harvest the resource faster than it regenerates, the temptation arises to harvest the resource quickly, before someone else does. The commons dilemma, as Hardin (1968) christened it, is thus concerned with the quality of resource management and with inter-consumer relationships.

Hardin, supported by some research (Edney, 1979), is not optimistic that groups of consumers can cooperate, even when cooperation means greater long-term benefits to individual consumers. Instead, it is expected that individuals will succumb to their mistrust of others' intentions, panic harvesting will begin, and to everyone's chagrin the entire resource will be eliminated. In this paper, the terms success, cooperation, and effective resource management are all used to indicate a pattern of response to a commons dilemma situation characterized by individual harvesting restraint in favor of two outcomes which tend to occur simultaneously: (a) the resource is not extinguished (in very successful management, it even remains at a level that allows for full

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recovery during a natural cycle, such as a season or year) and (b) individual consumers grow wealthy, not quickly, but steadily.

While not much empirical research on the commons dilemma has yet emerged, enough has appeared to suggest that the original pessimism is unjustified in some circumstances. More successful resource management occurs when separate territories are established (Cass & Edney, 1978), when participants are allowed or encouraged to communicate, when there is public disclosure of harvesting, and when expectations about others' behavior are positive (Dawes, 1980). However, the literature on the commons dilemma has so far not included the developmental aspects of managing a resource. The present study examines responses to a simulated commons dilemma situation across the age range 3 to 16.

Successful management of a commons dilemma requires cooperation. Cooperation in children has been studied from a variety of perspectives using numerous (often incompatible) definitions of the word cooperation, measured with techniques ranging from games to questionnaires. The unsurprising result is that conclusions about the development of cooperation have disagreed strongly. While some argue that cooperativeness rises with age (e.g., Lefrancois, 1977, p. 318), there are also studies reporting a decline in cooperation from age 2 to age 12 (e.g., Ahlgren & Johnson, 1979).

A second issue is whether or not there are gender differences in cooperation. Evidence has appeared (Maccoby & Jacklin, 1974) to support all three possible positions on the issue (females more, males more, no difference). Again, such differences may be the result of differences among studies in methodology, sex differences in goals (e.g., mastery for males and social facilitation for females), and operational definitions (Minton & Schneider, 1980, pp. 298-300).

A third issue turns on the question of whether or not children's groups will manage the commons more or less effectively as their experience grows. Hardin's (1968) original work suggests that once consumers see the vulnerability of the resource and that others have the capability to harvest most or all of a valuable commodity, they will behave in accordance with an individual-gain strategy. That is, as consumers learn how common dilemmas work, they will act in an ultimately *less* successful, uncooperative manner. Cass and Edney (1978) and Edney and Harper (1978) also have noted the persistence of individual-gain strategies, even when information about successful strategies is supplied. None of this work has involved children, but an initial hypothesis would have to be that children generally will move toward less cooperative behavior as they learn more about the nature of the commons dilemma.

Field research on commons dilemmas is especially difficult and therefore rare in this area [but see Acheson (1975) for one example] and so far researchers have relied on simulated commons dilemma situations. Edney (1979) has introduced a commons dilemma simulation he calls "practical, manageable, concise and conceptually defensible." This analog is described in Edney (1979) and later in this report, but briefly it involves a group seated around a shallow bowl of small valued objects. During a defined time interval, any participant may withdraw any or all of the objects at any time. However, if any objects remain at the end of the period, their number is doubled (sometimes to a maximum, such as the original number of objects). As long as the pool of objects is not exhausted, an indefinite series of such replenishments may be made. In this study, each such sequence of time intervals will be called a period. Each time interval, during which harvesting occurs or does not occur, is called a trial.

This simple exercise easily lends itself to the study of many independent and dependent variables hypothesized to influence or reflect effective management. Edney and Harper (1978) have argued that the commons dilemma is a better vehicle for the investigation of cooperation than such older techniques as the Prisoner's Dilemma game because it is, while still a laboratory exercise, more realistic: Since there are more participants (as is typical of daily life), there are more possible strategies, more communication possibilities, and more outcome possibilities. Anecdotal evidence suggests that commons dilemma exercises are extremely interesting and involving to the participants, if not always pleasant in their outcomes.

This study examines the quality of resource management as a function of age, gender, and experience. The specific origin of this study is Edney's (1979) comment that in "pilot work I have found that approximately 65% of groups never in practice reach the first replenishment stage because they exhaust the pool . . . in the first few moments of the game" (p. 253).

Method

Subjects

The participants were drawn from classrooms and summer recreation programs in Victoria, British Columbia. After teacher or recreation supervisor permission was obtained, children were asked to volunteer. Four to six same-age, same-sex triads of each sex were formed for each of the following ages: 3, 4, 6, 8, 9, 10, 11, 12, 14, 16. In sum, 255 children (132 males in 44 groups and 123 females in 41 groups) participated. The members of each triad tended to be acquaintances rather than best friends or strangers, due to the way in which triads were formed: After the teacher or supervisor gave permission, the experimenter asked all the children who wished to participate to raise their hands. The experimenter then chose three children from different areas of the classroom or recreation group.

The participants ranged across the socioeconomic spectrum since they were drawn from classrooms and recreation programs in neighborhoods which varied from lower to upper class in predominance. The participants were nearly all Caucasian, with a few Oriental children.

Design and Apparatus

The goal was to sample both sexes and nearly all ages from the youngest found capable in pilot work of understanding the rules, to the near-adult stage. In pilot work, we found that at least some 3-year-olds clearly could understand the rules. While none of the 3-year-olds tested displayed any inappropriate behavior, probably not all of the youngest children fully understood the rules.

The apparatus was similar to that described by Edney (1979). A large, flat bowl is filled with 12 plastic golf balls. The experimenter also has a large bag filled with many more golf balls: It is important that participants believe the supply of new resources *could* go on indefinitely. The experimenter is also supplied with a data sheet prepared so as to facilitate the scoring of the dependent measures. Under these conditions, harvesting is a public behavior and no individual territories exist. Communication was neither encouraged nor discouraged in this study. Most groups engaged in some discussion during the exercise.

Procedure

Each participant engaged in four periods: two practice periods as an individual and two experimental periods as a group member. The purposes of the two individual practice periods were to introduce the exercise, to demonstrate the rules, and to assess how well each participant understood the rules. When a single person participates, the heat of competition is gone. A child who understands the rules should be able to avoid destroying the pool, if not to maximize yield.

The instructions given for the practice periods were as follows:

> This is a game in which the object is to take out as many balls from this bowl as possible. There are 12 balls in the bowl now. For every four balls you get, I will give you a reward (the specific rewards are explained below) when the game is finished. The more balls you take out, the more rewards you will get later. Now, when I tell you to go ahead, you can reach in and take out as many balls as you want. You can take them all out or just some of them or take none of them out. When I tell you to start, I will count to ten. After I have finished, if there are any balls left in the bowl, I will put the same number of balls in the bowl from this bag and you can take some out again. But I will not put in more balls than are there right now. If you take all the balls out, I cannot put any more balls back in the bowl and the game will be over.

The participants were asked if they understood the rules and any questions were answered. The first practice period ensued, which made it obvious whether or not the child understood. If the child immediately harvested all 12 balls, thereby exhausting the pool, the appropriate reward was given to the child, but the rules were carefully explained again and it was emphasized that he or she could have obtained a larger reward by leaving some balls in the bowl each time. The second practice period followed. A maximum of four replenishments occurred in each of the two practice periods. Then the experimenter said that the game was over for now, but there would be another chance to play soon.

The goal of teaching each participant that partial harvesting during each replenishment trial leads to a greater long-term reward was met for nearly all children (92%) of all ages. In fact, we discontinued the second practice period for some of the older children because they all understood the maximal strategy (to harvest half the objects in each trial) so well after one period. Not all children grasped this maximal strategy, but almost all of them learned the basic principle that one ought not to harvest all 12 objects in one trial.

After three participants had been through this didactic phase, they were assembled as a group. The instructions were essentially the same, but the experimenter emphasized that while the rules were the same, there were now three people who could take balls out at any time. Further, they were told that if they wished to participate again (as part of a group), they would have to pay the experimenter one reward item as an entrance fee. This requirement was intended to simulate the initial capital outlay necessary in most real resource harvesting situations. No subjects decided not to join in. Period 1 followed.

If the group harvested all the balls in Period 1, the experimenter explained the rules again before Period 2 and emphasized that everyone could obtain larger rewards if some balls were left, to allow for replenishment. Pilot testing showed that seven replenishments were enough to demonstrate the pattern for a group's harvesting behavior: By the seventh replenishment, groups usually had either destroyed the pool or stabilized their harvesting behavior at some level which allowed the pool to remain viable.

Reward systems for wide age ranges are always a problem. On the one hand, if an experimenter dispenses the same reward to all ages, the reward is bound to be more desirable to some ages than to others. If, on the other hand, the experimenter attempts to alter the reward to suit the age, there is a risk that the different types or amounts of reward dispensed to different age groups will not be exactly proportional to age. In this study, the decision was to (a) dispense three kinds of rewards to three age categories based on our estimate of what would be desirable to those three groups and (b) to increase the monetary value of the rewards to the three age groups based on the assumption that to have equal reward value to older children, a reinforcement must have higher retail value. Further, likely total winnings were estimated, based on pilot testing, so that to the typical participant the final total reward seemed neither too skimpy nor so numerous that the rewards lost their initial value. Thus, after pilot testing, the following reward system was chosen. Each participant was rewarded after each practice and experimental period based on his or her total harvest for that period. For the younger participants (ages 3 to 6), the reward consisted of one animal cookie for each set of four balls harvested. For the middle children (ages 8 to 11), the reward was one piece of red or black licorice (their choice) about 10 cm long for each set of four balls harvested. The older participants were rewarded with pens of variously colored inks (their choice). They could choose any combination of ball-point pens (1 for each 5 balls) or felt pens (1 for each 10 balls).

Dependent Measures

Several ways of measuring harvesting behavior have been suggested (Edney, 1979). The present measures are based on these suggestions. Harvest is defined as the total number of balls harvested in one period (i.e., until the pool is exhausted by the group or the maximum number of replenishments of the supply by the experimenter had been reached). Replenishment, a second measure, measures the total number of balls replenished by the experimenter. Number of Replenishments, the third measure, simply counts the total number of replenishments made by the experimenter, independent of the number of balls replenished each time.

These measures are both conceptually and empirically related to one another. In this study, the correlations among them for Period 1 across all ages were: Harvest-Replenishment, .97; Harvest-Number of Replenishments, .75; Replenishment-Number of Replenishments, .79. For Period 2, the respective correlations were .98, .71, and .75. The close association among the three measures led to the creation of an index termed Harvest Index. Across periods, the three dependent measure scores were standardized and then summed to form a Harvest Index score. The Cronbach alpha reliabilities for these composites were .94 for Trial 1 and .93 for Trial 2. Harvest Index was deemed sufficiently reliable for use as a general measure of harvesting behavior.

Results

The data were analyzed with a 10 (Ages) × 2 (Period) × 2 (Sex) ANOVA in which Age and Sex were between-subjects variables and Period was a within-subjects factor. The means and standards deviations of the Harvest Index dependent variable are displayed in Table 1. Three trends shown by the means are for harvest to (a) increase with Age, (b) increase from Period 1 to Period 2, and (c) for females to harvest more than males. Figure 1 presents these trends graphically, using Harvest, itself, as the dependent variable.

TABLE 1

HARVEST INDEX MEANS AND STANDARD DEVIATIONS BY AGE, SEX, AND PERIOD

Age	n^a	Males		Females		Age means
		Period 1	Period 2	Period 1	Period 2	
3	6,3	-3.50/.00	-3.10/.68	-1.82/2.91	-1.58/3.33	-2.77
4	4,4	-2.96/.76	-2.27/2.09	-3.36/.28	-1.62/2.75	-2.55
6	5,5	-2.86/.71	-1.26/2.98	-2.07/3.19	-1.21/2.93	-1.85
8	6,4	-3.01/.75	-1.59/2.41	.46/3.23	.64/4.61	-1.16
9	4,4	2.27/1.41	.72/1.37	-.96/.58	-.89/1.96	.29
10	4,4	1.52/.67	2.73/.99	-2.10/2.45	-.48/1.64	.42
11	4,4	.83/1.74	1.50/1.32	-1.31/2.55	1.12/2.74	.54
12	4,4	4.13/2.23	3.06/2.45	.94/1.43	1.65/.82	2.45
14	3,5	1.40/1.28	3.15/3.55	4.21/1.81	4.92/1.70	3.71
16	4,4	2.70/2.90	2.53/3.71	.84/2.06	2.10/2.96	2.05
Period Means		-1.52	.81	-1.67	2.39	
Sex Means		-.36		.36		

[a]Number of male and female groups, respectively.

Age

Results of the analysis of variance confirm the significance of the age trend [$F(9,65) = 10.02$, $p < .001$]. As children develop, groups are able to manage the resource so the group obtains more total rewards. Due to the nature of the rules of the analog used, this can only happen when individuals make implicit or explicit agreements not to withdraw large numbers of objects as individuals, but to harvest objects at a moderate rate which will ensure that a future supply of objects will exist. A real-world parallel would be to a group of fishermen who agree to limit individual catches to a certain total (even though each fishermen has the capability to catch all the fish) so that the fish stock will replenish itself for subsequent fishing seasons. Inspection of Table 1 reveals a trend for resource management effectiveness to decline from age 14 to age 16, against the general age pattern. A post hoc t-test between the groups indicated that the decline is a nonsignificant one. However, for this comparison of only two age groups, the sample size is fairly small; with a larger sample of 14 and 16-year-olds, the decline might be statistically significant.

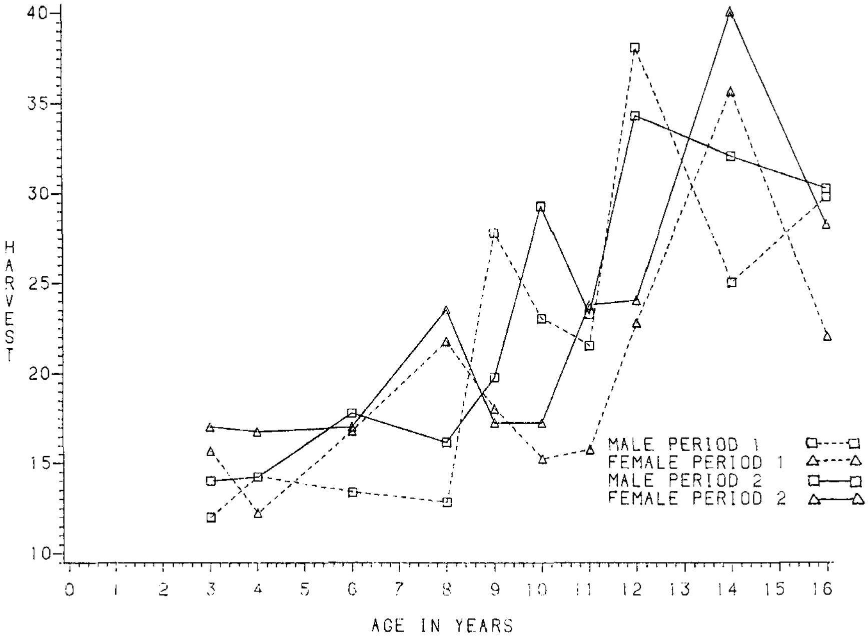

FIG. 1. Mean total harvest in each period by age and sex.

Improvement Over Periods

The results also support the idea that children learn how to improve their management of the commons from a first to a second period [$F(1,65) = 8.47$, $p < .01$]. Since it was a reasonable possibility that imperfect management on Period 1 (which was nearly always the case in this experiment) might have led to more selfish, individualistic responses on Period 2, it is noteworthy that the opposite occurred. Despite less than ideal cooperation in their first experience, it is encouraging that the children moved significantly toward increased, rather than decreased, cooperation in a subsequent experience.

Sex Differences

The small trend for females to manage the resource more effectively than males was not statistically significant [$F(1,65) = .62, p > .40$].

Interactions

Of several possible interactions effects among the independent variables, only one reached significance. Quality of resource management appears to be a joint function of Age and Sex [$F(9,65) = 2.68, p = .01$]. Table 1 indicates that between ages 3 and 8, girls cooperate more than boys; while between 9 and 12, boys cooperate more than girls. Ages 14 and 16 show mixed results, with girls cooperating more at 14 and boys at 16.

Discussion

The results are clearly more optimistic than a reader of Hardin's (1968) original article might expect. Participants in this study are surprisingly able to control their immediate self-interest and their distrust of others to keep a vulnerable resource viable and simultaneously to enhance their own wealth.

The Strategies of Success

Observations of the participants as they grappled with the conflict between immediate self-interest and cooperative behavior suggest that numerous strategies, with varying success rates, are employed. For example, the less successful groups often learned to cooperate enough to keep the resource pool viable, yet an element of self-interest is also present. In practice, this means that often the less successful groups would harvest *many* (e.g., 10) balls in the first replenishment period, leaving only a few balls to be matched by the experimenter. For the next several replenishment periods, the struggle was to withdraw *only* one or two balls (for the entire group) so as to avoid extinguishing the resource. Those groups who succeeded in lasting until the end of the planned series of seven replenishments often were nursing an endangered species.

In contrast, the more successful groups not only realized that the pool must be kept alive, but also that there is an optimal number of objects to leave (6 in this case, so that 6 more are replenished to the ceiling of 12). This increment in strategy yields an increase in the total harvest. If the minimal definition of success is keeping the pool alive throughout the seven replenishment periods, failure might be defined as destroying the pool at the first opportunity. This leaves several intermediate levels, which might be called partial success. In Period 1, 74% of all groups either succeeded *or* failed; in Period 2, 72% either succeeded *or* failed (in keeping with the trend across periods to more cooperation, the 72% for Period 2 includes more "success" groups). This means that only about a quarter of all groups were partial successes, even though there are more possible levels of partial success, viz., all the intermediate number of replenishment trials from 2 to 6. In short, groups tended largely either to cooperate *or* to fail to cooperate, but not to cooperate partially. An especially deserving avenue of future work would be an examination of the reasons for this tendency of groups to either succeed or fail. One reasonable possibility is that something about the *combination* of particular individuals leads to success or failure (but not partial success). This should indicate that such variables as degree of acquaintance, trust, expectations of others' behavior and communication, which have shown some promise in earlier work (Edney & Harper, 1978), should be investigated as group composition variables, i.e., not as individual scores but as group profile scores.

Procedural Parameters

The relatively high level of cooperation obtained in this study may be due to the specific choices of procedure made. For example, one might argue that the decision to require an investment by participants spurred greater interest in cooperation by encouraging participants to seek a good return on their investment. On the other hand, participants acting in an individual-gain strategy could have obtained many times their investment simply by grabbing a dozen objects at the first opportunity. Also, participants were encouraged to cooperate between periods, as they might be in a real situation where poor management practices are noticed. The increase in cooperation from Period 1 to Period 2 is probably the result both of experience and further education.

There is also the question of the size of rewards. Intuitively, one might posit a curvilinear relationship between size of reward and degree of cooperative behavior. When the reward is trivial, as it has been in some commons dilemma research, participants may not behave in a serious manner. There is no great loss attached to acting uncooperatively; in fact, some participants may see the exercise as an opportunity to entertain their friends or to "fool the experimenter." When the reward is meaningful but not extremely large (as intended in the present study), one might expect a fairly high level of cooperation because participants value the reward enough that they do not wish to pass up the chance to obtain it, but neither are they extremely worried about *not* gaining the reward. When the reward is very great, or the consumer's need is very great, Hardin's pessimism may be more justified.

Age

The results generally support the notion that children are able to manage resources more effectively as they get older. Indeed, one intriguing facet of the study is that it seems to show that children cooperate better than young adults. Edney (1979) reports only anecdotal data, but it shows that 65% of his college-age groups destroyed the pool at the first opportunity. While at first this seems counter to present age trend results, it should be recalled that in the present study a decline in quality of resource management from a peak at age 14 to age 16 was observed. If confirmed with larger samples, such a trend could be compatible with a further decline from 16 to college age. If this further work found that the decline persisted into middle adulthood, one would be tempted to recommend that resource policymaking be turned over to 14-year-olds!

However, there are other plausible interpretations. For one thing, Edney's subjects were not a general sample of young adults, but a sample which had survived a competitive educational system and which continued to exist in an educational climate characterized by moderate to severe competition. This competitive atmosphere might have influenced its management of the commons. Perhaps a noncollege sample of 18-year-olds would not destroy the pool so quickly, although if that were to be found, one would then be forced to wonder about the value of the postsecondary education as a cooperation-facilitating experience or as a recommended background for careers in resource management.

The success rate by age is of interest. If a minimum operational definition of effective resource management is maintaining the viability of the pool of resource for all seven replenishments periods, then even 3-year-olds are capable of success on this task (one group out of nine did so in Period 1 and Period 2). Twenty percent of the 6-year-olds succeeded, 30% of the 8-year-olds, 69% of the 10-year-olds, and 87.5% of the 14-year-olds (across both Periods). Across all ages and both periods, the success rate was 41% on Period 1 and 51% on Period 2. In sum, about half of all children 3 to 16 are able to cooperate to keep a resource pool viable for at least seven replenishment trials, if not to maximize their potential yield. At the upper end of management effectiveness, 87.5% of 14-year-olds were successful, as mentioned, but also the 14-year-old groups managed to garner an average of nearly 80% of the *maximum possible* harvest.

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