A Cue Utilization Approach for Investigating Harvest Decisions in Commons Dilemmas

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Hierarchical linear modeling (HLM) is introduced as a new tool for investigating decision making in commons dilemmas. University undergraduates ($N = 171$) managed a virtual fishery, with 2 computer-simulated fishers, over 60 seasons. Level 1 HLM analyses revealed that participants took significantly more fish during seasons when feedback suggested fish stocks, fish value, and fishing expenses were high; and when noncooperative and cooperative others had taken more fish and fewer fish, respectively, in the previous season. Level 2 analyses produced several cross-level interactions, indicating that participants' use of feedback information varied as a function of their social values and environmental attitudes.

Social dilemmas are situations that involve a conflict between individual and collective rationality. The dilemma involves choosing between an action that clearly benefits the self and an action that benefits a larger group to which one belongs (Dawes, 1980). Individuals usually make this choice knowing that if most or all of their fellow group members choose to maximize personal payoffs, the consequences for the group can be dire. On the other hand, if one limits his or her own payoff to help the group, there is no guarantee that others will act in a similar manner.

Social dilemmas involving the management of a limited shared resource are known as *commons dilemmas*. Although *commons* originally referred to jointly owned grazing pastures (Hardin, 1968; Lloyd, 1837/1968), the term now is used more broadly to refer to any desirable resource accessed, owned, or managed by a group (Gifford, 2002). Examples of common pool resources include fisheries, forests, fossil fuels, groundwater reserves, fresh air, and roadways. In the case of fisheries, if most harvesters take many fish each

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season, overharvesting will outstrip the fishery's ability to replenish itself, and the resource will become depleted and possibly extinguished. On the other hand, if harvesters take fewer fish per season, the fishery will remain viable, and more fish can be harvested over the long run.

Hierarchical Linear Modeling: A New Approach for Analyzing Commons Dilemma Data

Psychological research on commons dilemmas typically involves groups of participants managing a simulated, shared resource pool over multiple seasons or trials. In almost all studies, repeated-measures ANOVA is used to identify changes in participants' harvest decisions over time in response to feedback about the state of the resource pool, the harvest patterns of the other group members, and other situational and individual-difference variables that may be of interest. In the present study, hierarchical linear modeling (HLM; Bryk & Raudenbush, 1992; Raudenbush & Bryk, 2002) is introduced as an alternative approach for analyzing commons dilemma data to determine which feedback cues participants employ when making harvest decisions, and whether cue-usage patterns vary as a function of individual differences in social values and environmental attitudes.

HLM is an extension of multiple regression that is designed specifically to analyze nested data. Nested data can take many forms, but perhaps the most common example presented in textbooks involves educational research in which students are nested within classrooms, which in turn are nested within schools. In commons dilemma research, data can be nested in two ways. First, in studies in which participants harvest from a resource pool over several seasons or trials, individual harvest decisions are nested within participants. Thus, all studies involving repeated measures can be thought of as nested designs. Second, in studies in which participants manage the resource as a part of a larger group, individual participants are nested within groups.

Nested data can create numerous challenges related to statistical analysis and interpretation.[2] For the present purposes, we will outline several advantages of HLM that make it an attractive alternative to repeated-measures ANOVA for commons dilemma researchers.

Non-Independence in Nested Data Structures

In some commons dilemma studies, data are collected simultaneously from groups of participants who jointly harvest from the same resource pool.

[2]For a detailed review of these issues, see Hox (2002), Raudenbush and Bryk (2002). For a more general introduction, see Tabachnick and Fidell (2007).

Participants receive feedback about the state of the resource pool and other group members' harvests following each harvest trial (e.g., Hine & Gifford, 1996). Given that each participant's harvest decisions are determined partly by the actions of other group members in such studies, the data are not independent. This violates a fundamental assumption of ANOVA, as well as most other standard statistical approaches employed by psychologists.

A common approach to avoid the dependent observations problem involves aggregating scores across individuals within each group and using the group as the unit of analysis (e.g., Bell, Petersen, & Hautaluoma, 1989; Edney & Bell, 1987).[3] However, this can result in a substantial reduction of statistical power (given that there are fewer groups than individuals) and can also obscure individual-level effects that may be of interest to the researcher.

HLM partitions variance into within-individual, between-individual, and (when required) between-group components. This enables researchers to control for potential dependency problems, and simultaneously investigate effects at several distinct levels of analysis. For example, researchers can assess (a) the relationship between feedback cues and harvest decisions within individuals across trials (Level 1 analysis); (b) whether the feedback–harvest relationships vary as a function of individual-difference variables, such as values and attitudes (Level 2 analysis); and (c) whether the individual-difference effects vary as a function of group-level variables, such as group size, gender composition, and so forth (Level 3 analysis).

Missing Observations

Repeated-measures ANOVA requires that all participants' harvest decisions are assessed at a predetermined and equal number of time points; typically once during each harvest season or trial. This requirement can create problems in studies in which different participants manage the resource for different periods of time (e.g., some participants may extinguish the resource after only 10 trials, whereas others maintain resource for 30 trials or more). In HLM, Level 1 regression intercepts and slopes are computed for each participant based solely on the data available for that participant. Thus, there is no requirement to collect an identical number of data points from each participant.

[3]In some studies, such as the present one, the group dependency issue is resolved by providing bogus feedback to all participants. That is, participants are led to believe that they are managing the resource with others when, in fact, they are receiving preprogrammed computer feedback. Independent responding can be further ensured by having participants complete the resource-management simulations in separate rooms or by asking them not to communicate with other group members.

Interactions Between Continuous Predictor Variables

Like multiple regression, HLM enables researchers to investigate possible statistical interactions (i.e., moderation effects) involving continuous predictor variables. ANOVA, in contrast, requires that continuous variables be transformed into ordinal or nominal categories, which may result in a considerable loss of power (Cohen, Cohen, West, & Aiken, 2003) and, under some circumstances, may produce spurious significance tests (Maxwell & Delaney, 1993).

Collapsing Harvest Trials Into Blocks

In commons dilemma studies that involve a large number of harvest trials, researchers routinely collapse trials into smaller number of blocks (typically 4 or 5) prior to analyzing their data. Although blocking can facilitate the interpretation of repeated-measures ANOVAs, it also can reduce the sensitivity of the analysis to detect changes that occur over time. In HLM, blocking is unnecessary and undesirable, given that it reduces the number of data points used to compute the Level 1 intercepts and regression slopes for each study participant.

Social Values and Harvest Behavior

Numerous studies have demonstrated reliable correlations between values and environmental behavior (Gardner & Stern, 2002; Schultz et al., 2005). Most values-related research on commons dilemmas has focused on the relation between social values and harvest behavior. Messick and McClintock (1968) defined *social values* as a general tendency to choose options that produce a desired combination of own–other outcomes. Usually, three types of social values are considered: *individualistic* (maximizing one's own gain, regardless of the outcomes for others), *competitive* (maximizing relative gain), and *cooperative* (maximizing joint gain). Individuals with individualistic and competitive values are sometimes described as having *proself* orientations, whereas those with cooperative values are described as having *prosocial* orientations. A fourth type of social value, *altruism* (maximizing others' gain) unfortunately appears to be relatively uncommon (Liebrand & McClintock, 1988) and is not investigated in the present study.

Previous research has suggested that individuals with proself value orientations are more likely to overharvest jointly managed resources than are individuals with prosocial orientations (Kramer, McClintock, & Messick, 1986; Parks, 1994; Roch & Samuelson, 1997). Kramer et al. found that proselfs, relative to prosocials, are less likely to reduce their harvests in response to feedback that suggests that a resource is being depleted. In terms of cue utilization, this suggests that proselfs should rely less on feedback cues related to resource pool viability when making their harvest decisions than should prosocials.

Little research has been conducted on the use of the other feedback cues manipulated in the present study (i.e., economic value of the fish, seasonal fishing expenses, and number of fish taken by other harvesters).[4] Nevertheless, it is reasonable to speculate that the use of these cues might vary also as a function of social value orientation. For example, given that fish value and fishing expenses relate directly to maximizing personal profit, one might expect these cues to be particularly salient to proselfs. Given that prosocials are driven by motives that emphasize maximizing collective outcomes, they can be expected to monitor the harvests of other group members so that they can adjust their own harvests upward or downward in an effort to avoid suboptimal group outcomes in response to underharvesting or overharvesting by others. Harvesters with proself values might also be expected to monitor others' harvests closely. However, unlike prosocials, their goal should be directed toward personal profit, rather than optimizing group outcomes. Thus, whereas prosocials might be expected to respond to overharvesting by others by taking less for themselves, proselfs should respond by increasing their own harvests to ensure that they obtain more than others (competitors) or maximize their own payoffs before others exhaust the resource (individualists).

Environmental Attitudes and Harvest Behavior

Thompson and Barton (1994) proposed that individuals may be distinguished on three environmental attitudes: ecocentrism, anthropocentrism, and environmental apathy. *Ecocentrism* represents the extent to which individuals perceive nature as being valuable for its own sake, derive positive

[4]Several studies (e.g., Messick et al., 1983; Samuelson & Messick, 1986) have examined the impact of the number of fish taken by others on harvest decisions. However, the focus of these studies was on conformity pressure stemming from false feedback that other fishers are harvesting either highly similar or highly dissimilar amounts from the resource pool. The primary finding has been that participants reduce their harvests in response to a strong social norm of responsible harvesting, and increase their harvest when such a norm is absent. In the present study, there was little normative pressure to increase or reduce one's harvest, given that participants experienced one computer-simulated fisher who consistently harvested a larger number of fish across seasons and a second computer-simulated fisher who took substantially fewer fish per season.

affect from interacting with nature, and view a connectedness between humans and animals. *Anthropocentrism* refers to a tendency to value nature for its contributions to maintaining or enhancing the quality of human life; while *environmental apathy* reflects a lack of caring and interest in the environment.

To the best of our knowledge, the relation between environmental attitudes and harvest behavior in computer-simulated commons dilemmas has not been studied. Nor have any studies explored whether individuals with different environmental attitudes exhibit different cue-utilization patterns. We hypothesize that ecocentrism will be negatively related to overharvesting, given that individuals with stronger ecocentric attitudes view natural resources as inherently valuable; and, therefore, are more likely to exhibit a stronger resource-preservation ethic. Conversely, we predict that harvesters who score higher on environmental apathy and anthropocentrism, relative to low scorers, will harvest more, given that they are less likely to value the environment and more likely to view natural resources as something to exploit for one's personal benefit.

Another goal of the present study is to determine whether environmental attitudes will predict cue-utilization patterns of harvesters in commons dilemmas. Given their strong concern for the environment, we expect that ecocentric harvesters, more than low scorers, will attend more closely to feedback about the number of fish remaining in the resource pool and others' harvests; decreasing their harvests in response to feedback that suggests the fishery is depleting or others are overharvesting. We also expect that highly ecocentric harvesters' concern for the environment will lead them to pay less attention to economic feedback cues (e.g., value of fish) and operating expenses than their less ecocentric peers.

In terms of anthropocentrism, we predict that harvesters who score higher on this attitude will attend more closely to the number of fish available in the resource pool, given that they are more likely to value the tangible benefits (e.g., money, food) generated by using the resource than their less anthropocentric counterparts. We also predict that harvesters with more anthropocentric attitudes will attend to other factors such as the value of fish, fishing expenses, and others' harvests, given that all of these factors could potentially affect their ability to derive maximum benefits from the resource. Given their propensity to view environmental resources as a means for increasing human comfort and wealth, we also predict that higher anthropocentrism will be associated with a lower propensity to reduce harvests in response to pool-depletion feedback.

Finally, given their lack of interest in environmental matters, we predict that harvesters who score higher on environmental apathy will be less likely to utilize feedback about the state of the resource pool than will less apathetic harvesters. It is less clear how environmental apathy might relate to the use of the other feedback cues included in the study. Thus, no additional hypotheses for this individual-difference variable are offered.

In summary, in the current study, HLM is employed to identify the feedback cues harvesters employ when making resource-management decisions in a multi-season commons dilemmas simulation, and whether cue utilization patterns vary as a function of harvesters' social values and environmental attitudes. We hypothesize that individuals with different values and attitudes will attend to different aspects of the simulation when deciding how many fish to harvest from the fishery during each fishing season.

Method

Participants

The study participants were 171 introductory psychology students (58 male, 113 female) from medium-sized universities in Canada ($n = 96$; 33 male, 63 female) and Australia ($n = 75$; 25 male, 50 female). The percentage of male and female participants was similar across locations (66% female in Canada; 67% female in Australia).

Computer Software and Hardware

A new resource-management computer simulation, modeled after the program used by Hine and Gifford (1997), was developed for the present study. Participants' harvest choices were recorded and stored in a data file created by the program. Each data file was given a unique identification number that was later used to match participants' harvest decisions with their responses to the social values and environmental attitudes questionnaires.

Values and Attitude Measures

Social value orientation was assessed using van Lange and Kuhlman's (1994) triple dominance measure of social values. The measure includes nine decomposed games; each game involves choosing between three combined outcomes for oneself and a hypothetical other, who is described as "someone you do not know and will not knowingly meet in the future." Each of the three outcomes in the games corresponds to one social value orientation: competitive, individualistic, or prosocial.

The following example illustrates the procedure. A participant is provided with three options: Choices A, B, and C. Choice A involves allocating 480 points for self and 80 points for other. Choice B involves allocating 540 points for self and 280 points for other. Choice C involves allocating 480 points for self and 480 points for other. Choosing A corresponds to a *competitive* orientation because it produces the largest relative gain among the three choices (480 – 80 = 400). Choice B represents an *individualistic* orientation because the allocation to self (540) is the largest among the three choices. Finally, Choice C represents a *prosocial* choice because it produces the largest joint outcome (480 + 480 = 960) and also the least difference between self and other (480 – 480 = 0).

Participants were classified into one of three possible social value orientations if they made at least six orientation-consistent choices across the nine decomposed games. As in many previous studies investigating social values, individualistic and competitive participants were combined to form a group labeled *proself* (Kramer et al., 1986; Samuelson & Allison, 1994; van Lange & Liebrand, 1989). The percentage of participants classified into each group did not differ significantly across the two samples, $\chi^2(2, N = 171) = 0.53$, *ns*. In the Canadian sample, 48% ($n = 46$) participants were classified as proscocial, 38% ($n = 36$) as proself, and 15% ($n = 14$) could not be reliably classified. Classification for the Australian sample followed a similar pattern: 53% ($n = 40$) were classified as prosocial, 35% as proself ($n = 26$), and 12% ($n = 9$) could not be classified. Unclassifiable participants were not included in subsequent analyses, so the final sample size was 148 ($n = 82$ in Canada; $n = 66$ in Australia).

Environmental attitudes were assessed using Thompson and Barton's (1994) ecocentrism, anthropocentrism, and environmental apathy scales. The ecocentrism scale consists of 12 items that assess the extent to which individuals feel connected to nature and value it for its inherent worth. Representative items include "I can enjoy spending time in natural settings just for the sake of being out in nature," and "It makes me sad to see natural environments destroyed." The anthropocentrism scale also consists of 12 items, and assesses individuals' tendency to value nature for its ability to maintain or enhance the quality of human life. Representative items include "The worst thing about the loss of the rainforest is that it will restrict the development of new medicines," and "We need to preserve resources to maintain a high quality of life." Finally, environmental apathy is measured using 9 items that assess the extent to which individuals are not interested in environmental problems or do not perceive environmental degradation as problematic. Sample items include "I don't care about environmental problems," and "Environmental problems such as deforestation and ozone depletion are overstated." For all three scales, respondents indicate how much they agree with each item on a 5-point scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Scale scores were computed by averaging responses to all scale-relevant items. All three scales exhibited acceptable internal consistency in this study (Cronbach's $\alpha = .82$, .74, and .81 for ecocentrism, anthropocentrism, and environmental apathy, respectively).

Procedure

After arriving at the laboratory, participants were told that it would take several minutes to set up and link the computers to be used in the study. They were told that they could assist the experimenter by completing a short questionnaire, which contained the values measures that the experimenter's supervisor was ostensibly developing for an unrelated research project.

After completing the questionnaires, participants were informed that the computer network was now operational. Each participant was seated at a personal computer separated from the other participants in the study. In Canada, 6 participants were run in each session in a large university computer laboratory. In Australia, 3 participants were run in each session in separate soundproof booths. Communication between participants during the simulation was not permitted in either setting.

Participants were told that they would be responsible for managing a simulated fishery with two other group members: a Blue fisher and a Green fisher. During each season, they were provided with feedback about the number of fish available for harvesting, the current market value of fish, the projected expenses per fisher, the rate at which the fishery replenishes itself, and the number of fish taken by each group member during the previous season.

Their task during each season was to evaluate this feedback to determine how many fish (between 0 and 30) they themselves should harvest from the fishery. The simulation was preprogrammed for 60 seasons, although the participants were told that the simulation would continue for an indefinite number of seasons or until there were no fish left in the fishery. The instructions emphasized the relation between the simulation and real-world management of scarce resources. Participants were instructed to maximize their fishing profits over the course of the simulation, and also to try to make the resource last as long as possible in order to maximize the amount of time that fish can be harvested.

Participants were told that they were interacting with fellow students to manage the fishery. However, they all received identical bogus feedback about the number of fish available for harvesting, the value of fish, the expenses associated with fishing per harvester, and the number of fish harvested by each of the other group members during the previous season.

In terms of feedback, the number of fish available for harvesting declined gradually over the simulation, beginning at 900 fish at Season 1 and ending at 0 fish following Season 60. The value of each fish ranged from \$1 to \$5 across seasons, and the expenses associated with fishing ranged from \$10 to \$100 per season. To minimize inter-cue correlations, the specific values for fish value and fishing expenses were created suing a random-number generator. Participants were told in the instructions that in some seasons, the configuration of fish value and expenses would make it impossible to make a profit. Feedback about other fishers' harvests was also randomly determined for each season, but within fixed ranges. The Blue (cooperative) fisher harvested between 10 and 20 fish during each season ($M = 15.33$, $SD = 3.00$), while the Green (noncooperative) fisher harvested between 20 and 30 fish during each season ($M = 24.92$, $SD = 3.34$).

Participants were told that following each season, the computer program would multiply the number of fish remaining in the pool by a replenishment factor of approximately 1.07. The instructions emphasized that this replenishment factor was approximate only. Participants were told that on some trials the rate would be slightly higher, whereas on others it would be slightly lower, and that they would not be told the precise rate. A complete list of the feedback provided to harvesters over the 60-season game is presented in the Appendix.

Following the simulation, participants were debriefed, thanked for their participation, and asked not to discuss the study with other potential participants. In Australia, all participants were given a \$10 honorarium and course credit, although, to maximize ecological validity, they were told before the simulation that they would be paid, based on their performance, \$0.05 for every dollar earned. The honorarium was slightly larger than the amount participants would have earned if they had harvested the maximum number of fish during each season. In Canada, participants were given either course credit or performance-based payment, but not both. The different payment strategies employed reflect slightly dissimilar ethics board polices for dealing with human research participants in the two countries.

Analysis Strategy

The data for this study were analyzed using HLM 6.04 (Raudenbush, Bryk, Cheong, & Congdon, 2004). The data were hierarchical in the sense that harvest decisions across the 60 seasons of the computer simulation were nested within participants. That is, participants made 60 harvest decisions during the simulation, each in response to a unique combination of feedback cues. In the Level 1 (within-person) analysis, regression equations were computed for each participant using the number of fish taken by the participant during each fishing season as the criterion variable; and the five resource-management feedback cues (i.e., number of fish available, market value of fish, seasonal fishing expenses, Blue's harvest during previous season, and Green's harvest on the previous season) as predictors.

The Level 2 (between-person) analysis employed a restricted maximum likelihood approach in which the intercept and beta coefficients from the Level 1 analyses were regressed onto Level 2 individual-difference variables (i.e., social values, environmental attitudes, and country). This analysis enabled us to assess whether the relation between the feedback cues and harvest decisions systematically varied as a function of individual differences, and to test the hypothesis that individuals with different values and attitudes would use different cues when making their harvest decisions.

Given that all participants were provided with identical bogus feedback during the simulation (i.e., they were managing the resource with preprogrammed computer simulated harvesters, not real people) and were instructed not to communicate with the others, harvest decisions for participants at the same data-collection sessions were assumed to be independent. Thus, group membership was not included as a Level 3 variable in this study.

Results

Descriptive Statistics

Table 1 contains descriptive statistics for the Level 1 and Level 2 variables. In addition to the three metric environmental values variables described in Table 1, there were two additional, dichotomous Level 2 variables: country and social values. As noted earlier, 55% ($n = 82$) of the respondents involved in the HLM analyses attended university in Canada, and 45% ($n = 66$) attended university in Australia. Of those who could be classified on the social values measure, 58% ($n = 86$) were prosocials and 42% ($n = 62$) were proselfs.

Unconditional Model

As an initial step, an unconditional model (i.e., no predictors at within-individual or between-individual levels) was used to decompose the total variance in harvest decisions into within- and between-person components.

Table 1

Descriptive Statistics for Metric Level 1 and Level 2 Variables Measured or Manipulated in Resource-Management Simulation

Variable	*M*	*SD*	Range
Level 1			
Fish number[a]	688.78	227.87	31–900
Fish value ($)[a]	2.77	1.47	1–5
Expenses ($)[a]	52.00	30.41	10–100
Blue harvest[a]	15.33	3.00	10–20
Green harvest[a]	24.92	3.34	20–30
Participant's harvest[b]	21.99	8.54	0–30
Level 2			
Ecocentrism[b]	4.05	0.53	2.42–5.00
Anthropocentrism[b]	2.85	0.53	1.75–4.25
Environmental apathy[b]	1.98	0.58	1.00–3.33

[a]Variables manipulated by experimenter during resource-management task. [b]Measured participant variables.

The intraclass correlation from the unconditional model was .22, indicating that just under one fourth of the variance in participants' harvests was attributable to individual differences. Thus, there was considerable variance to be explained potentially for the Level 2 analyses.

Level 1 Model

The Level 1 analysis involved regressing fish harvested (the criterion variable) on the number of fish remaining, fish value, fishing expenses, Blue's harvest on the previous trial, and Green's harvest on the previous trial. To determine the amount of variance in fish harvested accounted for by these five feedback cues, we subtracted the residual variance from the Level 1 analysis (33.1%) from the residual variance from the unconditional model described earlier (57.4%, representing the total variance for the analysis) and divided by the total variance (57.4%). This indicated that the feedback cues accounted for 42.3% of the explainable variance in harvest behavior at Level 1.

Table 2

HLM Level 1 Analysis: Relationships Between Feedback Cues and Harvest Behavior

Variable	Coefficient	*SE*	*t*(8727)
Intercept	21.972	.348	65.07**
Fish number	0.003	.001	4.11**
Fish value	1.572	.209	7.51**
Expenses	0.010	.004	2.24*
Blue harvest	–0.129	.022	–5.76**
Green harvest	0.059	.022	2.74**

Note. $df = 147$ for all significance tests. HLM = hierarchical linear modeling. Coefficients were computed using HLM's restricted maximum likelihood algorithm, and are interpreted as mean unstandardized beta weights.
$^*p < .05$. $^{**}p < .01$.

Mean unstandardized coefficients, robust standard errors for the intercept, and each of the feedback cues are presented in Table 2. The intercept value indicates that, on average, participants harvested just fewer than 22 fish per season during the simulation. All five of the feedback cues significantly predicted harvest behavior: Participants harvested significantly more fish when there were more fish available, when the value of fish was higher, when expenses associated with fishing were higher, when the Green fisher took more fish on the previous trial, and when the Blue fisher took fewer fish on the previous trial.

A summary of standard deviations, variance components, and chi-square statistics for the five feedback cues is presented in Table 3.[5] Significant variation across participants in the Level 1 beta coefficients was found for fish number, fish value, and expenses, suggesting that participants differed in the utilization of these cues. Participants did not significantly differ from each other in their use of cues relating to Blue's harvest and Green's harvest, although in both cases, variability in the weighting of these cues approached significance.

[5]To determine whether there were any curvilinear relations between the feedback cues and number of fish harvested, a second Level 1 analysis was conducted that included the feedback cues and their squares as predictors. The squared feedback cues explained only 1.6% of additional variance in number of fish harvested, suggesting that the simpler linear model reported in the Results was adequate for the purposes of the present study.

Table 3

Within-Participant Variability in Use of Resource Feedback Cues to Make Harvest Decisions

Feedback cue	*SD*	Variance component	$\chi^2(147)$
Fish number	0.01	0.00	745.12**
Fish value	2.49	6.21	3162.16**
Expenses	0.05	0.00	683.77**
Blue harvest	0.14	0.02	175.73†
Green harvest	0.11	0.01	172.67†

†$p < .08$. **$p < .01$.

Level 2 Model

A second major aim of the present study was to determine whether participants' idiographic use of feedback cues during the resource-management simulation could be predicted from individual differences in social values, environmental attitudes (i.e., ecocentrism, anthropocentrism, and environmental apathy), and country of residence. This was addressed by conducting a Level 2 analysis in which individual-difference variables were used to predict the intercept and beta coefficients associated with feedback cues from the Level 1 analysis. Significant Level 2 effects are sometimes referred to as *cross-level interactions* because the magnitude of the relation between Level 1 predictors and criterion vary as a function of the value of one or more Level 2 predictors. To aid in the interpretation of the cross-level interactions, all significant Level 2 effects were plotted using HLM's graph module. A summary of the Level 2 analysis is presented in Table 4.

Social values significantly predicted variation in the Level 1 intercept and the beta coefficient for Green's (i.e., the noncooperative other) harvest, but not variation in any of the other feedback cues used in the present study. The significant effect for the intercept indicates that proselfs harvested more fish per season than did prosocials. The significant cross-level interaction between social values and Green's harvest reveals that the magnitude of the relation between Green's harvest and fish harvested by the participants was significantly different for proselfs and prosocials. When feedback indicated that Green had taken a large amount of fish during the previous season, proselfs responded by increasing their own harvests. In contrast, prosocials' harvest

Table 4

HLM Level 2 Analyses: Feedback Cue Utilization as a Function of Individual Differences in Social Values, Environmental Attitudes, and Country

Effect	Coefficient	*SE*	*t*(142)
Level 1 intercept (mean harvest)			
Social values	1.489	.634	2.35*
Ecocentrism	–0.226	.763	–0.30
Anthropocentrism	1.335	.616	2.17*
Apathy	0.498	.757	0.66
Country	0.648	.644	–1.01
Fish available			
Social values	–0.001	.001	–0.67
Ecocentrism	0.001	.001	0.35
Anthropocentrism	–0.004	.001	3.07**
Apathy	–0.001	.001	–0.87
Country	–0.002	.001	–1.45
Fish cost			
Social values	–0.301	.412	–0.73
Ecocentrism	–0.648	.521	–1.24
Anthropocentrism	–0.193	.390	–0.49
Apathy	0.013	.523	0.03
Country	1.17	.397	2.95**
Fishing expenses			
Social values	0.005	.009	0.50
Ecocentrism	0.008	.012	0.69
Anthropocentrism	–0.012	.009	1.39
Apathy	0.009	.010	0.91
Country	0.007	.009	0.74
Blue harvest			
Social values	–0.005	.046	–0.12
Ecocentrism	0.025	.045	0.56
Anthropocentrism	–0.112	.048	–2.33*
Apathy	0.025	.050	–0.49
Country	0.049	.043	–1.13
Green harvest			
Social values	0.084	.043	1.98*
Ecocentrism	–0.076	.045	–1.70
Anthropocentrism	0.083	.039	2.14*
Apathy	–0.117	.044	–2.64**
Country	–0.040	.041	–0.97

Note. Social values: 0 = prosocial; 1 = proself. Country: 0 = Australia; 1 = Canada. All significance tests are based on robust standard errors.
$^*p < .05$. $^{**}p < .01$.

decisions were unrelated to Green's actions, suggesting that they did not rely on this feedback cue.

Environmental attitudes significantly predicted variation in the Level 1 intercept and the beta coefficients for fish number, Green's harvest, and Blue's (i.e., the more cooperative other) harvest. Relative to their less anthropocentric counterparts, high scorers on anthropocentrism harvested more fish per season, decreased their harvests less in response to feedback that the number of fish in the resource pool was declining, increased their harvests more in response to feedback that the Green fisher had made a large harvest on the previous trial, and increased their harvests more in response to feedback that the Blue fisher had made a small harvest on the previous trial. Participants who were less apathetic increased their harvest more in response to feedback that Green had harvested heavily on the previous trial. Ecocentrism was not significantly related to the Level 1 intercepts or beta coefficients.[6] Finally, there was only one country effect: Australian participants increased their harvests more than did Canadian participants in response to increasing fish values.

Discussion

HLM was also introduced as an approach for investigating which feedback cues are most strongly associated with participants' harvest decisions. HLM also addresses whether cue-utilization and harvest behavior varied as a function of individual differences in social values and environmental attitudes.

Level 1 Effects: Feedback Cues and Harvest Decisions

The results of the HLM Level 1 analyses suggest that when the sample is considered as a whole, participants used all five feedback cues from the simulation to guide their harvest decisions. Participants harvested more fish during seasons when there were more fish available in the fishery, the fish had a higher monetary value, fishing expenses were higher, Blue (the cooperative other) had taken fewer fish during the previous season, and Green (the noncooperative other) had taken more fish during the previous season.

[6]A supplementary Level 2 analysis including interactions between social values and the three environmental values measures was also conducted. None of the interactions were statistically significant, so only the results associated with the main effects model are reported.

Level 2 Effects: Values, Attitudes, and Cue-Utilization Patterns

The Level 1 effects were qualified by several cross-level interactions between the Level 2 individual-difference variables and the feedback cues. These interactions support our general hypothesis that cue-utilization patterns vary significantly across individuals, and that at least some of this variance may be explained by individual differences in social values and environmental attitudes.

In terms of social values, our results indicate that fishers with prosocial and proself orientations responded in similar ways to feedback about number of fish available, fish value, fishing expenses, and harvests by the cooperative computer-simulated player. Both types of fishers harvested more during seasons when more fish were available, when fish were more valuable, when fishing expenses were higher, and when the cooperative player harvested less during the previous season.

This last effect is particularly interesting, given that it suggests that both proselfs and prosocials responded to underharvesting by a cooperative other by increasing their own harvests. It is important to note that even though the behavioral response is similar, the underlying motives may be quite different. For example, proselfs may view underharvesting by others as an opportunity to maximize their own profit or the difference between their profit and others' profit. On the other hand, prosocials are likely to be motivated to maximize the overall group's outcome by compensating for what they perceive to be underuse or inefficient use by other group members.

Although, for the most part, proselfs and prosocials appeared to employ similar cue-utilization strategies, two key differences emerged during the simulation. First, proselfs, on average, harvested more fish per season than did prosocials, a finding consistent with our hypotheses and several other commons-dilemma simulation studies (e.g., Kramer et al., 1986; Parks, 1994; Roch & Samuelson, 1997). Second, proselfs responded to heavy harvesting by noncooperative others by increasing their own harvests, whereas prosocials' harvests were unrelated to the harvests of noncooperative others, suggesting that prosocials did not use this feedback cue when deciding how many fish to harvest for themselves.

This pattern of results is only partially consistent with the hypothesis that both proselfs and prosocials would closely monitor the harvests of noncooperative others. Our results suggest that proselfs monitored the behavior of other fishers, presumably to ensure that they would either maximize their own payoffs relative to others (competitors) or maximize their own outcomes before the noncooperative others exhausted the resource. Prosocials, on the other hand, appeared to focus more generally on the other feedback cues provided during the simulation, rather than on the actions of noncooperators.

Harvesters' cue-utilization patterns also varied as a function of environmental values. Relative to their less anthropocentric counterparts, high scorers on the anthropocentrism scale harvested significantly more fish per season, increased their harvests more when the Blue (cooperative) fisher took less and when the Green (noncooperative) fisher took more, and decreased their harvest less in response to feedback that the number of fish in the resource pool was declining. Similarly, individuals who scored higher on environmental apathy, relative to lower scorers, increased their harvests more after receiving feedback that the Green fisher had taken a large harvest. Contrary to our prediction, fishers' harvest and feedback use patterns did not vary with their ecocentrism.

The results for environmental values are somewhat at odds with previous findings showing ecocentrism to be a moderate to strong predictor of various types of proenvironmental behavior (Nordlund & Garvill, 2002; Thompson & Barton, 1994). A possible explanation for this is that high intercorrelations among the Level 2 predictors in the HLM model could have prevented ecocentrism from accounting for a significant amount of unique variance in harvest decisions. However, this does not appear to have been a problem: All of the correlations among the variables were small (i.e., $r < .24$), with the exception of two moderate correlations between apathy and ecocentrism ($r = -.59$), and apathy and anthropocentrism ($r = .37$). To determine whether the inclusion of environmental apathy had suppressed possible ecocentrism and anthropocentrism effects, we conducted the HLM analyses again, with environmental apathy excluded. This failed to produce any additional effects, which suggests that ecocentrism truly did not predict harvest behavior or variation in cue utilization.[7]

A second, more promising explanation is that the instructions presented to participants in the simulation, which emphasized maximizing personal profits, may have primed anthropocentric and apathetic environmental attitudes of participants more than ecocentric attitudes. If participants' ecocentric attitudes remained in a deactivated state during the simulation, these attitudes would be unlikely to guide their harvesting decisions.

Australian and Canadian participants harvested similar amounts of fish per season and exhibited similar cue-utilization patterns, with one exception. Australian and Canadian participants both harvested more fish when the value of fish was higher, although examination of the cross-level interaction plot reveals that this effect was stronger for Australians. This effect may not be cultural in nature, but instead likely reflects the slightly different manner in which the study was implemented in the two locations. Australians were

[7]The HLM model with ecocentrism as the sole Level 2 predictor was also considered. This also failed to produce any additional effects for this predictor.

told that their financial remuneration for participating in the study would be directly tied to their harvest profits ($0.05 for every dollar accumulated during the resource management simulation), whereas Canadian participants were told that they could either receive a payment based on performance or course credit. This difference in the payment methods may have provided the Australian sample with a stronger incentive to harvest heavily during seasons in which fish value was high.

Practical Implications

The present study clearly demonstrates that harvest decisions in a simulated commons dilemma are reliably related to feedback cues, and that individuals with different social and environmental values respond to feedback in different ways. These findings are consistent with the view that values are a filter through which people view the world, guiding attention and interpretation of the information they encounter and, ultimately, their behavior.

If values guide behavior, then one obvious strategy to increase responsible resource use would be to change individuals' values. Indeed, as noted by Schultz and Zelezny (2003), "changing values may be the only path to achieving long-term sustainable lifestyles" (p. 134). However, given that values are often deeply entrenched and difficult to modify, it is important to acknowledge that interventions aimed at changing values may not be effective in producing the rapid change in behavior required to save resources on the verge of extinction. As Gardner and Stern (2002) noted, changes in values occur slowly and it may take a generation or more for widespread change to take place within a population.

In situations in which rapid behavior change is required, it may be more efficient to bypass values and focus directly on more proximal determinants of resource-use decisions, such as changing the financial payoff structure in the dilemma so that the cost–benefit ratio associated with conservation is more favorable than the cost–benefit ratio associated with overconsumption. Unfortunately, in many jurisdictions, agencies responsible for regulating resource use have limited control over the financial payoffs associated with resource consumption (e.g., value of fish, operating expenses, fines for overconsumption).

Our results suggest that when control over the payoff structure is limited, cooperation in the commons may be elicited by increasing the salience of feedback cues that encourage conservation and decreasing the salience of cues that encourage overconsumption. If regulators were equipped with knowledge of the dominant social and environmental values of resource users within their constituency, they could target their messages even more effectively by modifying the salience of feedback cues most relevant to the group in question. For example, when dealing with a group of individuals with competitive social values, an effective strategy might involve reducing or eliminating feedback about the harvest choices of other group members, given that it is difficult to compete if there is no clear way to compare one's performance to that of others. Alternatively, introducing regulations that constrain all fishers to extract the same volume of fish would also eliminate negative effects associated with self–other comparisons.

Other potentially useful strategies might involve increasing the salience of resource-depletion feedback (which was associated with moderate harvest reductions in all participants except those with anthropocentric values). If practical, information about high fish values and fishing expenses (both of which were associated with higher levels of resource consumption in all participants) could be suppressed.

Limitations of the Present Study

The current study employed a research design in which all participants were provided with identical bogus feedback across 60 harvest trials of the commons dilemma simulation. This approach helps to facilitate cue-utilization comparisons, given that all participants are exposed to the same set of feedback cues. However, it also potentially limits the generalizability of the findings, given that only one pattern of cue configurations was employed.

In future studies, it would be useful to explore the generalizability issue by employing designs in which bogus feedback is not provided, and participants are free to interact with fellow group members in real time. In such a design, each participant, in essence, would be presented with a unique set of feedback cues based on their group's harvest decisions from previous trials. This approach also would more fully utilize the strengths of HLM by providing researchers with the opportunity to explore potential Level 3 effects (i.e., group variation in individual-difference effects), and also to systematically explore a range of resource-management outcomes in which all participants are not constrained to manage the resource for exactly the same number of harvest trials.

The present study is the first to systematically explore the relations between values/attitudes, the utilization of feedback cues, and harvest decisions in commons dilemmas using HLM. The results indicate that harvesters' resource-use decisions are reliably related to the feedback they receive, and that harvesters with different social and environmental values appear to attend to and use feedback in different ways. These results represent the first step in understanding the complex relations among values, cue-utilization patterns, and harvest behavior. Additional research will develop a more complete understanding of how these relations operate in commons dilemmas outside the research laboratory, and how this understanding can best be used to manage the world's resources more effectively.

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Appendix

Feedback Cues for Resource-Management Simulation

Season	Fish value ($)	Expenses ($)	Fish number	Blue harvest in previous trial	Green harvest in previous trial
1	5	20	900		
2	3	30	898	17	26
3	5	10	895	16	23
4	2	60	895	18	20
5	5	50	894	18	29
6	2	100	891	11	26
7	5	100	890	19	28
8	1	80	885	20	20
9	4	70	884	19	23
10	1	10	881	17	22
11	4	40	880	16	20
12	4	20	879	10	21
13	1	40	875	17	21
14	3	20	872	17	29
15	1	70	871	17	21
16	1	100	865	16	28
17	1	80	861	11	27
18	3	100	856	15	23
19	5	40	846	15	26
20	1	20	837	13	26
21	5	20	831	16	29

Appendix: *cont.*

Season	Fish value ($)	Expenses ($)	Fish number	Blue harvest in previous trial	Green harvest in previous trial
22	5	90	825	12	29
23	3	100	814	20	22
24	1	20	806	14	23
25	5	80	801	18	27
26	1	20	793	12	23
27	4	50	787	16	30
28	4	90	780	16	20
29	4	40	774	19	22
30	2	80	770	16	24
31	3	70	763	12	25
32	4	20	756	18	30
33	2	100	750	13	30
34	2	90	744	17	26
35	1	60	736	19	26
36	2	20	725	13	26
37	1	50	720	14	22
38	4	70	713	10	20
39	1	50	705	20	22
40	2	10	695	20	24
41	1	30	687	13	23
42	4	90	677	10	23
43	2	10	657	10	26
44	1	30	636	14	20
45	3	20	613	12	29
46	3	70	589	15	29
47	1	10	563	14	23
48	2	70	536	16	25
49	5	80	507	12	27
50	3	60	476	12	22
51	4	30	443	11	28
52	2	20	408	14	20

Appendix: *cont.*

Season	Fish value ($)	Expenses ($)	Fish number	Blue harvest in previous trial	Green harvest in previous trial
53	4	60	371	18	20
54	4	60	331	19	29
55	2	50	288	20	28
56	1	70	243	15	26
57	4	100	195	17	30
58	1	10	144	17	24
59	4	10	89	11	30
60	2	50	31	18	30