Journal of Environmental Psychology 34 (2013) 97–108

Contents lists available at SciVerse ScienceDirect

Journal of Environmental Psychology

journal homepage: www.elsevier.com/locate/jep

Relating values and consideration of future and immediate consequences to consumer preference for biofuels: A three-dimensional social dilemma analysis

Hayk Khachatryan [a,*], Jeff Joireman [b,1], Ken Casavant [c,2]

[a] Food and Resource Economics Department, Mid-Florida Research and Education Center, University of Florida, 2725 S Binion Rd, Apopka, FL 32703-8504, USA
[b] Department of Marketing, Washington State University, PO Box 644730, Pullman, WA 99164-4730, USA
[c] School of Economic Sciences, Washington State University, PO Box 646210, Pullman, WA 99164-6210, USA

ARTICLE INFO

Article history:
Available online 13 February 2013

Keywords:
Consideration of future and immediate consequences
Choice of biofuels
Environmental behavior
Discrete choice model
Values

ABSTRACT

The present study sets preference for biofuels (corn- and cellulose-based ethanol) vs. gasoline within a three-dimensional social dilemma framework recognizing a social conflict (individual vs. collective interests), a temporal conflict (immediate vs. future interests) and a biospheric conflict (human vs. biospheric interests). Using this framework, values (egoistic, altruistic, and biospheric) and time orientation (concern with immediate, and concern with future consequences) are hypothesized to relate to preference for biofuels. To test these hypotheses, a panel of U.S. consumers completed a brief inventory of values, the consideration of future consequences-14 scale, and made a series of choices in fueling scenarios. Results revealed that values and CFC overlap, and that preference for biofuels was inversely related to egoistic values and consideration of immediate consequences and positively related to biospheric values and consideration of future consequences, supporting the three-dimensional social dilemma framework.

1. Introduction

As the world struggles to cope with declining oil reserves and the environmental consequences of fossil fuel powered vehicles, marketers and consumers alike are considering more fuel efficient cars and alternative means of fueling those cars. Two growing alternatives to traditional gasoline include corn-based ethanol and cellulose-based ethanol (Sissine, 2007; Tilman et al., 2009). Both alternatives offer lower emissions than traditional gasoline (Farrell et al., 2006), but their limited availability and potential price premium may deter consumers from adopting these fuels. The present study adopts a social dilemma analysis to identify a core set of individual differences likely to be associated with support for biofuels. Although scholars have long viewed environmental decisions as social dilemmas, these frameworks have tended to overlook at least one (or more) of the (three) key dimensions that theoretically underlie environmental dilemmas. Accordingly, we discuss the different social dilemma approaches to environmental dilemmas, highlight how the choice between gasoline and biofuels fits within a three-dimensional social dilemma framework, and discuss research on individual differences relevant to our social dilemma framework. We then report a discrete choice study, using a panel of U.S. consumers, testing our framework.

1.1. Environmental problems and social dilemmas

The idea that environmental problems can be modeled as social dilemmas is not new. In his well-known article, "The Tragedy of the Commons," Hardin (1968) long ago illustrated the disastrous consequences that can result when individually-rational people share access to a common resource. In another heavily cited article, Messick and Brewer (1983) drew attention to the burgeoning literature on social dilemmas, which they characterized as situations in which "the collective consequence of reasonable individual choices is disaster." (p. 12). Since then, research on social dilemmas has expanded exponentially. While early studies tended to focus on simulated social dilemmas (e.g., resource dilemmas in the lab; Hine & Gifford, 1996; Kramer, McClintock, & Messick, 1986), over the years, researchers have increasingly applied social dilemma analyses to a variety of real-world settings (for reviews of the basic and applied dilemmas literatures, see Komorita & Parks, 1994; Parks, Joireman, & Van Lange, in press; Van Lange, Joireman, Parks, & van Dijk, 2013; Weber, Kopelman, & Messick, 2004).

* Corresponding author. Tel.: +1 407 410 6951.
E-mail addresses: hayk@ufl.edu (H. Khachatryan), joireman@wsu.edu (J. Joireman), casavantk@wsu.edu (K. Casavant).
[1] Tel.: +1 509 335 0191.
[2] Tel.: +1 509 335 5555.

0272-4944/$ – see front matter
http://dx.doi.org/10.1016/j.jenvp.2013.01.001

One domain in which researchers have often applied a social dilemma framework is the area of environmental decisions, including transportation decisions. Researchers applying a social dilemma analysis to environmental decisions have often defined social dilemmas as either (a) a conflict between individual and collective/societal interests (e.g., Karp, 1996; Kortenkamp & Moore, 2001; Van Lange, Van Vugt, Meertens, & Ruiter, 1998; Van Vugt & Samuelson, 1999) or (b) situations in which short-term self-interest is at odds with long-term collective interests (e.g., Cameron, Brown, & Chapman, 1998; Milfont & Gouveia, 2006; Nordlund & Garvill, 2003; Van Vugt, 1997; Van Vugt, Van Lange, & Meertens, 1996). Noting that the latter incorporates a social conflict (individual vs. collective interests) and a temporal conflict (short-term vs. long-term interests), some have referred to it as the "expanded definition of social dilemmas" (e.g., Joireman, Van Lange, & Van Vugt, 2004; Milfont & Gouveia, 2006).

While the expanded definition has brought renewed attention to the importance of social and temporal concerns, it also overlooks a number of the different conflicts of interest facing decision makers in environmental dilemmas. To be precise, environmental dilemmas also often pose a third conflict between what is good for humans and what is good for the biosphere. Indeed, reference to long-term environmental problems is commonplace in social dilemma studies, and numerous studies (reviewed below) have explored how biospheric concerns and values are related to environmental decisions that reflect a social dilemma. However, the biospheric conflict has not been *explicitly* incorporated in to definitions of environmental social dilemmas. Accordingly, we suggest that environmental social dilemmas should be defined as *situations in which the short-term interests of individual humans are in conflict with the long-term collective interests of humans* <u>*and*</u> *the environment*.

This novel (three-dimensional) definition underscores the importance of *social concerns* (i.e., the value one attaches to one's own vs. others outcomes), *temporal concerns* (i.e., the value one assigns to short-term vs. long-term outcomes), and *biospheric concerns* (i.e., the value one attaches to human vs. biospheric outcomes). As we review below, the role of social and biospheric concerns has generally been positioned within work on universal values, while the role of temporal concerns has been explored by linking environmental attitudes and behavior with individual differences in time orientation (Zimbardo & Boyd, 1999) and/or the consideration of future consequences (Strathman, Gleicher, Boninger, & Edwards, 1994). To date, however, no study has adopted a three-dimensional social dilemma analysis including all three dimensions, and only one study has incorporated all three concerns within the same study (Milfont & Gouveia, 2006). In that study, Milfont and Gouveia reported that scores on the ZTPI time perspective inventory were largely unrelated to universal values (self-enhancement, self-transcendent, openness, conservation, and biospheric values), and time perspective and values explained unique variance in preservation and utilization attitudes, suggesting the three sets of concerns (social/temporal/biospheric) are largely distinct.

While Milfont and Gouveia's (2006) results are promising, there remains little research exploring the role of all three concerns simultaneously. Thus, the purpose of the present study is to explore whether the probability of selecting corn- and cellulose-based ethanol over traditional gasoline is related to individual differences in three values relevant to the social and biospheric concerns including egoistic, altruistic, and biospheric values (e.g., de Groot & Steg, 2007, 2008; Steg, Dreijerink, & Abrahamse, 2005; Stern & Dietz, 1994; cf. Schultz, 2001) and to individual differences in consideration of future consequences (Strathman et al., 1994) which are relevant to temporal concerns. As we argue next, a case can be made that consumer preference for biofuels represents an environmental dilemma containing all three dimensions (temporal, social, target), and is therefore likely to be associated with all three concerns.

1.2. Preference for gasoline vs. biofuels as a three-dimensional social dilemma

During the past several years, interest in ethanol as a renewable source of energy with potential to reduce greenhouse gas emissions (Farrell et al., 2006) has escalated. Such biofuels can come from two sources, including corn and cellulosic material. Recent corn-ethanol life cycle analyses showed 48–59% reduction in greenhouse gas emissions compared to gasoline (Liska et al., 2009). Unfortunately, increased demand for corn-based biofuel also contributes to increasing corn prices, with subsequent ripple effects on food prices. Production of corn-based ethanol products also carries potential environmental problems related to use of fertilizers for corn production, such as nitrogen runoff into water supplies.

In contrast to corn, cellulosic feedstocks are resource-abundant (e.g., biomass, agricultural residue, hemicellulose, lignin, sugar, and municipal waste, to name a few). As a result, production of cellulose-based ethanol does not interfere with food crops, and thus, does not impact food prices. The use of cellulosic feedstocks for ethanol production also eliminates chemical fertilizer runoffs into groundwater sources associated with corn production.

Considering different environmental impacts associated with gasoline (carbon dioxide emissions) and corn-based ethanol (nitrogen runoff and agricultural land conversion), it is reasonable to rank gasoline as the most harmful to the environment and society, followed by corn-based ethanol, followed by cellulose-based ethanol, supporting the presence of social and biospheric conflicts. Attesting to the temporal conflict, the negative environmental impacts of gasoline are also largely delayed. While these considerations should make biofuels attractive, they also have their drawbacks, from a short-term, self-interested perspective. Namely, given their potential price premium and reduced availability (relative to gasoline), biofuels are likely to be considered less convenient and attractive from a short-term, egoistic perspective.

Combining these perspectives, preference for biofuels (vs. gasoline) presents consumers with a three-dimensional social dilemma involving a social conflict (egoistic vs. social consequences), a biospheric conflict (human vs. biospheric consequences), and a temporal conflict (short-term vs. long-term consequences). Within this framework, factors that increase concern with social (vs. egoistic) consequences, biospheric (vs. human) consequences, and long-term (vs. short-term) consequences, should be associated with a stronger preference for biofuels. In the following sections, we review research relevant to each of these concerns, and then consider whether values and temporal concerns represent unique or redundant concerns.

1.3. Values and environmental research

Environmental researchers have devoted much attention to identifying egoistic, altruistic, and biospheric values (and concerns) associated with environmentally-friendly attitudes and behavior (for an extensive review, see Dietz, Fitzgerald, & Shwom, 2005). Research comparing the three values has tended to show the strongest effects for biospheric and egoistic values. Research has shown, for example, that those expressing stronger biospheric values[3] report higher scores on the new environmental paradigm scale (e.g., de Groot & Steg, 2008; Poortinga, Steg, & Vlek, 2004;

[3] We use the term biospheric values after inspecting the value items included in the studies cited here. Readers should note, however, that these biospheric values are often labeled as universalism or self-transcendence.

Schultz & Zelezny, 1999; Steg, de Groot, Dreijerink, Abrahamse, & Siero, 2011), the environmental preservation scale (Milfont & Gouveia, 2006; Milfont, Duckitt, & Wagner, 2010), and the ecocentrism scale (e.g., Schultz & Zelezny, 1999); a greater likelihood of engaging in proenvironmental behavior (e.g., Hansla, Gamble, Juliusson, & Gärling, 2008; Karp, 1996; Schultz et al., 2005; Schultz & Zelezny, 1998); stronger support for policies that reduce energy use (e.g., Poortinga et al., 2004; Steg et al., 2011) and climate change among employees in public (but not private) institutions (Nilsson, von Vorgstede, & Biel, 2004); and a lower likelihood of buying genetically modified foods (Honkanen & Verplanken, 2004). Research also shows that those scoring high on egoistic values score lower in environmental concern (de Groot & Steg, 2008; Milfont et al., 2010; Poortinga et al., 2004) and preservation attitudes (Milfont & Duckitt, 2004, 2010); hold less favorable attitudes toward recycling (de Groot & Steg, 2008); and are less likely to support policies that reduce energy use (Poortinga et al., 2004; Steg et al., 2011).

Within the transportation domain, research has shown that biospheric values are positively associated with preference for commuting by public transportation (Collins & Chambers, 2005; Jansson, Marell, & Nordlund, 2010) and environmentally-friendly cars, including hybrids and those running on biofuels (de Groot & Steg, 2010; Jansson et al., 2010), while egoistic values are negatively associated with preference for commuting by public transportation (Collins & Chambers, 2005) and purchasing an environmentally-friendly car (de Groot & Steg, 2010). Consistent with these findings, we expected that preference for biofuels would be negatively associated with egoistic values (***Hypothesis 1***) and positively associated with altruistic (***Hypothesis 2***) and biospheric values (***Hypothesis 3***).

1.4. Consideration of future consequences (CFC) and environmental research

Research on environmental social dilemmas has also argued for the importance of temporal concerns (e.g., Hendrickx, Poortinga, & van der Kooij, 2001; Joireman, 2005; Mannix, 1991; Messick & Brewer, 1983; Messick & McClelland, 1983; Vlek & Keren, 1992). Consistent with this reasoning, numerous studies have shown that people are more likely to act in a proenvironmental manner when they are future-oriented (Zimbardo & Boyd, 1999) or score high on Strathman et al.'s (1994) CFC scale (for a recent meta-analysis, see Milfont, Wilson, & Diniz, 2012). The present study focuses on individual differences in CFC, which Strathman et al. (1994) defined as "…the extent to which people consider the potential distant outcomes of their current behaviors and the extent to which they are influenced by these potential outcomes" (Strathman et al., 1994, p. 743; for a review, see Joireman, Strathman, & Balliet, 2006).

Previous research using the CFC scale has shown that those scoring high (as opposed to low) in CFC report higher levels of recycling (Ebreo & Vining, 2001; Lindsay & Strathman, 1997; Strathman et al., 1994), cooperation in resource dilemmas (Joireman, Posey, Truelove, & Parks, 2009; Kortenkamp & Moore, 2006), proenvironmental political intentions and behavior (Joireman, Lasane, Bennett, Richards, & Solaimani, 2001), preference for public transportation (Collins & Chambers, 2005; Joireman et al., 2004) and supportive for plans to improve public transportation, if the plan is believed to reduce pollution (Joireman, Van Lange, et al., 2001) (cf. Milfont & Gouveia, 2006). These studies provide support for the relevance of CFC in the environmental arena. Nevertheless, several gaps exist in our understanding of how CFC correlates with environmental behavior. We address several of those gaps.

First, whereas previous research has connected CFC with transportation-related outcomes (e.g., preference for public transit), we explore whether CFC is associated with preference for biofuels. Second, whereas most past CFC/environmental research has utilized convenience samples of college students, or local residents, we recruit a panel of U.S. consumers. Third, whereas past CFC/environmental research has typically relied on self-reported intentions and behaviors, we report a discrete choice study in which consumers make a series of choices between the three fuel options (gasoline, corn-based ethanol, and cellulose-based ethanol) designed to vary in terms of price, emissions, and service availability. Fourth, whereas previous research has treated CFC as a unitary construct, building on several recent studies (Joireman, Balliet, Sprott, Spangenberg, & Schultz, 2008; Joireman, Shaffer, Balliet, & Strathman, 2012; Petrocelli, 2003; Rappange, Brouwer, & Van Exel, 2009; Ryack, 2012; Toepoel, 2010), we explore the value in distinguishing between two CFC subscales (cf. Joireman et al., 2008, 2012), one measuring consideration of future consequences (CFC-Future), the other measuring consideration of immediate consequences (CFC-Immediate). Similar to the five-factor Zimbardo and Boyd (1999) time perspective inventory, a two-factor approach to the CFC scale assumes that concern with future and concern with immediate consequences are not polar opposites.

Treating the CFC scale as a two-factor scale offers an advantage over a one-factor approach. To illustrate, assume that the total score on the CFC scale (future items merged with reverse coded immediate items) is positively correlated with preference for biofuels. Using a one-factor approach would lead to the conclusion that *people who are concerned with the future consequences of their actions are more likely to prefer alternative fuels* (e.g., due to their long-term environmental benefits). This appears reasonable, but a closer look suggests an alternative interpretation: it is possible that the positive correlation between CFC and preference for biofuels is entirely a function the immediate items. In other words, the positive correlation between CFC and preference for biofuels may be due to the fact that *people who are concerned with the immediate consequences of their actions are less likely to prefer alternative fuels*.

Given its ability to differentiate between these two interpretations, we explored how preference for biofuels (vs. gasoline) is related to concern with future consequences and concern with immediate consequences. We hypothesized that the CFC-Future subscale would be positively associated with preference for biofuels (***Hypothesis 4***), while the CFC-Immediate subscale would be negatively related to preference for biofuels (***Hypothesis 5***). An open question was whether the two CFC subscales would be uniquely associated with preference for biofuels.

1.5. Values and CFC: unique or redundant?

The preceding studies support the importance of values and CFC within the environmental domain. Combining values and CFC also raises the question: assuming they may overlap, is it useful to incorporate both into the same model, or might they be redundant? Unfortunately, little is known on this issue as only one paper has incorporated values and temporal concerns into the same study. In that study, Milfont and Gouveia (2006) assessed relationships among five values (egoistic, self-transcendent (sans biospheric), openness, conservation, and biospheric), the five dimensions of the Zimbardo and Boyd (1999) Time Perspective Inventory, and preservation/utilization attitudes. Their results suggested two conclusions. First, time orientation and values are essentially unrelated: of the 25 possible correlations (5 values $\times$ 5 time orientation dimensions), only three were significant. Second, values and time orientation were uniquely associated with preservation and utilization attitudes, suggesting preliminary support for the validity of incorporating values (egoistic, altruistic, and biospheric) and temporal concerns into the same model.

These results are promising, but additional tests are warranted for at least two reasons. First, in their meta-analysis, Milfont et al. (2012) reported that CFC is more strongly related to environmental behavior than the ZTPI-future time orientation scale, suggesting that biospheric values may overlap more strongly with CFC than the ZTPI-future scale. This is important because if values and CFC overlap, it may be unnecessary to incorporate both into the same model. Second, it is valuable to test the role of values and temporal concerns across a broader range of environmental decisions, as different environmental decisions may vary in terms of which concerns are the most relevant; some dilemmas may contain only two dimensions (e.g., social and temporal), while others may contain three dimensions (i.e., social, temporal, and biospheric). As we have argued, the decision to choose biofuels vs. gasoline appears to contain all three dimensions, but empirical tests are needed to evaluate that assumption. Toward that end, we asked a panel of U.S. citizens to complete scales assessing egoistic, altruistic, biospheric values, CFC and make fuel choices in a discrete choice task.

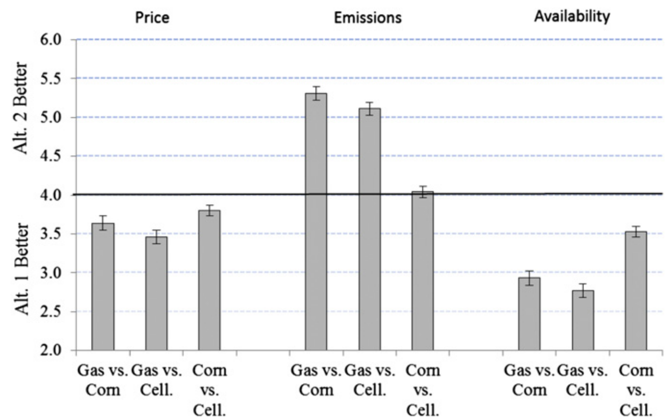

Fig. 1. Perceptions of relative price, emissions, and availability of gasoline, cellulose-based ethanol, and corn-based ethanol.

2. Methods

2.1. Participants and procedure

The data were collected in November 2009 using the online survey company Qualtrics. The online questionnaire was distributed to a random panel of 547 respondents from different regions within the U.S. Screening out participants who did not have a car, or left a large portion of the survey blank, a sample of 463 respondents was obtained. Additionally, embedded within the survey was a quality control check designed to assess respondents' attention which read: "To ensure that you are reading the statements, please choose Strongly Agree as your answer to this statement." Of the initial 463, 163 failed this attention check, leaving a sample of 300 respondents who completed the large majority of the survey (with occasional missing values). In our primary analyses (fuel choices), 273 respondents were included in the analyses. On average, the survey took 20 min to complete.

Fifty percent of the respondents were female, compared to the U.S. Census estimates at 50.8%, and 91.8% were Caucasian, compared to the national estimate of 72.4% (U.S. Census Bureau, 2010). The distribution of age groups were: 18–24 years old (3.1%), 25–44 years (27.3%), 45–64 years (57.4%), and over 65 years (12.1%), compared to the 2010 U.S. Census estimates (9.9%, 26.6%, 26.4, 13.0%, respectively). The average annual income for the sample was $50,000, which is comparable to the 2010 U.S. Census estimate of $50,831. Thus, relative to the 2010 U.S. Census, the sample was somewhat overrepresented by Caucasians, and those in the 45–64 year old age group, but was reasonably representative in terms of gender and income. Moreover, 62.5% were married and 53.2% had completed at least two years or more of college.

As described in more detail below, as part of a larger survey, participants gave their impressions of the perceived price, emissions and availability of corn-based and cellulose-based ethanol; indicated their familiarity and past/present use of these biofuels; read a brief overview of the fuels and completed a quiz assessing their understanding of that information; completed the discrete choice fuel survey; completed a 12-item value inventory (de Groot & Steg, 2008; Study 1) and the revised 14-item CFC scale (cf. Joireman et al., 2012); and then provided basic demographics and rated their political orientation (1 = liberal to 7 = conservative).

2.2. Initial perceptions of biofuels

To determine whether participants perceived the fuel types as intended (gas cheaper and more available, but worse on emissions than the biofuels), participants first responded to nine questions measuring their perceptions of the relative price, emissions, and availability of gasoline, corn-based and cellulose-based ethanol. Each fuel type was paired with each other fuel type, with participants responding on 7-point Likert scales (e.g., 1 = gasoline is much better than corn-based ethanol on price, 7 = corn-based ethanol is much better than gasoline on price). As shown in Fig. 1, participants believed gas was cheaper and more available, but also worse on emissions, when compared to the alternative fuels (as indicated by a significant deviation from the scale midpoint of 4, which represents equally…affordable, available, polluting).

To gauge participants' familiarity with the alternative fuels, participants also rated how knowledgeable they were about corn-based and cellulose-based ethanol (1 = not knowledgeable, 7 = very knowledgeable). As anticipated, participants scored fairly low on their knowledge of the alternative fuels, with participants being less knowledgeable about cellulose-based ethanol ($M = 2.24$, SD = 1.50) than corn-based ethanol ($M = 3.14$, SD = 1.65), $t(298) = -14.81$, $p < 0.001$.

2.3. Description of biofuels

Once they had given their impressions of biofuels, participants read brief definitions of cellulose-based and corn-based ethanol, and then completed a 3-item quiz measuring their understanding of those definitions (i.e., concerning corn-based ethanol, cellulose-based ethanol, and an E85 blend).[4] In the event that a respondent gave the wrong answer, a pop-up window informed them of the correct answer.

The majority of respondents correctly indicated that corn-based ethanol was made from corn (95.3%). Similarly, the majority of respondents correctly indicated that cellulose-based ethanol is made from forest biomass and agricultural residue (86.7%); the remaining participants indicated cellulose-based ethanol was made from forest biomass only (3.3%), agricultural crop residue only (5.7%), or corn (4.3%). In sum, 95.7% were entirely or partially correct in their understanding of cellulose-based ethanol. Finally, 62% correctly indicated that E85 ethanol is a blend of 85% ethanol and 15% gasoline, while another 33% believed E85 ethanol is a blend of 85% gasoline and 15% ethanol. Thus, 95% of the sample realized that E85 was a blend of ethanol and gasoline, but the performance on this question was clearly less than optimal. However, it is important to

[4] In this paper, ethanol refers to E85 fuel, which is a blend of 85 percent ethanol and 15 percent gasoline.

reiterate that if respondents gave the wrong answer, a pop-up window reminded them of the correct answer.

2.4. Fuel-choice task

Next, participants made a series of choices in eight fueling scenarios. Prior to making their choices, participants were presented with an example fuel-choice scenario (see Appendix for example and actual choice parameters). While a number of interesting attributes could have been manipulated, to keep the choice task straight forward and not overwhelming, we elected to vary three attributes that seemed most relevant to the choice between biofuels and gasoline: namely, (1) price (as one of the main factors in consumer decision making), (2) emissions levels (representing a major concern with gasoline), and (3) service availability (representing a proxy for search costs associated with finding stations that offer ethanol). In each of the eight orthogonal fueling scenarios, formed from a fractional factorial design (Kuhfeld, 2009), the two alternative fuels were either more or less expensive than gasoline (by 0.25/gallon; but on average, cost the same as gas), always offered lower emissions than gasoline (by 25%, on average), and were equally or less available than gasoline (i.e., whereas gasoline was available at every fueling station, the two alternative fuels were, on average, available at every other fueling station). In sum, the two alternative fuels were approximately the same price as gasoline, but offered lower emissions and somewhat limited availability relative to gasoline.

In all scenarios, gasoline cost $2.75/gallon – based on 2007–2009 retail gasoline sales data from Energy Information Administration's (EIA) *Retail Gasoline Historical Prices* database (EIA, 2009) – and was available at every fueling station. In addition, gasoline was said to have an emission rating of 20, which corresponded to the estimated number of pounds of CO_2 emitted for one gallon of gasoline consumed. As noted in the table provided to participants, while one gallon of gasoline weighs only 6.3 pounds, according to U.S. Environmental Protection Agency (EPA) calculations (EPA, 2005), one gallon of gasoline can produce 20 pounds of carbon dioxide (most of the weight of the CO_2 doesn't come from the gasoline itself, but the from the oxygen in the air). This occurs because burned gasoline produces carbon and hydrogen, which after interacting with the oxygen in the air, increases its weight to 20 pounds of carbon dioxide (CO_2) per gallon. By comparison, cellulose-based and corn-based ethanol had an average emission rating of 15 (25% reduction), but was only available (on average) at every other fueling station. Also, while the cost of the alternative fuels varied (either greater than or less than gasoline by 0.25/gallon), the average cost of the alternative fuels was the same as gasoline (between $2.75 and $2.81/gallon).

2.5. Individual differences

2.5.1. Egoistic, altruistic, and biospheric values

After completing the fuel-choice task, participants completed an abbreviated (12-item) inventory of egoistic, altruistic, and biospheric values (de Groot & Steg, 2008, Study 1) which combines value items from the larger Schwartz Value Scale (1992, 1994) into a single item (cf. Stern, Dietz, & Guagnano, 1998). Specifically, participants rated how important each of 12 values was as a guiding principle in their life (0 = opposed to my values, 5 = extremely important). The *egoistic* values included (1) social power: control over others, dominance; (2) wealth: material possessions, money, (3) authority: the right to lead or command, and (4) influential: having an impact on people and events. The *altruistic values* included: (1) equality: equal opportunity for all; (2) a world at peace: free of war and conflict; (3) social justice: correcting injustice, care for the weak; and (4) helpful: working for the welfare of others. The *biospheric values* included (1) preventing pollution: protecting natural resources; (2) respecting the earth: harmony with other species; (3) unity with nature: fitting into nature; and (4) protecting the environment: preserving nature. Internal reliabilities (Cronbach's alphas) for the scales in the current study (egoistic = 0.63, altruistic = 0.78, biospheric = 0.93) were in line with those reported by de Groot and Steg (egoistic = 0.65, altruistic = 0.72, biospheric = 0.83).

2.5.2. Consideration of future consequences-14 scale

Participants next completed the revised CFC-14 scale (Joireman et al., 2012). This scale combines Strathman et al.'s (1994) original 12-item scale (containing 7 "immediate" items and 5 "future" items) with 2 new "future" items which read: *(13) When I make a decision, I think about how it might affect me in the future. (14) My behavior is generally influenced by future consequences*. Using exploratory and confirmatory factor analysis, Joireman et al. demonstrated that the CFC-14 scale has two subfactors assessing consideration of immediate consequences (CFC-Immediate) and consideration of future consequences (CFC-Future). The internal reliability of the CFC subscales in the present study was acceptable (CFC-Immediate = 0.78, CFC-Future = 0.76) and in line with the averaged reliabilities reported by Joireman et al. (2012) across two studies (CFC-Immediate = 0.84, CFC-Future = 0.81).

As there has been some debate about whether the CFC scale contains one or two underlying factors, we used confirmatory factor analysis to evaluate the fit of the one-factor and two-factor models. We first tested the fit of the two-factor model reported in Joireman et al. (2012), which included seven correlated errors (CFC2, CFC6; CFC6, CFC10; CFC7, CFC9; CFC8, CFC14; CFC3, CFC12; CFC3, CFC4; and CFC4, CFC5). This model fit the data reasonably well, but did not meet typical cutoffs for a good fit: $\chi^2(69) = 246.44$, GFI = 0.890, CFI = 0.845, RMSEA = 0.095. The modification indexes indicated that model fit could be improved by estimating one additional correlated error (CFC13, CFC14). This slightly revised two-factor model fit the data well: $\chi^2(68) = 174.71$, GFI = 0.921, CFI = 0.907, RMSEA = 0.074. By comparison, the one-factor model (with the same correlated errors as our final two-factor model) fit the data poorly: $\chi^2(69) = 376.26$, GFI = 0.817, CFI = 0.732, RMSEA = 0.125. Moreover, the fit of the two-factor model was significantly better than the fit of the one-factor model: χ^2 difference test (1) = 201.85, $p < 0.001$. Together, these results support distinguishing between the two CFC subscales, in line with the majority of recent studies on the CFC scale (Joireman et al., 2008, 2012; Petrocelli, 2003; Rappange et al., 2009; Ryack, 2012; Toepoel, 2010; for an exception, see Hevey et al., 2010).

3. Results

3.1. Relationship between CFC and values

Before discussing our primary results, we consider the overlap between CFC and values. As noted earlier, only one prior study has explored relationships between time orientation and values. In that study, Milfont and Gouveia (2006) reported that egoistic, altruistic and biospheric values were largely distinct from the future time orientation on the Zimbardo and Boyd (1999) time perspective inventory. However, as also noted, in their recent meta-analysis, Milfont et al. (2012) reported that CFC was more closely related with environmental behavior than were the ZTPI time orientation scales. To evaluate whether CFC and values overlap, we computed correlations between the two CFC subscales and three values, and conducted a series of multiple regressions in which each of the three values was regressed on the two CFC subscales. Results of these analyses are summarized in Table 1. As can be seen, as a set,

Table 1
Relationship between CFC and values.

CFC Subscale	Egoistic values		Altruistic values		Biospheric values	
	r	β	r	β	r	β
CFC-Future	0.20***	0.29***	0.50***	0.46***	0.57***	0.52***
CFC-Immediate	0.21***	0.30***	−0.27***	−0.13*	−0.30***	−0.14**
Model R^2	0.12***		0.27***		0.34***	

Note. Simple correlations (r) and standardized regression coefficients (β) from regression of indicated values on CFC-Future and CFC-Immediate. Egoistic and biospheric values ($N = 286$), altruistic values ($N = 282$).
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

the two CFC subscales explained significant variance in egoistic values (12%), altruistic values (27%) and biospheric values (34%). Inspection of the standardized regression coefficients indicates that CFC-Future and CFC-Immediate are uniquely associated with each value. Specifically, CFC-Future is associated with higher egoistic, altruistic, and biospheric values, while CFC-Immediate is associated with higher egoistic values, and lower altruistic and biospheric values. In addition, while the two CFC subscales show approximately the same relationship with egoistic values, CFC-Future emerged as the stronger predictor of both altruistic and biospheric values. Taken together, these results suggest that CFC may be more strongly related to values than time orientation (in general). This is an interesting finding in its own right and carries implications for the generalized logit regression reported next, as it raises the possibility that CFC and values may potentially be redundant, and may not show unique associations with preference for biofuels.

3.2. Discrete choice model

We now turn to our primary focus on fuel choices. As noted earlier, in our study, individuals were presented with a number of choice scenarios and were asked to choose their most preferred fuel option. To analyze the effects of individuals' characteristics on choice behavior, we utilized a generalized logit model (Hensher & Greene, 2003; Kuhfeld, 2009; Train, 2007; Train & Wilson, 2008). The formal notation of the model is as follows. Consider an individual j facing m alternatives in a given choice set. Let the probability that individual j chooses alternative k be denoted Π_{jk}, and let X_j represent the characteristics of individual j. The probability of an individual j choosing alternative k can be expressed as (McFadden, 1974, 2001):

$$\Pi_{jk} = \frac{\exp(\beta_k' X_j)}{\sum_{i=1}^{m} \exp(\beta_i' X_j)} = \frac{1}{\sum_{i=1}^{m} \exp[(\beta_i - \beta_k)' X_j]}$$

where $\beta_1, \ldots, \beta_m$ represent m vectors of unknown weights to be estimated. Note that while βs are different, X_j stays constant across alternatives. Also, since $\sum_{j=1}^{m} \Pi_{jk} = 1$, the last set of regression coefficients (β_m) is set to null, so that β_k represents the effects of the variables included in X on the probability of choosing the kth alternative in relation to the last alternative. Therefore, $m - 1$ models were estimated.

To evaluate our hypotheses, we conducted this generalized logit model, with the fuel choice as the criterion variable, and values and CFC as the model variables. In addition, we included several covariates which could logically relate to preference for fuel alternatives (e.g., political orientation, current use of ethanol).

3.3. Regression coefficient interpretation

Results of the generalized logit model are summarized in Table 2. Coefficients for the model variables (e.g., values, CFC scales) for corn- and cellulose-based fuel alternatives are given in relation to the base alternative (i.e., gasoline). For ease of interpretation, the coefficients (βs) are represented in e^{β} rather than β form. This means that for a unit change in the explanatory variable, a particular fuel choice is more or less likely to be chosen by a factor of the respective coefficient (e^{β}), holding the rest of the variables in the model constant.

If the coefficient is >1, then for a one unit increase in the model variable, a particular fuel is *more likely* to be chosen (relative to base alternative − gasoline) by a factor indicated by that coefficient, holding the other variables in the model constant (Long & Freese, 2006). For example, the coefficient for CFC-Future for corn-based cellulose (1.31) means that for a one unit increase in CFC-Future, corn-based ethanol will be 1.31 times more likely than gasoline to be chosen. Likewise, if the coefficient is <1, then for a one unit increase in the model variable, a particular fuel is *less likely* to be chosen (relative to the base alternative − gasoline) by a factor indicated by that coefficient, holding the other variables in the model constant. For example, the coefficient for egoistic values for

Table 2
Generalized logit regression relating fuel choice with values and CFC.

Variables	Corn-based			Cellulose-based		
	Coeff.	*p*-Value	Std. err	Coeff.	*p*-Value	Std. err
Values						
Egoistic	**0.693**	0.001	0.058	**0.708**	0.001	0.058
Altruistic	1.048	0.644	0.107	1.034	0.735	0.102
Biospheric	**1.517**	0.001	0.137	**1.578**	0.001	0.139
CFC constructs						
CFC-Future	**1.315**	0.002	0.114	**1.429**	0.001	0.121
CFC-Immediate	1.007	0.895	0.056	**0.896**	0.037	0.047
Control variables						
Education level	**1.381**	0.011	0.174	**1.223**	0.100	0.150
Income level	1.029	0.241	0.025	**1.049**	0.040	0.024
Political orientation	**0.932**	0.093	0.039	**0.877**	0.001	0.035
Use ethanol now	**2.051**	0.001	0.279	**1.863**	0.001	0.246
Knowl. corn-ethanol	0.958	0.464	0.056	0.955	0.428	0.055
Knowl. cell-ethanol	0.937	0.306	0.060	1.025	0.682	0.063
Regional comparisons						
South	0.782	0.131	0.127	**0.657**	0.007	0.103
Midwest	0.805	0.226	0.144	**0.708**	0.043	0.121
Northeast	0.837	0.331	0.153	**0.740**	0.084	0.129
Log-likelihood						−2218.62
LR χ^2 (28)						304.15
Prob > χ^2						0.001
N						2188

Note: fuel choice is the dependent variable. Knowl = knowledge of the denoted fuel. Political orientation (high values reflect a more conservative orientation). Coefficients greater than 1 (less than 1) indicate that as the predictor increases, the likelihood of selecting the alternative fuel noted (corn, cellulose-based ethanol) over gasoline increases (decreases). In regional comparisons, West was the baseline. Significant coefficients shown in bold.

corn-based ethanol (0.69) means that for a one unit increase in the egoistic values, corn-based ethanol will be 0.69 times less likely to be chosen.

3.4. Egoistic, altruistic, and biospheric values and fuel choice

We begin by focusing on results linking values to the fuel choices. As shown in the top of Table 2, egoistic values were negatively related to preference for both corn-based ethanol (0.69, $p < 0.001$) and cellulose-based ethanol (0.71, $p < 0.001$). As just noted, these coefficients indicate that for each one unit increase in egoistic values, corn-based and cellulose-based ethanol are less likely to be chosen (compared to gasoline) by a factor of 0.69 and 0.71, respectively. Using these coefficients, in Fig. 2, we plotted probability curves showing the association between egoistic values and probability of selecting the three fuels. This figure shows that as egoistic values increase from minimum to maximum, the probability of selecting corn- and cellulose-based fuels decreases from 37% to 22% (15%↓), and 46% to 30% (16%↓), respectively. In contrast, as egoistic values increase from minimum to maximum, the probability of selecting gasoline increases from 17% to 48% (31%↑). In sum, results supported Hypothesis 1.

In contrast to egoistic values, biospheric values were, as expected, positively related to preference for both corn-based ethanol (1.52, $p < 0.001$) and cellulose-based ethanol (1.58, $p < 0.001$). These coefficients indicate that for each one unit increase in biospheric values, corn-based and cellulose-based ethanol are more likely to be chosen (compared to gasoline) by a factor of 1.52 and 1.58, respectively. Using these coefficients, in Fig. 3, we plotted probability curves showing the association between biospheric values and probability of selecting the three fuels. As can be seen, as biospheric values increase from minimum to maximum, the probability of selecting corn- and cellulose-based fuels increases from 17% to 36% (19%↑) and 19% to 48% (29%↑), respectively. On the contrary, as biospheric values increase from minimum to maximum, the probability of selecting gasoline decreases from 64% to 16% (48%↓). Thus, Hypothesis 3 was supported.

3.5. CFC-Future, CFC-Immediate and fuel choice

We next consider results for CFC. As can be seen in Table 2, results revealed a significant positive relationship between CFC-Future and preference for both corn-based ethanol (1.31, $p < 0.002$) and cellulose-based ethanol (1.43, $p < 0.001$). These coefficients indicate that for each one unit increase in CFC-Future, corn-based and cellulose-based ethanol are more likely to be chosen (compared to gasoline) by a factor of 1.31 and 1.43, respectively. Using these coefficients, in Fig. 4, we plotted probability curves showing the association between CFC-Future and probability of selecting the three fuels. As can be seen, as CFC-Future increases from minimum to maximum, the probability of selecting corn- and cellulose-based fuels increases from 25% to 34% (9%↑) and 24% to 50% (26%↑), respectively. In contrast, as CFC-Future increases from minimum to maximum, the probability of selecting gasoline decreases from 51% to 16% (35%↓). Thus, Hypothesis 4 was supported.

Results also revealed that CFC-Immediate was negatively related to preference for cellulose-based ethanol (0.90, $p < 0.037$), but was unrelated to preference for cellulose-based ethanol (1.01, $p = 0.895$). Thus, for each one unit increase in CFC-Immediate, cellulose-based ethanol is less likely to be chosen (compared to gasoline) by a factor of 0.90. Using these coefficients, in Fig. 5, we plotted probability curves showing the association between CFC-Immediate and probability of selecting the three fuels. As shown, as CFC-Immediate increases from minimum to maximum, the probability of selecting cellulose-based fuels decreases from 49% to

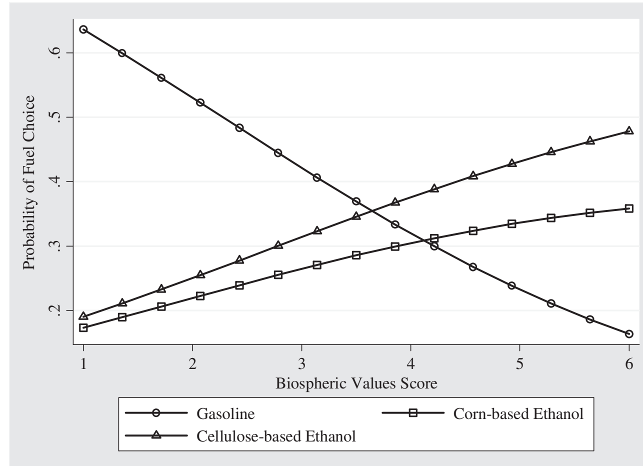

Fig. 3. Probabilities of choosing gasoline, cellulose-based, and corn-based ethanol in relation to biospheric values.

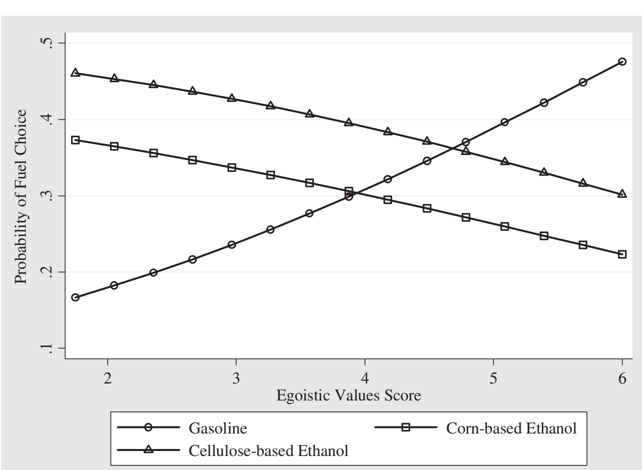

Fig. 2. Probabilities of choosing gasoline, cellulose-based, and corn-based ethanol in relation to egoistic values.

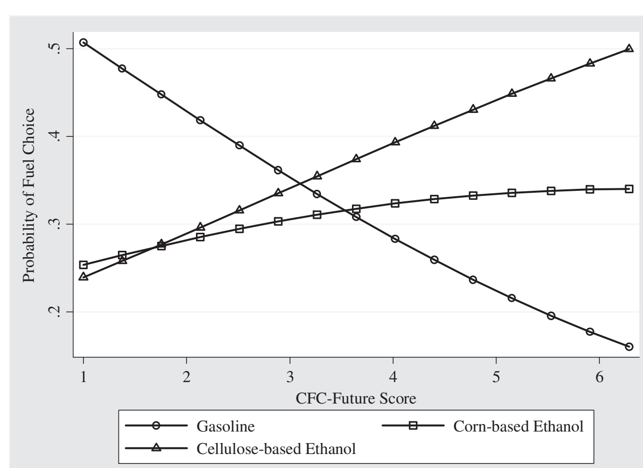

Fig. 4. Probabilities of choosing gasoline, cellulose-based, and corn-based ethanol in relation to CFC-Future.

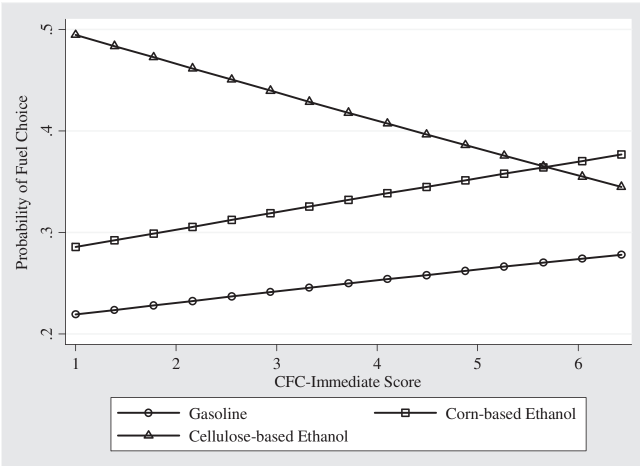

Fig. 5. Probabilities of choosing gasoline, cellulose-based, and corn-based ethanol in relation to CFC-Immediate.

35% (14%↓). In contrast, as CFC-Immediate increases from minimum to maximum, the probability of selecting gasoline increases from 22% to 28% (6%↑). In sum, Hypothesis 5 was partially supported.

4. Discussion

In this paper, we have argued that preference for biofuels reflects a social dilemma containing three conflicts of interest: a social conflict (individual vs. collective interests), a temporal conflict (immediate vs. delayed consequences) and a biospheric conflict (human vs. biospheric consequences). Supporting our framework, results showed that preference for biofuels was negatively associated with egoistic values and consideration of immediate consequences, and positively associated with biospheric values and consideration of future consequences. While preliminary, our results provide some support for the value of a three-dimensional social dilemma approach to preference for biofuels. Below, we discuss how the current results expand on research linking values, CFC and environmental behavior, outline some practical implications of the findings, and consider strengths, limitations and future research directions.

4.1. A three-dimensional social dilemma analysis

One contribution of the current paper is to advance a three-dimensional social dilemma analysis of environmental problems which argues for modeling social, biospheric, and temporal concerns in the same study. With one exception (Milfont & Gouveia, 2006), no studies have assessed all three sets of concerns within the context of an environmental social dilemma. This seems somewhat surprising, given that social dilemma analyses of environmental problems routinely make reference to the negative consequences of short-term self-interest for society and the environment. However, researchers using the social dilemma approach have typically stopped short of incorporating the biospheric conflict into their definitions, even in the so-called "expanded definition of social dilemmas" (i.e., as conflicts between short-term self-interest and long-term collective interests) (Joireman et al., 2004; Milfont & Gouveia, 2006). Given this, we argued that environmental dilemmas should be defined as *situations in which the short-term interests of individual humans are in conflict with the long-term collective interests of humans and the environment.*

Readers familiar with the environmental literature may be puzzled by the need to include the third (biospheric) dimension, as this conflict has long been recognized within the environmental literature. For example, Thompson and Barton (1994) distinguished between ecocentric and anthropocentric attitudes for acting in a proenvironmental manner which are relevant to the biospheric conflict: those with strong ecocentric attitudes believe in preserving nature for the benefit of nature, whereas those with strong anthropocentric attitudes believe in preserving nature for the benefit of humans (cf. Merchant, 1992). Drawing on this distinction, in their analysis of moral reasoning over ecological dilemmas, Kortenkamp and Moore (2001, p. 266) later used the term "land-use conflict" to refer to the conflict between what is good for humans and what is good for the land. Similarly, Milfont and Duckitt (2004) used the phrase "human-nature dilemmas" (p. 299) to capture the "dilemmas confronting people in trying to balance the conservation of the natural environment with the need for some forms of exploitation of the environment" (p. 290), and developed a scale to measure the strength of corresponding preservation and utilization attitudes: where preservation attitudes "reflect conservation and protection of the environment (i.e., biocentric preservation)" and utilization attitudes reflect a belief in the right of humans to "[utilize] natural resources (i.e., anthropocentric utilization)" (p. 290) (cf. Milfont & Duckitt, 2010). Thus, the biospheric conflict is well-engrained in the environmental literature. Despite this, little work has attempted to integrate the applied social dilemma framework and mainstream environmental literature to arrive at the three-dimensional social dilemma framework.

With that being said, it is important to recognize that there are additional dimensions that can come into play within environmental dilemmas. For example, many of the most challenging environmental dilemmas involve an intergenerational dilemma (between current and future generations) (e.g., Wade-Benzoni, 2008). Similar to the current three-dimensional approach, intergenerational dilemmas involve social and temporal conflict. However, intergenerational dilemmas also contain two other conflicts that play an important role in willingness to engage in pro-environmental behavior (such as preservation of natural resources, or willingness to pay taxes to promote a sustainable environment for future generations). One of the most important dimensions (uncertainty) differentiates between the certain outcomes accruing the current generation and the less certain outcomes accruing to future generations. Another dimension (affinity) differentiates between the outcomes to 'us' (our current generation) and 'them' (future generation of others). A similar line of reasoning has been advanced by Gattig and Hendrickx (2007), who have argued that "when dealing with environmental risks, it is frequently necessary to balance benefits that occur for sure, immediately, here, and to ourselves against losses that are uncertain, delayed, might occur elsewhere, and to others" (p. 22). While the "outcomes to others in different locations or times" dimensions overlap to some extent with the social and temporal dimensions advocated here, they are, in theory, distinct. Thus, future research on environmental dilemmas would benefit from a further integration of these frameworks.

It is also important to consider that the current framework, with its biospheric conflict, assumes an inherent conflict between what is good for humans and what is good for the environment. This is not entirely inconsistent with past distinctions (e.g., between ecocentrism and anthropocentrism), but recent theory and research suggest that the two dimensions (concern for humans and concern for the environment) may not necessarily be polar opposites, and some people and cultures may view the two as intricately linked. For example, Milfont and Duckitt (2004) have argued that preservation and utilization attitudes form separate factors, meaning one could be high on both. Moreover, researchers have argued that people vary in their belief that preservation of nature is essential for human progress within a new human interdependence paradigm (e.g., Corral-Verdugo, Carrus, Bonnes, Moser, & Sinha, 2008), and those who see the two as intertwined are more likely to conserve natural resources. Thus, one direction for future research would be to incorporate beliefs in the human interdependence paradigm within a larger, overarching social dilemma framework.

4.2. Contributions to the values–environmental behavior literature

In addition to highlighting the benefit of merging the three sets of concerns, the present research contributes to work on the link between values and environmental behavior. As we have detailed, environmental research has long recognized the important role of values in environmental decision making. To date, however, little research has explored the link between values and preference for biofuels (for exceptions, see de Groot & Steg, 2010; Jansson et al., 2010). The present study differed from these two prior studies in two respects: first, we used a discrete choice methodology rather than self-reports, and second, we evaluated the role of values while controlling for temporal concerns. Results showed a negative association between egoistic values and preference for biofuels, and a positive association between biospheric values and preference for biofuels, even after controlling for CFC. These results suggest the value in incorporating values and temporal concerns within the same study. Future research could build on this integrative values/temporal orientation framework within more mainstream contexts, such as recycling, conservation of natural resources, and proenvironmental political actions.

Another contribution of the methodology used in the present study is a more explicit presentation of the relationship between values and choice behavior through choice probability curves. While the covariate coefficients, reported in previous studies, reveal a snapshot of the relationship between different value orientations and behavior, the method offered in the present study allows depicting the probabilistic relationship between values and underlying choice behavior. The choice probability curves for each value orientation allow an explicit view of the extent to which the relationship between values and behavioral outcome changes as individual value scores increase from minimum to maximum.

Finally, the present study is, to our knowledge, the first to show significant links between values and CFC. Whereas past research utilizing the Zimbardo and Boyd (1999) time orientation scale suggested that values and time orientation were largely distinct (Milfont & Gouveia, 2006), the present results indicate that CFC-Future and CFC-Immediate show significant unique associations with egoistic, altruistic, and biospheric values: CFC-Future is associated with higher egoistic, altruistic and biospheric values, while CFC-Immediate is associated with higher egoistic, and lower altruistic and biospheric values. Despite this, within the generalized logit regression model, values and the CFC subscales showed unique associations with fuel choices, suggesting that while correlated, they are not redundant. This further suggests value in concurrently modeling social, temporal and biospheric concerns in the same analysis of environmental social dilemmas.

4.3. Contributions to the CFC–environmental behavior literature

Beyond the findings just noted, the present study also extended work on the link between CFC and environmental behavior. While CFC has received a significant amount of attention in the environmental literature, to date, no studies have explored how it is related to preference for biofuels, and no published studies have evaluated the value in distinguishing between the two CFC subscales. Our results showed that CFC-Future and CFC-Immediate were uniquely associated with preference for biofuels, even after controlling for values, suggesting that preference for biofuels will depend not only on a concern with future consequences, but a concern with immediate consequences as well. Overlooking this difference by focusing solely on the global CFC construct may lead researchers and practitioners alike to devote all of their attention to stressing the future benefits of biofuels without paying sufficient attention to the immediate barriers to adopting such fuels. The present results suggest that any campaign for promoting biofuels is likely to be more successful if it takes into account the role of both future and immediate consequences in the decision-making process.

Future research might also explore why CFC-Future is more strongly associated with preference for cellulose-based fuels than corn-based fuels. Although our results show, overall, that respondents believe these two fuels do not differ on environmental emissions (e.g., Fig. 1), those high on the CFC-Future scale were more likely to believe cellulose-based fuels were better on emissions than corn-based fuels ($r = 0.16$, $p < 0.01$). That said, it is possible that the stronger relationship between CFC-Future and preference for cellulose-based (vs. corn-based) fuels is related to other future-oriented concerns, such as the belief that corn-based fuel production will reduce availability of food and increase food prices in the future.

Future research could also build on the present work by testing whether the association between CFC and preference for biofuels, or environmental behavior in general, is mediated by temporal discounting. Indeed, temporal discounting has been recognized as an important process that leads people to be less concerned with shared resources (e.g., Hendrickx et al., 2001; Mannix, 1991), and past research has shown a positive relationship between CFC-immediate and temporal discounting (Joireman et al., 2008). However, no published research has explored if temporal discounting acts as a mediator of CFC's relationship with environmental behavior.

4.4. Strengths, limitations and future directions

The current paper has at least two limitations that should be addressed in future research. First, due to the relative unavailability of biofuels to many in the market (especially cellulose-based fuels), we gave participants eight hypothetical fuel scenarios. It will be necessary to validate the current findings in more realistic settings when such fuels become more widely available. With that being said, the discrete choice methodology we used has the advantage of offering a more realistic range of fueling scenarios than simply asking potential consumers if the support each form of biofuel, in general. Second, the correlational nature of the findings prevents firm conclusions about causality. Cross-lagged panel designs could be used to evaluate the presumed causal order of the constructs (from values and CFC to preference for biofuels).

Although the current study has some limitations, it also has several strengths. First, rather than using self-reported preference for biofuels in the abstract, we provided respondents with eight more realistic fueling choice scenarios. Second, whereas past research has often used college student samples, the current study solicited responses from a panel of U.S. consumers varying substantially in age, income, region of residence, and employment status, enhancing the generalizability of the findings. Finally, we tested a three-dimensional social dilemma framework of preference for biofuels which could be applied to other environmental decisions. Future research testing the validity of this framework within various domains could expand our understanding of how people make decisions that hold implications for the future well-being of humans and the biosphere.

Appendix. Fueling scenarios

Introduction to cellulose-based and corn-based ethanol

On the next several slides, we will be asking you about your preference for three different forms of transportation fuels (gas, cellulose-based ethanol, and corn-based ethanol). Some of these fuels are widely available today, while others are less available or still under development.

In today's study, we will be asking you to imagine eight *future* "fuel-choice scenarios" and indicate your preference for the three types of fuels in these scenarios. Before presenting the scenarios, we would like to provide some background information on the two ethanol-based fuels. Please read this information carefully before moving on.

Cellulose-based ethanol is processed from cellulose, which is extracted from such sources as forest biomass, wood chips, agricultural crop residue, animal manure, or municipal solid waste.

Corn-based ethanol is processed from corn.

After production, the pure ethanol is blended with gasoline to create different grades of motor fuels. In this study, both cellulose-based and corn-based ethanol fuels refer to E85 grade (a blend of 85% ethanol and 15% gasoline).

Both cellulose-based and corn-based biofuels contribute to U.S. oil independence.

Introduction to the fuel-choice scenarios

In this part of the survey, we would like you to imagine that you are at a service station and you have a choice between the three types of fuels shown below.

1. Gasoline
2. Cellulose-based ethanol
3. Corn-based ethanol

On each of the following eight pages, we will present a fuel-choice scenario. In each scenario, you will find a table listing the price, environmental emissions and service availability for each type of fuel.

Each table contains a different combination of price, emissions and service availability for cellulose-based and corn-based ethanol fuels. The emissions and service availability for gasoline are the same in every table.

Please read each table carefully before selecting your preferred fuel type.

Here is an example. In this fuel-choice scenario, we would like you to imagine:

- Gas costs $2.75/gallon, while cellulose-based and corn-based ethanol cost $2.50/gallon.
- Gas has an emissions rating of 20 (lbs. per gallon)[a], while cellulose-based ethanol has an emissions rating of 16, and corn-based ethanol has an emissions rating of 14.
- Gas is available at every fueling station; cellulose-based and corn-based ethanol are available at every third fueling station.

This is an example. On the following eight pages, we would like you to select your preferred fueling option after carefully reviewing the information provided in the table on that page. Please note that the information in each table will change from page to page.

Example fueling scenario provided to participants.

	Gasoline	Cellulose-based ethanol	Corn-based ethanol
Price/gallon	2.75	2.50	2.50
Emissions (in lbs/gallon)	20[a]	16	14
Service availability	Every fueling station	Every 3rd fueling station	Every 3rd fueling station

[a] One gallon of gasoline weighs only 6.3 pounds. However, according to U.S. Department of Energy calculations, 1 gallon of gasoline can produce 20 pounds of carbon dioxide (most of the weight of the CO_2 doesn't come from the gasoline itself, but the from the oxygen in the air). This occurs because burned gasoline produces carbon and hydrogen, which after interacting with the oxygen in the air, increases its weight to 20 pounds of carbon dioxide (CO_2) per gallon.

Parameters used in the eight fueling scenarios.[a]

Scenario	Price per gallon		Emissions		Availability	
	Cellulose	Corn	Cellulose	Corn	Cellulose	Corn
1	3.00	2.50	16	16	3	3
2	2.50	3.00	16	16	1	1
3	3.00	2.50	16	14	1	1
4	3.00	3.00	14	16	3	1
5	2.50	3.00	16	14	3	3
6	3.00	3.00	14	14	1	3
7	2.50	2.50	14	14	3	1
8	2.50	3.00	14	16	1	3
Averages	2.75	2.81	15	15	2	2

[a] Gasoline always cost 2.75; its emissions were listed as 20 (see previous section for an explanation provided to participants); and it was always available at every fueling station. Availability refers to whether the noted fuel is available at every station (1), or every third station (3).

Carbon dioxide (CO_2) emission statistics are available from the EPA Office of Transportation and Air Quality (http://www.epa.gov/otaq/climate/documents/420f11041.pdf).

References

Cameron, L. D., Brown, P. M., & Chapman, J. G. (1998). Social value orientations and decisions to take proenvironmental action. *Journal of Applied Social Psychology, 28*, 675–697.

Collins, C. M., & Chambers, S. M. (2005). Psychological and situational influences on commuter-transport-mode choice. *Environment and Behavior, 37*, 640–661.

Corral-Verdugo, V., Carrus, G., Bonnes, M., Moser, G., & Sinha, J. B. P. (2008). Environmental beliefs and endorsement of sustainable development principles in water conservation. *Environment and Behavior, 40*, 703–725.

Dietz, T., Fitzgerald, A., & Shwom, R. (2005). Environmental values. *Annual Review of Environment and Resources, 30*, 335–372.

Ebreo, A., & Vining, J. (2001). How similar are recycling and waste reduction? Future orientation and reasons for reducing waste as predictors of self-reported behavior. *Environment and Behavior, 33*, 424–448.

Energy Information Administration (EIA). (2009). Retail gasoline historical prices: Minnesota weekly retail. http://www.eia.gov/oil_gas/petroleum/data_publications/wrgp/mogas_history.html.

Environmental Protection Agency (EPA). (2005). *Emission facts, average carbon dioxide emissions resulting from gasoline and diesel fuel*. Environmental Protection Agency, Office of Transportation and Air Quality. http://www.epa.gov/otaq/climate/documents/420f11041.pdf.

Farrell, A. E., Plevin, R. J., Turner, B. T., Jones, A. D., O'Hare, M., & Kammen, D. M. (2006). Ethanol can contribute to energy and environmental goals. *Science, 311*, 506–508.

Gattig, A., & Hendrickx, L. (2007). Judgmental discounting and environmental risk perception: Dimensional similarities, domain differences, and implications for sustainability. *Journal of Social Issues, 63*, 21–39.

de Groot, J. I. M., & Steg, L. (2007). Value orientations and environmental beliefs in five countries: Validity of an instrument to measure egoistic, altruistic, and biospheric value orientations. *Journal of Cross Cultural Psychology, 38*, 318–332.

de Groot, J. I. M., & Steg, L. (2008). Value orientations to explain beliefs related to environmental significant behavior: How to measure egoistic, altruistic, and biospheric value orientations. *Environment and Behavior, 40*, 330–354.

de Groot, J. I. M., & Steg, L. (2010). Relationships between value orientations, self-determined motivational types and pro-environmental behavioural intentions. *Journal of Environmental Psychology, 30*, 368–378.

Hansla, A., Gamble, A., Juliusson, A., & Gärling, T. (2008). The relationships between awareness of consequences, environmental concern, and value orientations. *Journal of Environmental Psychology, 28*, 1–9.

Hardin, G. (1968). The tragedy of the commons. *Science, 162*, 1243–1248.

Hendrickx, L., Poortinga, W., & van der Kooij, R. (2001). Temporal factors in resource dilemmas. *Acta Psychologica, 108*, 137–154.

Hensher, D., & Greene, W. (2003). The mixed logit model: The state of practice. *Transportation, 30*, 133–176.

Hevey, D., Perti, M., Thomas, K., Maher, L., Craig, A., & Chuinneagain, S. N. (2010). Consideration of future consequences scale: Confirmatory factor analysis. *Personality and Individual Differences, 48*, 654–657.

Hine, D. W., & Gifford, R. (1996). Individual restraint and group efficiency in commons dilemmas: The effects of two types of environmental uncertainty. *Journal of Applied Social Psychology, 26*, 993–1009.

Honkanen, P., & Verplanken, B. (2004). Understanding attitudes towards genetically modified food: The role of values and attitude strength. *Journal of Consumer Policy, 27*, 401–420.

Jansson, J., Marell, A., & Nordlund, A. (2010). Green consumer behavior: Determinants of curtailment and eco-innovation adoption. *Journal of Consumer Marketing, 27*, 358–370.

Joireman, J. (2005). Environmental problems as social dilemmas: The temporal dimension. In A. Strathman, & J. Joireman (Eds.), *Understanding behavior in the context of time: Theory, research, and application* (pp. 289–304). Mahwah, NJ: Lawrence Erlbaum.

Joireman, J., Balliet, D., Sprott, D., Spangenberg, E., & Schultz, J. (2008). Consideration of future consequences, ego-depletion, and self-control: Support for distinguishing between CFC-immediate and CFC-future sub-scales. *Personality and Individual Differences, 45*, 15–21.

Joireman, J. A., Lasane, T. P., Bennett, J., Richards, D., & Solaimani, S. (2001). Integrating social value orientation and the consideration of future consequences within the extended norm activation model of proenvironmental behaviour. *British Journal of Social Psychology, 40*, 133–155.

Joireman, J., Posey, D. C., Truelove, H. B., & Parks, C. D. (2009). The environmentalist who cried drought: Reactions to repeated warnings about depleting resources under conditions of uncertainty. *Journal of Environmental Psychology, 29*, 181–192.

Joireman, J., Shaffer, M. J., Balliet, D., & Strathman, A. (2012). Promotion orientation explains why future-oriented people exercise and eat healthy: Evidence from the two-factor consideration of future consequences 14 scale. *Personality and Social Psychology Bulletin, 38*, 1272–1287.

Joireman, J., Strathman, A., & Balliet, D. (2006). Considering future consequences: An integrative model. In *Judgments over time: The interplay of thoughts, feelings, and behaviors* (pp. 82–99). Oxford: Oxford University Press.

Joireman, J., Van Lange, P. A. M., & Van Vugt, M. (2004). Who cares about the environmental impact of cars? Those with an eye toward the future. *Environment & Behavior, 36*, 187–206.

Joireman, J. A., Van Lange, P. A. M., Van Vugt, M., Wood, A., Vander Leest, T., & Lambert, C. (2001). Structural solutions to social dilemmas: A field study on commuters' willingness to fund improvements in public transit. *Journal of Applied Social Psychology, 31*, 504–526.

Karp, D. G. (1996). Values and their effect on proenvironmental behavior. *Environment and Behavior, 28*, 111–133.

Komorita, S. S., & Parks, C. D. (1994). *Social dilemmas*. Dubuque, IA: Brown & Benchmark Publishers.

Kortenkamp, K. V., & Moore, C. F. (2006). Time, uncertainty, and individual differences in decisions to cooperate in resource dilemmas. *Personality and Social Psychology Bulletin, 32*, 603–615.

Kortenkamp, K. V., & Moore, C. F. (2001). Ecocentrism and anthropocentrism: Moral reasoning about ecological commons dilemmas. *Journal of Environmental Psychology, 21*, 261–272.

Kramer, R. M., McClintock, C. G., & Messick, D. M. (1986). Social values and cooperative response to a simulated resource conservation crisis. *Journal of Personality, 54*, 576–592.

Kuhfeld, W. (2009). *Marketing research methods in SAS: Experimental design, choice, conjoint and graphical techniques*. Cary, NC: SAS Institute.

Lindsay, J. J., & Strathman, A. (1997). Predictors of recycling behavior: An application of a modified health belief model. *Journal of Applied Social Psychology, 27*, 1799–1823.

Liska, A. J., Yang, H. S., Bremer, V. R., Klopfenstein, T. J., Walters, D. T., Erickson, G. E., et al. (2009). Improvements in life cycle energy efficiency and greenhouse gas emissions of corn-ethanol. *Journal of Industrial Ecology, 13*, 58–74.

Long, S., & Freese, J. (2006). *Regression models for categorical dependent variables using stata*. College Station, TX: Stata Press.

Mannix, E. A. (1991). Resource dilemmas and discount rates in organizational decision making groups. *Journal of Experimental Social Psychology, 27*, 379–391.

McFadden, D. (1974). Conditional logit analysis of qualitative choice behavior. In *Frontiers in econometrica* (pp. 105–142). New York: Academic Press.

McFadden, D. (2001). Economic choices. *The American Economic Review, 91*, 351–378.

Merchant, C. (1992). *Radical ecology: The search for a livable world*. New York: Routledge.

Messick, D. M., & Brewer, M. B. (1983). Solving social dilemmas: A review. In L. Wheeler, & P. Shaver (Eds.). *Review of personality and social psychology, Vol. 4* (pp. 11–44). Beverly Hills, CA: Sage.

Messick, D. M., & McClelland, C. L. (1983). Social traps and temporal traps. *Personality and Social Psychology Bulletin, 9*, 105–110.

Milfont, T. L., & Duckitt, J. (2004). The structure of environmental attitudes: A first- and second-order confirmatory factor analysis. *Journal of Environmental Psychology, 24*, 289–303.

Milfont, T. L., & Duckitt, J. (2010). The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. *Journal of Environmental Psychology, 30*, 80–94.

Milfont, T. L., Duckitt, J., & Wagner, C. (2010). A cross-cultural test of the value–attitude–behavior hierarchy. *Journal of Applied Social Psychology, 40*, 2791–2813.

Milfont, T. L., & Gouveia, V. V. (2006). Time perspective and values: An exploratory study of their relations to environmental attitudes. *Journal of Environmental Psychology, 26*, 72–82.

Milfont, T. L., Wilson, J., & Diniz, P. (2012). Time perspective and environmental engagement: A meta-analysis. *International Journal of Psychology, 47*, 325–334.

Nilsson, A., von Vorgstede, C., & Biel, A. (2004). Willingness to accept climate change strategies: The effects of values and norms. *Journal of Environmental Psychology, 24*, 267–277.

Nordlund, A.,M., & Garvill, J. (2003). Effects of values, problem awareness, and personal norm on willingness to reduce personal car use. *Journal of Environmental Psychology, 23*, 339–347.

Parks, C. D., Joireman, J., & Van Lange, P. A. M. Cooperation, trust and antagonism: How public goods are promoted. *Psychological Science in the Public Interest*, in press.

Petrocelli, J. V. (2003). Factor validation of the consideration of future consequences scale: Evidence for a shorter version. *Journal of Social Psychology, 143*, 405–413.

Poortinga, W., Steg, L., & Vlek, C. (2004). Values, environmental concern, and environmental behavior: A study into household energy use. *Environment and Behavior, 36*, 70–93.

Rappange, D. R., Brouwer, W. B. F., & Van Exel, N. J. A. (2009). Back to the consideration of the future consequences scale: Time to reconsider? *Journal of Social Psychology, 149*, 562–584.

Ryack, K. (2012). Evidence that time perspective factors depend on the group: Factor analyses of the CFC and ZTPI scales with professional financial advisors. *Personality and Individual Differences, 52*, 723–727.

Schultz, P. W. (2001). The structure of environmental concern: Concern for the self, other people, and the biosphere. *Journal of Environmental Psychology, 21*, 327–339.

Schultz, P. W., Gouveia, V. V., Cameron, L. D., Tankha, G., Schmuck, P., & Franěk, M. (2005). Values and their relationship to environmental concern and conservation behavior. *Journal of Cross-Cultural Psychology, 36*, 457–475.

Schultz, P. W., & Zelezny, L. (1998). Values and proenvironmental behavior: A five-country survey. *Environment and Behavior, 29*, 540–558.

Schultz, P. W., & Zelezny, L. (1999). Values as predictors of environmental attitudes: Evidence for consistency across 14 countries. *Journal of Environmental Psychology, 19*, 255–265.

Schwartz, S. H. (1992). Universals in the content and structure of values: Theoretical advances and empirical tests in 20 countries. *Advances in Experimental Social Psychology, 25*, 1–65.

Schwartz, S. H. (1994). Are there universal aspects in the structure and contents of human values? *Journal of Social Issues, 50*, 19–45.

Sissine, F. (2007). *Energy independence and security act of 2007: A summary of major provisions*. Congressional Research Service report for congress. http://energy.senate.gov/public/_files/RL342941.pdf.

Steg, L., Dreijerink, L., & Abrahamse, W. (2005). Factors influencing the acceptability of energy policies: A test of VBN theory. *Journal of Environmental Psychology, 25*, 415–425.

Steg, L., de Groot, J. I. M., Dreijerink, L., Abrahamse, W., & Siero, F. (2011). General antecedents of personal norms, policy acceptability, and intentions: The role of values, worldviews, and environmental concern. *Society and Natural Resources, 24*, 349–367.

Stern, P. C., & Dietz, T. (1994). The value basis of environmental concern. *Journal of Social Issues, 50*, 65–84.

Stern, P. C., Dietz, T., & Guagnano, G. A. (1998). A brief inventory of values. *Educational and Psychological Measurement, 58*, 984–1001.

Strathman, A., Gleicher, F., Boninger, D. S., & Edwards, C. S. (1994). The consideration of future consequences: Weighing immediate and distant outcomes of behavior. *Journal of Personality and Social Psychology, 66*, 742–752.

Thompson, S. G. G., & Barton, M. A. (1994). Ecocentric and anthropocentric attitudes toward the environment. *Journal of Environmental Psychology, 14*, 149–157.

Tilman, D., Socolow, R., Foley, J. A., Hill, J., Larson, E., Lynd, L., et al. (2009). Beneficial biofuels: The food, energy, and environment trilemma. *Science, 325*, 270–271.

Toepoel, V. (2010). Is consideration of future consequences a changeable construct? *Personality and Individual Differences, 48*, 951–956.

Train, K. (2007). *Discrete choice models with simulation*. New York: Cambridge University Press.

Train, K., & Wilson, W. W. (2008). Estimation on stated-preference experiments constructed from revealed-preference choices. *Transportation Research Part B: Methodological, 42*, 191–203.

U.S. Census Bureau. (2010). American fact finder: People and households. http://www.census.gov/people/.

Van Lange, P. A. M., Joireman, J., Parks, C. D., & van Dijk, E. (2013). The psychology of social dilemmas: A review. *Organizational Behavior and Human Decision Processes, 120*, 125–141.

Van Lange, P. A. M., Van Vugt, M., Meertens, R. M., & Ruiter, R. A. C. (1998). A social dilemma analysis of commuting preferences: The roles of social value orientation and trust. *Journal of Applied Social Psychology, 28*, 796–820.

Van Vugt, M. (1997). Concerns about the privatization of public goods: A social dilemma analysis. *Social Psychology Quarterly, 60*, 355–367.

Van Vugt, M., & Samuelson, C. D. (1999). The impact of personal metering in the management of a natural resource crisis: A social dilemma analysis. *Personality and Social Psychology Bulletin, 25*, 735–750.

Van Vugt, M., Van Lange, P. A. M., & Meertens, R. M. (1996). Commuting by car or public transportation? A social dilemma analysis of travel mode judgments. *European Journal of Social Psychology, 26*, 373–395.

Vlek, C., & Keren, G. B. (1992). Behavioral decision theory and environmental risk management: Assessment and resolution of four 'survival' dilemmas. *Acta Psychologica, 80*, 249–278.

Wade-Benzoni, K. A. (2008). Maple trees and weeping willows: The role of time, uncertainty and affinity in intergenerational decisions. *Negotiation and Conflict Management Research, 1*, 220–245.

Weber, J. M., Kopelman, S., & Messick, D. M. (2004). A conceptual review of decision making in social dilemmas: Applying a logic of appropriateness. *Personality and Social Psychology Review, 8*, 281–307.

Zimbardo, P. G., & Boyd, J. N. (1999). Putting time in perspective: A valid, reliable individual differences metric. *Journal of Personality and Social Psychology, 77*, 1271–1288.