You are what you drive: Environmentalist and social innovator symbolism drives electric vehicle adoption intentions

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Abstract

Electric vehicles (EVs) have the potential to dramatically reduce vehicle emissions contributing to climate change without significantly reducing convenience or mobility. Despite their potential, EV market share remains low, necessitating research to identify factors that could encourage more widespread adoption. For instance, concern about climate change is associated with intent to adopt an EV, but little is known about mechanisms through which this concern may translate into action. This study builds on previous work investigating the roles of symbolic and instrumental attributes in low-emission vehicle adoption, focusing exclusively on EVs to better understand perceptions associated with their unique technical capabilities. Prior work has examined symbolism rather generally (e.g., in terms of status). We examine specific aspects of self-identity that EVs may reflect, representing the extent to which consumers perceive EVs as symbols that they are environmentalists and/or social innovators. In addition, extending prior work, we quantify the relative influence of these separate aspects of symbolism on EV adoption intentions alongside instrumental, psychological, and demographic factors. We find differing impacts of these two symbols on EV adoption intentions. Environmentalist symbolism is consistently the strongest predictor of adoption, across three dependent variables. Innovator symbolism predicts willingness to lease/buy an EV, trailing only environmentalist symbolism in effect size, and outperforming instrumental attributes as well as psychological and demographic factors. Additionally, we examine a potential mechanism through which concern about climate change may translate into EV adoption intentions: we find that seeing EVs as environmentalist and social innovator symbols partially mediates the relationship between concern about climate change and EV adoption intentions. These results have implications for EV marketing and policy, and suggest that emphasizing the potential for EVs to reinforce specific self-identities may be a more promising strategy to increase adoption rates than emphasizing instrumental attributes such as fuel efficiency.

1 Introduction

Significant reductions in anthropogenic emissions of greenhouse gases, including carbon dioxide, are necessary to stem climate change and its associated consequences (Allen et al., 2009; Meinshausen et al., 2009). In the United States (U.S.), the transportation sector accounts for roughly 28% of all greenhouse gas emissions, with light duty vehicles making up 62% of transportation sector emissions (U.S. Environmental Protection Agency, 2015). Gasoline vehicles emit myriad additional pollutants with deleterious health effects, such as nitrogen oxide and fine particulate matter (Brugge et al., 2007), positioning the transportation sector in an important role for public health (World Health Organization, 2005; Zhang and Batterman, 2013).

Alternative fuel vehicles offer one promising solution to these issues. In particular, fully electric vehicles (henceforth referred to as "EVs") receive 100% of their energy from the electrical grid, allowing for very low emissions if they are charged on low carbon-intensity electric grids. Notwithstanding the U.S.'s currently coal-heavy electricity portfolio, the growing share of renewable energy sources and improving efficiency of power plants allow EVs to reduce total average emissions to nearly half those of a gasoline-fueled vehicle (U.S. Department of Energy, 2015a).

Additionally, efforts are being made to integrate EVs into the power grid using "Vehicle to Grid" technology, whereby EV batteries are used as distributed storage. In light of this emerging technology, a large EV fleet could offer additional benefits to the power sector including power grid regulation, spinning reserve, peak load shaving, and load leveling (Tan et al., 2016). In some situations, it may even be possible for EVs to obviate the need for additional electricity generation, for instance, by discharging unused battery energy back onto the grid during peak demand periods (Jochem et al., 2015).

Despite these advantages and various government subsidies, EVs accounted for only 0.7% of U.S. market share in 2015 (IEA, 2016). Although the availability of financial incentives is positively correlated with EV adoption rates, price signals represent only one predictor of EV adoption; these decisions cannot be understood without considering additional factors, including symbolic attributes, that consumers perceive as important in these purchases (Heffner et al., 2007; Kurani et al., 2006; Steg, 2005). Developing a more comprehensive understanding of the motivators and barriers to consumer adoption of EVs is imperative to improving their market penetration.

1.1 Contributions

Previous work examining symbolic attributes related to EV adoption intentions has operationalized symbolic attributes somewhat generically in terms of whether EVs convey a positive message about their drivers (Noppers et al., 2015; Schuitema et al., 2013). This leaves an open question of what particular positive messages drivers may be seeking. However, little research has investigated specific aspects of symbolism and how these are perceived to reflect on one's self-identity; the few studies that have done so have either studied hybrid electric vehicles (hybrids; see last paragraph in this section for why this may not accurately represent EVs), or have used analytic approaches that fell short of examining multiple components of symbolism while accounting for other important predictors of adoption simultaneously (Axsen and Kurani, 2013; Krupa et al., 2014). We advance the literature on symbolism by operationalizing EV symbolic attributes as the extent to which people perceive EVs to reinforce specific aspects of self-identity. This study examines the extent to which EVs may symbolize two specific aspects of self-identity: environmentalist and social innovator. Further, we evaluate the separate influences of these symbolic attributes in multiple regression models alongside instrumental, demographic, and psychological predictors of adoption.

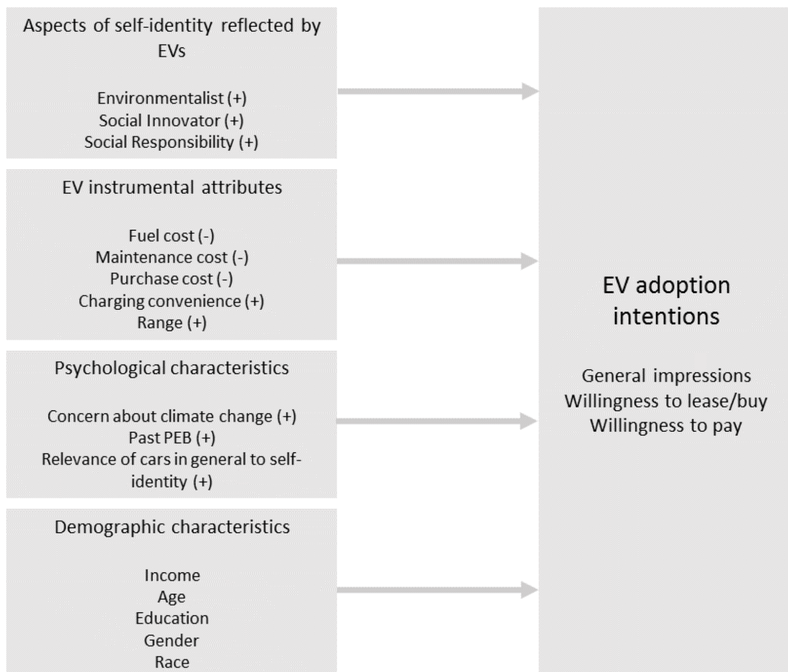
The climate change mitigation potential of EVs is a commonly cited driver of consumer interest in these vehicles. Previous studies have established the influence of concern about climate change on EV adoption intentions (Carley et al., 2013; Egbue and Long, 2012; Skippon and Garwood, 2011). We extend this by examining whether symbolic attributes may be a mechanism through which concern about climate change translates into willingness to adopt EVs. This area of investigation has implications for efforts to promote EV uptake, as appeals to reflect self-identity may be more effective in promoting EV adoption than elevating levels of concern over climate change (Steg et al., 2014).

Additionally, this study focuses exclusively on battery-operated EVs, excluding hybrids. Unlike EVs, hybrids still utilize the familiar technology of combustion engines, and can be refueled at regular gas stations. Technical attributes of EVs and hybrids differ considerably, particularly regarding concerns about vehicle range (Rezvani et al., 2015). Hybrids may be owned and operated with very little change of habit, and as such may represent an easier-to-adopt pro-environmental behavior (PEB) compared to EVs. Hybrids also still produce emissions directly, so may reflect environmentalist self-identity to a lesser extent compared to EVs. For these reasons, results from studies focused on hybrid adoption may not fully transfer to EVs.

1.2 Predictors of EV adoption intentions

Predictors of EV adoption can be divided across multiple dimensions. Following Steg's (2005) categorization of instrumental (associated with practical concerns such as cost) and symbolic (associated with imagery and identity aspects of EVs) attributes, below we review the evidence for these two types of predictors. We additionally examine evidence for demographic and psychological predictors. Groups of predictors examined are summarized in Figure 1.

Figure 1: Expected predictors of EV adoption intentions, and their hypothesized directions



1.2.1 Symbolic attributes

1.2.1.1 Symbolic attributes and inconsistencies in the literature

Steg et al. (2005) introduce the term symbolic attributes to refer to the group of factors affecting car choices due to emotions and symbolism associated with cars. Symbolic attributes associated with EVs have been linked to the concept of identity, such that the symbolism associated with EVs can "construct and express identity" (Rezvani et al., 2015) and "define and express self-identity and social status" (Burgess et al., 2013), with symbolic attributes being "related to a sense of self or social identity that is reflected by, or built from the possession of new technologies" (Schuitema et al., 2013). Previous studies have established the importance of symbolic attributes for predicting EV adoption (Noppers et al., 2015, 2014), and have found that symbolic attributes can mediate the effect of perceived instrumental attributes on EV purchase (Schuitema et al., 2013).

However, the term "symbolic attributes" has been used somewhat inconsistently across studies to describe groups of questions which seem to tap slightly different psychological constructs. Furthermore, most previous assessments of symbolic attributes have fallen short of assessing a range of unique symbols relevant to self-identity. See Table 1 for a summary of questions from prior studies which have purported to measure symbolic attributes or imagery associated with EVs. Most studies applying the term "symbolic attributes" have operationalized symbolism quite broadly, with questions such as "An electric car gives me status" (Noppers et al., 2015, 2014; Schuitema et al., 2013). In some cases, symbolism has been operationalized to reflect (environmental) benefits of cars without specific reference to status, image, or self-identity (Nayum and Klöckner, 2014). What might the broad category of "status" mean to different individuals? The questions used in previous work generally do not tap into specific types of status, nor aspects of self-identity, that people may be trying to reflect (Noppers et al., 2015, 2014; Schuitema et al., 2013). It is important to define these specific aspects, as individuals may value some aspects of self-identity more highly than others when considering adopting EVs. Therefore, for the purposes of this paper, we define symbolic attributes as attributes which reflect specific aspects of self-identity.

A few studies have assessed specific aspects of self-identity reflected by EVs, but have not accounted for the influences of these variables alongside those of instrumental EV attributes in models of adoption intentions (Table 1). For instance, Krupa and colleagues (2014) assessed environmental and technological imagery, but only included environmental imagery in a multivariable model (which was not significantly associated with adoption intentions), and examined intent to adopt *compact* hybrids rather than EVs. Axsen and Kurani (2013) assessed environmental, intelligent, and responsible imagery associated with EVs, but these questions asked about others' perceptions of the vehicle itself, not individuals' perception of how the vehicle reflects on them. As well, they primarily relied on chi-squared analyses. These approaches limit conclusions about the extent to which specific aspects of symbolism predict EV adoption (and adoption intentions), as they have not fully adjusted for the impacts of other established predictors of adoption (for review, see Rezvani et al., 2015).

Table 1: Operationalization of low-emission vehicle symbolism in prior quantitative work, compared to present study operationalization

Authors (year) location, sample	Vehicle type	Questions	Term used by authors to describe construct	Analyses applied to symbolism questions
Noppers et al. (2014) Netherlands, community sample	EVs	"The electric car shows who I am" "The electric car enhances my social status" (a total of eight items that load onto the same factor, not all detailed in paper)	Symbolic Attributes	Bivariate correlations; Multiple regression
Noppers et al. (2015) Netherlands, commercial sample	EVs	*To what extent do you think that the following characteristics are advantages of an electric vehicle?* 'An electric car gives me status' 'An electric car enables me to distinguish myself from others' 'I can show who I am with an electric car'	Symbolic Attributes	Multiple regression

		‘An electric car fits me’ ‘An electric car says something about me’		
Schuitema et al. (2013) United Kingdom, recent car buyers	Hybrids and EVs	‘Compared to a normal car, plug-in hybrid electric cars/plug-in fully electric cars not suitable for my lifestyle’ ‘I would feel proud of having a plug-in hybrid electric car/plug-in fully electric car outside my house’ ‘I would feel embarrassed to drive a plug-in hybrid electric car/plug-in fully electric car’	Symbolic Attributes	OLS regression testing mediation effects
Krupa et al. (2014) U.S., online sample	Hybrids	‘Owning a [hybrid] would make a statement regarding my strong environmental values’ ‘Owning a [hybrid] would make it clear to others that I am on the forefront of new technology’	Imagery	Spearman correlations; Multiple logistic regression including one symbolism item
Nayum & Klockner (2014) Norway, community sample	Fuel-efficient cars	*How important did you find following aspects for you when you made purchasing decision of your new car?* Environmentally friendly materials Fuel economy CO_2 reducing tires The energy label of the car Greenhouse gas emissions Emission of polluting chemicals	Symbolic Attributes	Structural Equation Modelling
Axsen & Kurani (2013) U.S., new vehicles drivers	All passenger vehicles including EVs	*Other people will think this vehicle looks…* …intelligent …responsible …supportive of the environment …supportive of the U.S. …powerful	Imagery	Chi-square analysis
Present study (2017), U.S., power utility customers	EVs	‘Owning an EV demonstrates to others that I care about the environment’ ‘Changing from a gasoline-powered vehicle to an EV will lessen my impact on the environment’ ‘Driving an EV means that I am doing the right thing’ ‘Driving an EV means that I am a trendsetter for environmentally friendly technologies’	Symbolic Attributes reflecting aspects of self-identity	Multiple OLS regression, mediation analyses

		'Driving an EV means that I am socially responsible'		

We identified three aspects of symbolism suggested by prior literature. In particular, previous work suggests that EVs have the potential to communicate a variety of specific meanings on behalf of their owners, including care for the environment, support for new technology, and concern for general social welfare (Heffner et al., 2007). We consider these as three symbolic reflections of self-identity: environmentalist, innovator, and socially responsible citizen, and examine them in the following sections 1.2.1.2 to 1.2.1.4.

1.2.1.2 EVs as symbols for environmentalists

Self-identity can be defined as "a set of meanings attached to roles individuals occupy in the social structure, and unique ways in which they see themselves in these roles" (Barbarossa et al., 2015). Previous research has established that pro-environmental self-identity, or the extent to which one sees oneself as an environmentalist, is a predictor of PEB in general (Van der Werff et al., 2013a; Whitmarsh and O'Neill, 2010a). EVs can serve as highly visible symbols for consumers wishing to advertise environmentalist self-identities to others, and may also reinforce existing environmentalist self-identities by acting as a symbol to oneself (Noppers et al., 2014; Sexton and Sexton, 2014).

Supporting this idea, studies have found associations between environmental self-identity and favorability towards EVs (Axsen et al., 2012; Graham-Rowe et al., 2012), higher ratings of EV instrumental and symbolic attributes (Schuitema et al., 2013), and perceptions that EVs are symbols of environmental concern (Axsen and Kurani, 2013). Environmentalist self-identity has also been found to influence consumer attitudes towards EVs, and in turn has been found to enhance intentions to adopt EVs (Barbarossa et al., 2015). Hence, the extent to which respondents perceive EVs as symbols to reflect environmentalist self-identity should enhance adoption likelihood. Although previous studies have shed light on related questions, this particular topic remains under-explored.

1.2.1.3 EVs as symbols for innovators

As noted by Heffner et al. (2007) with reference to hybrid vehicles, emerging vehicle markets have the potential to embody new combinations of meanings. In addition to acting as a symbol for environmentalists, EVs may also act as symbols for consumers who wish to show an affinity for technological innovation as part of their self-identities.

Consumers often adopt technologically innovative systems due to enjoyment of innovations and technical aspects, even in absence of economic benefits or environmental concerns (Schelly, 2014). Cars are publicly consumed products, and social identity concerns have been found to drive consumer adoption of such products, being both highly visible and projecting an image of technological innovativeness (Grewal et al., 2000). For instance, some consumers are willing to pay more for EVs if they perceive them as superior to existing technology (Hahnel et al., 2014), and symbolic attributes more strongly predict interest in EVs by potential early adopters if instrumental attributes are evaluated poorly (Noppers et al., 2015). Households have also expressed that they see symbolic meaning in hybrids for marking their self-identity as part of a "technological vanguard" (Heffner et al., 2007). Noppers et al. (2014) concluded that EVs signal a status motivation separate from environmental concern, and although unmeasured, that EV may also signal innovativeness, suggesting that future research explore this topic.

If consumers enjoy interacting with new technology and view EVs as a way to set new trends, this may increase their enjoyment of driving an EV, which in turn could make EV adoption more likely (Steg et al., 2014). In fact, some consumers who perceive that EVs are not easy to use have stronger adoption intentions than those who think they are easy to use, which may indicate that they see status in adopting a new and somewhat challenging technology (Peters and Dütschke, 2014).

1.2.1.4 EVs as a symbol of social responsibility

EVs can embody meanings which are only secondarily related to the environment. Notably, EVs can embody support for the nation (Axsen and Kurani, 2013), or opposition to war and imported oil (Heffner et al., 2007). Consumers who purchase EVs with these types of meaning in mind may feel that EVs serve as a way to show social responsibility, for instance by supporting issues that are not directly associated with "green" imagery. In fact, consumers without previous histories of environmental purchasing have responded positively to EVs as a way to construct new identities encompassing moral concern and care for others (Heffner et al., 2007).

Based on prior literature, we advance the following hypotheses:

EVs will be perceived as reflecting multiple unique aspects of self-identity (H1a), in particular, environmentalist, innovator, and socially responsible self-identities (H1b)

Perceptions that EVs symbolize unique aspects of self-identity will each positively predict intent to adopt an EV (H2a), with environmentalist symbolism acting as the strongest symbolic predictor of EV adoption intentions (H2b)

1.2.2 Concern about climate change and the role of symbolic attributes

In EV research, concern about climate change is often assessed by asking whether individuals view climate change as a problem (Carley et al., 2013; Krupa et al., 2014) and/or by asking whether the emissions reduction potential of EVs is seen as a benefit (Egbue and Long, 2012; Krupa et al., 2014; Skippon and Garwood, 2011). Both measures are associated with stronger EV adoption intentions (Carley et al., 2013; Egbue and Long, 2012; Krupa et al., 2014; Skippon and Garwood, 2011). However, previous literature has fallen short of determining whether or how concern about climate change may act to influence adoption through linkages with sense of self. For instance, environmentalist consumers may be especially motivated to adopt EVs as an emissions reduction tool (Steg et al., 2014) to respond to their concerns over climate change.

Self-identity has been found to mediate the relationship between values and behavior, shedding some light on psychological mechanisms through which environmental concern may translate into PEB (Van der Werff et al., 2014, 2013a; Whitmarsh and O'Neill, 2010b). It follows that viewing EVs to symbolize aspects of self-identity may similarly mediate the association between concern about climate change and EV adoption, though this has not previously been tested. The saliency of EVs as a symbol for environmentalist self-identity is expected to be stronger amongst individuals who are concerned about climate change, and in turn, stronger perceptions of environmentalist symbolism are expected to increase adoption intentions. A similar link is expected for those viewing EVs as a symbol for innovator self-identity, who may look to EVs as a new technology that can also help address societal issues.

H3a: Concern about climate change will positively predict intent to adopt an EV, and this relationship will be mediated by the extent to which EVs are perceived to symbolize environmentalist self-identity

H3b: Viewing EVs as a symbol for innovator self-identity will also mediate the relationship between concern about climate change and EV adoption, although to a lesser extent than viewing EVs as a symbol for environmentalists

1.2.3 Instrumental attributes

Instrumental attributes describe practical issues such as economic and convenience concerns associated with cars. EV adoption is influenced by these instrumental attributes, including purchase costs, range, and charging locations (Axsen and Kurani, 2013; Caperello and Kurani, 2012; Carley et al., 2013; Graham-Rowe et al., 2012; Jensen et al., 2013; Krupa et al., 2014; Wang et al., 2012). Following the definitions used in Noppers et al. (2014), we consider economic and convenience measures as instrumental attributes, and review relevant prior work below.

1.2.3.1 Economic concerns

Many consumers perceive the purchase cost of an EV as a barrier to adoption. For instance, in one U.S.-based survey, over half of respondents listed the purchase price as a major disadvantage (Carley et al., 2013). Moving beyond perceptions to behavior, actual EV purchase data from several countries offering support policies and infrastructure for EVs revealed that government rebate programs encouraged EV adoption (Sierzchula et al., 2014). However, a recent U.S. study found that purchase incentives predicted greater adoption likelihood for plug-in hybrids but not for battery EVs (Vergis and Chen, 2015), suggesting that context may play a role in the influence of purchase price.

Related to fuel costs, on average across the U.S. it costs about half as much per gallon-equivalent to fuel a car using electricity rather than gasoline (U.S. Department of Energy, 2015b). Although consumers often rate fuel savings as a major benefit of EVs (Carley et al., 2013; Egbue and Long, 2012), this is not always reflected in intent to purchase EVs (Carley et al., 2013). This may be related to the fact that the savings achievable by switching from gasoline to electricity as a fuel are not immediately apparent, and consumers are sometimes concerned about or fail to fully appreciate fuel savings repaying the higher purchase cost over the vehicle's lifetime (Graham-Rowe et al., 2012). Consumers have also been found to have little idea how much they spend on gasoline in any given month (Turrentine and Kurani, 2007), and may be unable to determine actual fuel cost savings associated with an EV. Studies have found varying degrees of success in increasing adoption intentions by providing consumers with five-year fuel savings or total cost of ownership data (Dumortier et al., 2015; Nixon and Saphores, 2011), highlighting that price is not the only determinant of EV purchase, and that people are not making purely rational decisions in purchasing EVs.

1.2.3.2 Convenience: Charging and Range

Perceptions of the convenience of EVs also impact adoption intentions, with reduced range and long charging times being two major factors that reduce likelihood of adoption. Limited EV range has had a major negative impact on adoption intentions in some studies (Jensen et al., 2014, 2013) and range limitations have been linked to consumer frustration in others (Graham-Rowe et al., 2012). However, some studies have found no relation between actual driving patterns and intent to purchase an EV (Carley et al., 2013; Kurani et al., 1996), and current EV drivers are generally satisfied with available range

(Franke and Krems, 2013; Pearre et al., 2011). In sum, the findings related to range are somewhat inconclusive. It is possible that different individual- or household- level characteristics affect the impact of range on adoption. For instance, individuals living in households with access to multiple vehicles did not find EV range limitations to be a barrier (Kurani et al., 1996), as they could use a gasoline vehicle for longer trips. Additionally, some consumers may view adaptation to instrumental limitations such as shorter range as a symbolic benefit of EVs (Axsen and Kurani, 2013). Further research is needed to understand for whom EV limited range is a benefit vs. a barrier.

The ability to charge an EV with minimal disruption to typical routines has emerged as another important convenience factor associated with higher likelihood of adoption. Consumers who needed to alter their daily routines to allow EVs time to charge at workplaces reported frustration at the limitations imposed on their movement (Graham-Rowe et al., 2012), and those who trialed EVs reported higher willingness to pay if they had the option to charge at work or access to public chargers (Jensen et al., 2013). Charging at home has been found to be most preferred, with workplace charging rated second (Skippon and Garwood, 2011). Further, the ability to charge at home, thereby avoiding refueling at gas stations, may be considered a positive attribute of EVs relative to gasoline vehicles (Kurani et al., 1996). Overall, findings support convenient charging as a factor that encourages EV adoption.

1.2.4 Demographic characteristics

Previous empirical studies examining the relationship between demographic characteristics and EV adoption have yielded inconclusive or conflicting results. With respect to gender for instance, men have generally been found to express more interest in EVs than women (Egbue and Long, 2012; Peters and Dütschke, 2014; Plötz et al., 2014). However, interest does not always translate into intent to purchase (Egbue and Long, 2012). Furthermore, in some cases, gender has not been found to affect interest in EVs at all (Jensen et al., 2014), and another study controlling for psychological variables yielded slightly higher adoption intentions among women (Nayum and Klöckner, 2014). Thus, the literature does not provide a conclusive prediction of the impact of gender on EV adoption intentions.

Demographic findings related to age, income and education are similarly mixed. Regarding age, whereas older individuals have generally been found to express greater interest in EVs (Barth et al., 2016; Egbue and Long, 2012), adoption intentions are generally higher among middle-aged individuals (Peters and Dütschke, 2014; Plötz et al., 2014). Additional studies have found that younger individuals express stronger intentions to purchase an EV (Carley et al., 2013; Hidrue et al., 2011), and higher willingness to pay (Achtnicht, 2012). However, other work controlling for psychological factors found no significant impact of age (Nayum and Klöckner, 2014). With respect to income, some studies have found higher earnings to have no impact (Carley et al., 2013; Egbue and Long, 2012), or only marginal impacts (Barth et al., 2016) on adoption intentions, yet another found a small positive effect even when controlling for psychological factors (Nayum and Klöckner, 2014). Finally, higher education levels have been found in various studies to predict interest in EVs but not necessarily purchase intent (Egbue and Long, 2012), to have a weak positive effect on adoption (Nayum and Klöckner, 2014), to have a negative effect on adoption intent (Carley et al., 2013), and to have no effect on adoption (Moons and De Pelsmacker, 2012; Peters and Dütschke, 2014). Concluding, the findings on associations between EV adoption intentions and gender, age, income, and education are mixed, necessitating further work to clarify our understanding of these relationships.

1.2.5 Past pro-environmental behavior

Broad-ranging research highlights the importance of accounting for past behavior in predicting future behavior (Ouellette and Wood, 1998). We consider that past PEB may impact EV adoption intentions. Supporting this notion, Whitmarsh and O'Neill (2010) note that past PEB significantly influences intentions to perform PEBs in the future. Past PEB has been linked to stronger intentions to use EVs (Moons and De Pelsmacker, 2012), but has not previously been considered as a predictor of EV adoption intentions alongside EV symbolic attributes (Axsen and Kurani, 2013; Krupa et al., 2014).

1.2.6 Social norms

Social norms (broadly, the social pressure to behave "appropriately"), can be encouraged by observing others meeting norms for a given situation (Keizer et al., 2013). Thus, if consumers perceive that many people around them are taking positive action for the environment and society by adopting EVs, they may perceive it as the "appropriate" thing to do, and develop stronger intentions to adopt EVs themselves. Supporting this idea, social norms related to EVs have been found to predict EV adoption intent (Peters and Dütschke, 2014). However, previous studies have not attempted to directly influence social norms as they pertain to EVs, for instance, through messaging that aims to give consumers the impression that their peers are engaging in PEB through EV purchases. Our study incorporated a messaging experiment in which respondents were randomly assigned to receive a message focused on either financial benefits of EVs or social norms surrounding EVs, the latter of which was intended to examine this potential.

H4: Receipt of social norms messaging will predict stronger intent to adopt an EV than receipt of financial messaging

2 Methods

The following section describes how we used survey data from a sample of Los Angeles (L.A.) County residents to test our hypotheses.

2.1 Procedures

Surveys were mailed to a random sample of residential customers of a large power utility in southern California in 2014. Sequentially, surveys first assessed dependent variables assessing dimensions of EV adoption intentions, followed by instrumental attributes, symbolism, and psychological characteristics, with demographic variables assessed last.

Additionally, households were randomly assigned to receive one of two persuasive cover letters introducing the study and inviting participation: half the sample received a social norms-focused persuasive message, emphasizing the increasing popularity, preponderance, and public acceptance of EVs in L.A. The other half received a financially-focused persuasive message, emphasizing the financial benefits of EVs including lower fuel and maintenance costs.

2.2 Participants

A total of 481 surveys were returned, including 218 from respondents who had received financial messaging and 263 from respondents who had received social norms messaging. Of these, 437 respondents answered all three dependent variables. 124 individuals with missing data on predictor variables were then dropped. An additional two respondents who provided outlier responses of over 10,000 miles to questions asking for perceived EV range and daily driving distances were coded as having missing responses to these questions, raising the missing count to 126. This yielded a final sample of 355 observations, which includes 155 and 200 respondents who received financial and social norms persuasive messages, respectively.

The sample had a median age of 53.0 years and was roughly half female. Nearly three-quarters had bachelor's degrees, and approximately two-thirds identified as Caucasian, with one-third identifying as minority or multi-racial. Compared to L.A. county, our sample was older, had higher income and education levels, and contained a lower proportion of individuals identifying as a minority ethnicity or multi-racial. See Table 2 for a summary of sample characteristics.

Table 2: Participant demographic characteristics relative to Los Angeles County.

Characteristic	Sample (%)[a]	Los Angeles County[b] (%)
Ethnicity		
African American	2.3	8.1
Asian / Asian American	11.9	13.7
Caucasian	67.6	27.5
Latino	10.7	47.9
Native American / Pacific Islander	0.6	0.2
Multiracial	4.9	2.1
Other	2.0	0.2
Educational Attainment (>= 25 yrs)		
Less than High School	1.1	23.4
High school diploma	4.3	20.5
Some college / Associate's degree	22.1	26.5
4-year college degree	37.7	19.4
Graduate / professional degree	34.8	10.2
High School diploma or higher	98.9	76.6
Bachelor's degree or higher	72.5	29.7
Annual household income		
<$25,000	9.9	Median household income:
$25,001-$50,000	13.6	$55,909
$50,001-$75,000	20.4	
$75,001-$100,000	13.6	
>$100,000	42.5	
Home ownership rate	60.8	46.9
Home type		
Single Family Home	52.8	49.7
Apartment/Condo	35.9	34.3
Duplex, Triplex	5.9	8.0
Townhouse	4.5	6.5
Mobile Home	0.6	1.5
Other	0.3	
Gender (% male)	51.8	49.3
Age (median)	53.0	35.1

[a] Not all respondents answered all demographic questions. Available data for respondents who answered questions is as follows: $N_{ethnicity} = 346$, $N_{education}=353$, $N_{income}=294$, $N_{home\ ownership}=355$, $N_{home\ type}=354$, $N_{gender}=284$, $N_{age}=246$. [b](U.S. Census Bureau, 2013).

2.2.1 Drop-out analyses

Wilcoxon rank-sum tests were used to compare the median distribution of each dependent variable (see section 2.3.1 below for variable details) among the final main dataset (355 observations) to those excluded due to missing data (126 observations in total, though only 103-106 observations could be included in each test as many incomplete responses did not include the necessary dependent variable). The Wilcoxon rank-sum test is the nonparametric alternative to an independent samples t-test, and was used given the non-normal distributions of the dependent variables. No differences between completers and non-completers were observed for willingness to lease/buy. However, the distribution of completers was significantly different from that of non-completers for willingness to pay and impressions, such that completers scored significantly higher (for willingness to pay $M_{pay\ complete} = 5.46$, $M_{pay\ dropped} = 4.76$, $Mdn_{pay\ complete} = 5$, $Mdn_{pay\ dropped} = 4$, $U = 15934.5$, $p < 0.03$; for impressions $M_{impressions\ complete} = 3.99$ $M_{impressions\ dropped} = 3.64$, $Mdn_{impressions\ complete} = 4$, $Mdn_{impressions\ dropped} = 4$, $U = 15205.5$, $p < 0.01$). This suggests that the respondents included in the present study were more favorable towards EVs, indicating that the results may not generalize to the general population. Results should be interpreted with caution in light of this.

2.3 Measures

The survey assessed three dependent variables and a number of independent variables, grouped into the following categories: instrumental attributes, symbolic attributes, demographic factors, and psychological factors. Table 3 provides summary statistics for these variables.

2.3.1 Dependent variables

The survey assessed three dependent variables selected to reflect increasing levels of commitment to EV adoption[1]. First, respondents provided their general impression of EVs on a 5-point scale ranging from 1 = Strongly Unfavorable to 5 = Strongly Favorable. Second, they rated their willingness to lease or buy an EV as their next personal vehicle on a 10-point scale ranging from 1 = Extremely Unlikely to 10 = Extremely Likely. Finally, participants were asked to imagine they were interested in a car model that was also available in an all-electric vehicle. They were asked how much more they would be willing to pay for the EV compared to the conventional gas vehicle, with all other features of the vehicle being identical. Responses were provided on a 13-point scale ranging from 1 = \$0 to 13 = \$6000[2]. In all cases, a higher number corresponds to stronger EV adoption intentions.

2.3.2 Symbolic attributes

The survey included five questions focused on specific aspects of self-identity that EVs have been found to reflect (see Table 4 for question text). Responses were given on a 7-point Likert scale ranging from 1 = Strongly Disagree to 7 = Strongly Agree, with higher numbers indicating stronger endorsement of self-identity symbols in EVs.

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[1] Following Schuitema, we use the common assumption that Likert scales can be treated as interval-level data and analyzed using parametric methods (Schuitema et al., 2012; Kline, 2000; Nunally, 1978).

[2]This type of willingness to pay scale has been considered to lead to more valid values than using open-ended prompts, with respondents providing fewer zero values and with predictors explaining a greater amount of variance in willingness to pay (Donaldson et al., 1997).

2.3.3 Instrumental attributes

2.3.3.1 Cost

A total of three questions asked respondents to rate perceived EV costs compared to gasoline vehicle costs, using a 5 point Likert response scale where 1 = Much less and 5 = Much more. Questions separately assessed perceptions of (1) purchase costs, (2) maintenance costs, and (3) fuel costs.

2.3.3.2 Charging Convenience

Charging convenience was assessed with a binary variable. Respondents were asked "Do you have access to an electrical outlet where your car is parked at your primary residence?" with responses of no coded as "1" and yes as "2".

2.3.3.3 Range and driving distance

Respondents were asked two open ended questions regarding driving distances. One question assessed perceived EV range, ("Approximately how many miles do you believe a fully-charged EV can drive before the battery is drained?"). A second question assessed estimated daily travel mileage ("On an average day, approximately how many miles do you drive in a car that you lease or own? Include trips made for work, school, shopping, errands, entertainment, etc."). Responses to both questions were open-ended and requested in miles, and were coded as numeric integers. Additionally, we examined the difference between perceived EV range and daily driving distance (calculated as perceived EV range – estimated daily travel mileage, coded as a numeric integer); this was intended to measure perceptions that an EV could fulfill average daily driving needs on a single charge. Our main analyses (Tables 5 and 6) include only the perceived EV range variable. However, we also ran the models using the difference between perceived EV range and estimated daily travel mileage, and found similar patterns of results.

2.3.4 Psychological characteristics

2.3.4.1 Concern about climate change

We adapted a scale from Bostrom et al. (2012) to examine concern about climate change. Our scale comprised five questions ("To what extent are you concerned about air pollution in your city? ", "How serious a threat is climate change to humankind?", "How well is climate change understood by science?", "How much does the idea of climate change fill you with dread?", and "To what extent do you have moral concern about climate change?"). Each was rated on a 7-point Likert scale where a higher number corresponded to a stronger concern about climate change. Factor analysis showed that the variables loaded onto one factor. To create a climate change concern scale, we took the mean of responses to available items[3].

2.3.4.2 Past pro-environmental behavior

Past PEB was assessed with three items. Respondents rated, on a scale of 1 (Strongly Disagree) to 7 (Strongly Agree), whether they made an effort to recycle, whether they had purchased lightbulbs that were more expensive but saved energy, and whether they have encouraged family or friends not to buy environmentally harmful products. A scale was created by taking the mean of available responses (at least two of the questions had to be answered to receive a scale score).

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[3] Only respondents who answered more than half of items (at least 3) were retained in the final sample and received a scale score.

2.3.4.3 Relevance of cars in general to self-identity

Respondents rated, on a Likert scale of 1 to 7 with 1 = Strongly Disagree and 7 = Strongly Agree, the statement "I think the kind of car a person drives says something about the person". This "car identity" variable separates out variance associated with the belief that cars impact identity in general (i.e., generic symbolic attributes), from variance associated with the ability of EVs to reinforce aspects of self-identity corresponding to one or more symbolic reflections of self-identity.

2.3.5 Demographic characteristics

Income. Income was provided on a categorical scale (see Table 2). For analyses, we created a binary variable, split roughly at the median income for L.A. county of $55,909 (U.S. Census Bureau, 2013). Those with incomes of $50,000 or greater received 1, and others received 0.

Education. Education was assessed using a categorical scale (see Table 2 for response options). For analyses, we created a binary variable, coded 1 if respondents had a four-year college degree or higher, and 0 otherwise.

Age. The survey assessed birth year. Age (in years) was calculated accordingly and coded as a continuous variable.

Gender. Male gender was coded as 1, and female was coded as 0.

Table 3: Descriptive statistics for key variables (main sample, N=355)

		Response range	Mean	Std. Dev
Dependent Variables (N = 355)	Impressions	1-5	3.99	1.13
	Willingness to lease/buy	1-10	5.48	3.07
	Willingness to pay	1-13	5.46	3.36
Symbolism of unique aspects of self-identity (N = 355)	Environmentalist[a]	1-7	5.22	1.39
	Social Innovator[b]	1-7	5.07	1.08
Instrumental Attributes (N = 355)	Purchase cost	1-5	3.85	0.87
	Maintenance cost	1-5	2.93	1.17
	Fuel cost	1-5	1.77	1.04
	Charging convenience	1 / 2	1.47	0.50
	Estimated EV range	15-600	126.10	89.71
	Estimated daily driving mileage	0-250	24.95	24.00
Psychological characteristics (N = 355)	Past PEB[c]	1.67-7	5.70	1.00
	Concern about climate change[d]	1.4-7	5.39	1.18
	Car identity	1-7	5.08	1.42
Demographic characteristics (N = 224)[e]	Income	0 / 1	76	
	Education	0 / 1	77	
	Gender (% male)	0 / 1	50	
	Age	22-93	48.25	15.79

[a]Cronbach's alpha = 0.87, [b]Spearman's rho = 0.35, [c]Cronbach's alpha = 0.56, [d]Cronbach's alpha = 0.87, [e]Note that the demographic sub-sample of 224 respondents is presented here, for consistency with the results presented in Table 6 which were generated based on this sub-sample.

2.4 Data preparation

To test H1a and H1b we conducted iterative principal factor analysis using our full sample of 355 respondents. To test H2a and H2b, we conducted OLS multiple regression analyses. To test H3a and H3b, we conducted mediation analyses by (1) using causal chain path diagrams (after Baron and Kenny, 1986) and (2) calculating indirect effect sizes and using the distribution of the product of coefficients method to test their significance (Tofighi and MacKinnon, 2011). To examine H4, we conducted an additional univariate OLS analysis.

In constructing OLS models, we visually inspected normal quantile plots of residuals against the inverse normal for each dependent variable to identify skewness or kurtosis. Excessive skewness was found for impressions of EVs, so the variable was square-transformed to adjust for this. The Huber-White test was used to assess heteroscedasticity in our models, which was found for willingness to pay and willingness to lease/buy. Hence, Huber-White standard errors were used for all three models, to ensure unbiased estimation of variance even in presence of heteroscedasticity (White, 1980). Huber-White standard errors were additionally applied to mediation analysis testing following tests that indicated heteroscedasticity in main models and these are reflected in both the path diagrams and the indirect effect significance tests.

3 Results

3.1 Factor analysis of symbolic attributes

To examine H1a, we conducted iterative principal factor analysis constrained to three factors. Promax rotation was then applied. Results of this analysis are presented in Table 4. Factors were extracted based on Cattell's Scree test, which, being less impacted by the number of variables (Zwick and Velicer, 1986), can be more accurate than traditional K1 methods (Fabrigar and Wegener, 2011; Osborne and Costello, 2009) although both methods in this case would yield two factors. The Scree plot indicates a two-factor solution (see Appendix 2) as inter-factor differences in eigenvalues fall off markedly from the third factor on. This two-factor solution is not in support of H1b, which predicted three specific aspects of self-identity would be symbolized by EVs. Constraining the solution to two factors returned similar results, provided in Appendix 3.

Following the recommendations of Osborne and Costello (2009), we used a minimum item loading cut-off of 0.40 to indicate that an item belongs to a factor. The first three questions loaded onto Factor 1, "environmentalist" symbolism, representing the perception that EVs reflect environmentalist self-identity. We therefore define the environmentalist symbol as the average score of the three underlying items. Cronbach's alpha for these three items was 0.87.

The remaining two questions, which were expected to load separately as innovator and social responsibility symbolism, both loaded onto Factor 2. The constituent items both reference the broader social fabric, and furthermore suggest an element of social innovation, indicated by technology "trendsetting" and taking responsible action for the good of society. Thus, Factor 2 is considered to represent "social innovator" symbolism. A spearman correlation examining the correlation between the two constituent items found a statistically significant relationship between the two variables ($\rho = 0.35$, $p = 0.000$).

Table 4: Promax rotated factor loadings and uniqueness of symbolic attributes items based on iterative principal factor analysis constrained to three factors

Question	Factor 1: Environmentalist	Factor 2: Social Innovator	Factor 3: Unsupported	Uniqueness
(1) Owning an EV demonstrates to others that I care about the environment	0.81	-0.06	0.13	0.34
(2) Changing from a gasoline-powered vehicle to an EV will lessen my impact on the environment	0.81	0.04	-0.07	0.32
(3) Driving an EV means that I am doing the right thing	0.71	0.26	0.04	0.20
(4) Driving an EV means that I am a trendsetter for environmentally friendly technologies	0.26	0.59	0.01	0.40
(5) Driving an EV means that I am socially responsible	-0.02	0.41	0.21	0.72
Eigenvalues:	2.48	1.70	0.40	

3.2 Factors impacting EV adoption intentions

Given the findings in section 3.1, to address H2a and H2b, we investigated the unique impacts of "environmentalist" and "social innovator" symbolism on EV adoption intentions, rather than "environmentalist, "innovator" and "social responsibility" symbolism separately as initially proposed. To test H2a and H2b, we built three OLS multiple regression models, each of which examined one of our dependent variables: impressions of EVs, willingness to lease/buy an EVs, and willingness to pay more for an EV than an equivalent conventional vehicle. Predictors included symbolic attributes (environmentalist and social innovator symbolism), instrumental attributes (purchase cost, maintenance cost, fuel costs, access to charging outlet, and perceived EV range for a single charge), psychological characteristics (concern about climate change, past PEB, and perceived relevance of cars to identity), and demographic characteristics (income, education, age, and gender). Results are shown in Table 5.

Across all three dependent variables, the extent to which EVs were seen as symbolizing environmentalist self-identity had greater predictive power than any other variable in any of the models, supporting H2b (see Table 5). In addition, the extent to which respondents perceived EVs to symbolize social innovator self-identity had a unique effect on impressions and intent to lease/buy an EV (and for both DVs was the second strongest predictor after environmentalist symbolism), supporting H2a.

Instrumental attributes were also significant predictors of EV adoption intentions, but in general they had weaker predictive strength than the symbolic attributes. Neither purchase cost nor fuel costs were large predictors, though higher perceived purchase costs predicted lower willingness to lease/buy, and lower perceived fuel costs predicted more positive impressions. Perceiving lower maintenance costs had larger impacts that were significant for both willingness to lease/buy and willingness to pay. Additionally, charging convenience predicted willingness to pay with a decent effect size, and had marginal significance as a predictor of willingness to lease/buy. Surprisingly, perceived EV range was not significantly associated with any of the dependent variables; nor was daily driving distance or the difference between estimated range and daily driving distance (tested, but not reported here). We did not find large impacts of psychological characteristics; concern about climate change had no effect on EV adoption intent, and past PEB was only a marginal predictor of greater willingness to lease/buy.

Table 5: Results of multiple regression analysis predicting EV adoption intentions (n =355)

		Impressions (sq)	Willingness to lease/buy	Willingness to pay
Symbolic attributes	Environmentalist	0.48***	0.28***	0.27***
		(0.32)	(0.12)	(0.17)
	Social Innovator	0.13*	0.27***	0.04
		(0.39)	(0.16)	(0.18)
Instrumental attributes	Purchase cost	-0.01	-0.09*	0.03
		(0.40)	(0.14)	(0.20)
	Maintenance cost	-0.07	-0.21***	-0.17**
		(0.31)	(0.13)	(0.15)
	Fuel cost	-0.12*	-0.01	-0.08+
		(0.34)	(0.14)	(0.16)
	Charging convenience	-0.03	0.06	0.20***
		(0.64)	(0.25)	(0.31)
	Estimated EV range	0.01	-0.05	0.02
		(0.00)	(0.00)	(0.00)
Psychological characteristics	Concern about climate change	-0.02	0.04	0.08
		(0.36)	(0.14)	(0.19)
	Past PEB scale	0.07	0.09+	0.02
		(0.41)	(0.16)	(0.17)
	Car identity	0.04	-0.00	0.01
		(0.23)	(0.10)	(0.12)
	R^2	0.43	0.44	0.27
	N	355	355	355

Standardized beta coefficients; Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Because there were a large number of respondents missing demographic data, we evaluated the impact of demographic variables on EV adoption intentions as a sub-analysis (Table 6; see Appendix 1 for a summary of descriptive statistics on sub-sample). Specifically, we limited this sub-analysis to a sub-sample of the 224 respondents who provided complete data for all dependent variables, independent variables, and demographics. We added income, education, gender, and age to the OLS model described above.

Table 6: Results of multiple regression analysis predicting EV adoption intentions including demographic characteristics (n = 224)

		Impressions (sq)	Willingness to lease/buy	Willingness to pay
Symbolic attributes	Environmentalist	0.52***	0.27***	0.29***
		(0.46)	(0.18)	(0.23)
	Social Innovator	0.05	0.21**	0.04
		(0.53)	(0.22)	(0.22)
Instrumental attributes	Purchase cost	0.04	-0.10^{+}	0.01
		(0.57)	(0.20)	(0.28)
	Maintenance cost	-0.12*	-0.23***	-0.18**
		(0.37)	(0.18)	(0.20)
	Fuel cost	-0.10^{+}	0.05	-0.05
		(0.39)	(0.16)	(0.18)
	Charging convenience	-0.02	0.09	0.15*
		(0.85)	(0.38)	(0.43)
	Estimated EV range	-0.03	-0.08	-0.01
		(0.00)	(0.00)	(0.00)
Psychological characteristics	Concern about climate change	-0.05	0.01	0.01
		(0.50)	(0.19)	(0.24)
	Past PEB scale	0.08	0.15*	0.02
		(0.56)	(0.24)	(0.25)
	Car identity	0.07	0.07	0.03
		(0.28)	(0.12)	(0.14)
Demographic characteristics	Income	0.00	-0.03	0.13*
		(0.99)	(0.44)	(0.46)
	Education	0.06	0.00	0.05
		(0.92)	(0.40)	(0.48)
	Gender	0.06	0.05	0.19**

		(0.84)	(0.36)	(0.43)
	Age	-0.08	-0.04	-0.16^{*}
		(0.03)	(0.01)	(0.01)
	R^2	0.43	0.39	0.28
	N	224	224	224

Standardized beta coefficients; Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

In general, the same pattern of results emerged with respect to symbolic and instrumental attributes. Symbolic attributes, in particular the environmentalist symbol, remained strong predictors for all three dependent variables, indicating that H2a and H2b are robust to inclusion of demographic variables. Table 6 additionally revealed that higher incomes were associated with higher willingness to pay. Being female or older was associated with lower willingness to pay. Demographic variables did not have an impact on the other dependent variables.

3.3 Concern about climate change: mediation

To test H3a and H3b, we conducted a single-level mediation analysis. Concern about climate change was the independent variable; the three dependent variables were impressions, willingness to lease/buy, and willingness to pay; and two mediators were environmentalist and social innovator symbolism. We began by estimating the three basic mediation equations for each dependent variable-mediator pair (Baron and Kenny, 1986):

Equation 1: $$y_i = c_{01} + \tau x_i + e_{1i}$$

Equation 2: $$m_i = c_{02} + \alpha x_i + e_{2i}$$

Equation 3: $$y_i = c_{03} + \beta m_i + \tau' x_i + e_{3i}$$

where y_i represents EV adoption intentions and τ represents the direct effect of the independent variable (concern about climate change) on adoption intentions; m_i represents the mediator (environmentalist or social innovator symbolism) and α represents the direct effect of the independent variable on the mediator; and β represents the effect size of the mediator holding the effect of the dependent variable constant, τ' represents the effect size of the independent variable on EV adoption intentions holding the effect of the mediator (either environmentalist or social innovator symbolism) constant, and x_i represents the independent variable.

Based on the α and β estimates produced by equations 2 and 3 for each dependent variable-mediator pair, we calculated the coefficient of the indirect effect (αβ) for each mediator using the product of coefficients method outlined in MacKinnon et al. (2002). Next, we tested the significance of each indirect effect size using the distribution of the product of coefficients method (Tofighi & MacKinnon, 2011). Mediation was considered to occur if the indirect effect (αβ) was significant, and if additionally the mediation path through both α and β was significant (see Figure 2). Table 7 shows the effect sizes, standard errors, and significance of the indirect effects.

All six dependent variable-mediator pairs showed significant indirect effects (Table 7), and in addition significant paths existed along α and β in path diagrams (Figure 2), indicating that mediation occurred for all six pairs. Large indirect effects found for environmentalist and social innovator symbolism support H3a and H3b. In addition, indirect effect sizes for environmentalist symbolism were consistently larger than for social innovator symbolism, further supporting H3a.

Table 7: Indirect effect sizes with standard errors in parentheses. Significance tested using the distribution of the product of coefficients method.

	Impressions	Willingness to lease/buy	Willingness to pay
Environmentalist	0.35 (0.04)***	0.77 (0.10)***	0.65 (0.13)***
Social Innovator	0.15 (0.03)***	0.57 (0.09)***	0.27 (0.09)**

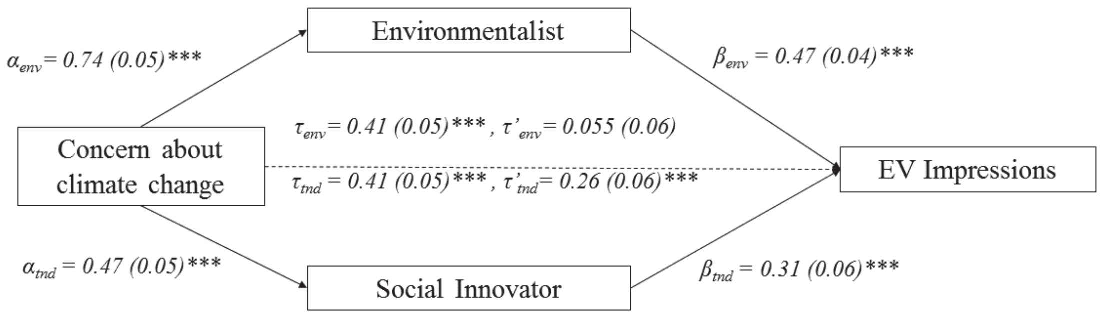
$^{+}p < 0.10$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

Figure 2 (a, b, and c) presents models of mediation paths. Each path τ describes the direct effect of concern about climate change on each dependent variable, as described in equation 1, while the path τ' describes the effect of concern about climate change on each dependent variable when the impact of either environmentalist or innovator symbolism is controlled for. Baron and Kenny (1986) specify the use of unstandardized coefficients for this comparison. In Figure 2, paths α and β are always positive and statistically significant, and τ' is always smaller than τ such that the model passes the difference in coefficients test (Baron and Kenny, 1986; MacKinnon et al., 2002). Thus, in conjunction with the findings on the significance of indirect effect sizes presented in Table 7, Figure 2 supports H3a and H3b that the relationship between concern about climate change and EV adoption intentions is mediated by environmentalist and social innovator symbolism.

Figure 2a-c: Causal chain path diagrams depicting the mediating roles of environmentalist and innovator symbolism in the relationship between concern about climate change and EV adoption intentions.[4]

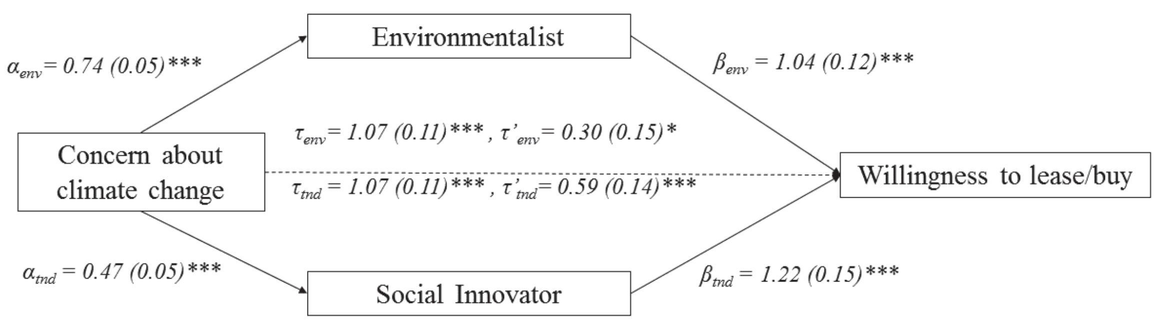
[4] *Mediation of the relationship between concern about climate change and EV adoption intention are shown for three dependent variables (impressions, willingness to lease/buy, willingness to pay). Labels (α, β, τ, τ') correspond to the paths described in equations 1, 2, and 3. The direct effect is shown by τ, and the indirect path passes through the mediator via α and β. τ' represents the size of the former direct path (τ) when the indirect path through α and β is simultaneously taken into account.*

2a) Dependent variable: EV impressions



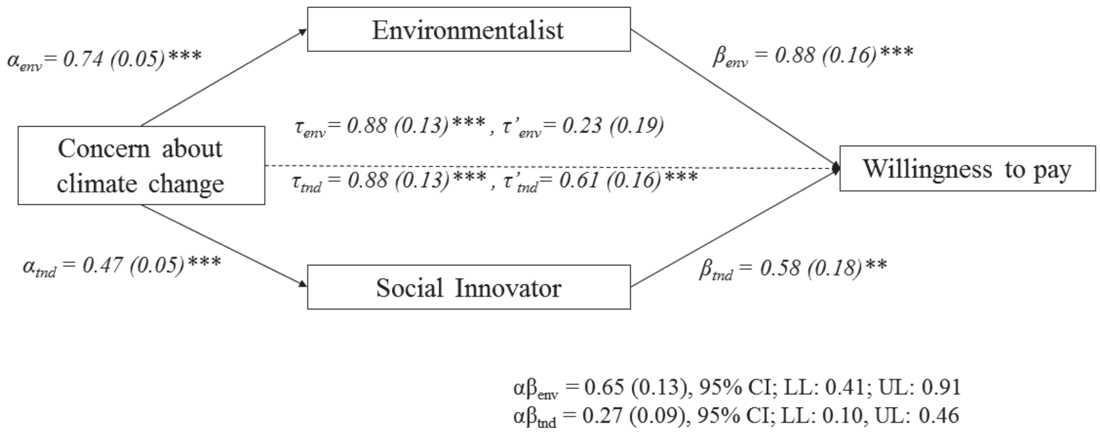
$\alpha\beta_{env}$ = 0.35 (0.04), 95% CI; LL: 0.28; UL: 0.43
$\alpha\beta_{tnd}$ = 0.15 (0.03), 95% CI; LL: 0.09, UL: 0.21

2b) Dependent variable: willingness to lease/buy EV



$\alpha\beta_{env}$ = 0.77 (0.10), 95% CI; LL: 0.58; UL: 0.97
$\alpha\beta_{tnd}$ = 0.57 (0.09), 95% CI; LL: 0.41, UL: 0.76

2c) Dependent variable: willingness to pay



3.4 Normative messaging intervention

3.4.1 Validity check

A validity check was included whereby responses to two questions were expected to differ as a function of the persuasive message received. These include the fuel and maintenance cost questions (see Section 2.3.3.1), which we expected those who received the financial message to rate lower (indicating lower costs associated with EVs vs. conventional vehicles). Using Wilcoxon rank-sum tests (the non-parametric alternative to the independent samples t-test, given the non-normal distributions of the relevant variables), we did not find statistically significant differences on responses to the fuel cost question. However, those who received financial messaging reported marginally lower maintenance costs than those who received social messaging ($U = 13909.5$, $p < 0.09$, $M_{financial} = 2.83$, $Mdn_{financial} = 3$, $M_{social} = 3.02$, $Mdn_{social} = 3$), which was in the predicted direction. This provides modest evidence that respondents read messages.

3.4.2 Influence of messaging on adoption intentions

A set of regression models was conducted to test H4. Impressions, willingness to lease/buy, and willingness to pay were the dependent variables, and type of messaging received was the sole independent variable. Contrary to expectations, type of messaging had no impact on adoption likelihood ($\beta = 0.05$, sd = 0.13 $p < 0.38$ for impressions, $\beta = -0.01$, sd = 0.36, $p < 0.83$ for willingness to lease/buy; and $\beta = 0.07$, sd = 0.39, $p < 0.21$ for willingness to pay). We additionally tested whether messaging type acted as a moderator of the relationships between each of the dependent variables and income, symbolic attributes, and instrumental attributes, and found no evidence for moderation in any of these cases.

4 Discussion

This study builds on previous findings that symbolic attributes are important predictors of EV adoption intentions (Noppers et al., 2014; Schuitema et al., 2013). We refined the concept of symbolic attributes, defining this construct as "attributes which reflect specific aspects of self-identity". We advance prior work which has fallen short of examining symbolism associated with specific aspects of self-identity, the impacts of such symbolism on adoption intentions, or symbolism alongside other important predictors of EV adoption (Axsen and Kurani, 2013; Krupa et al., 2014). Specifically, we define and evaluate two specific aspects of self-identity that EVs may be perceived to reflect: environmentalist and social innovator.

4.1 Specification of symbolic attributes reflecting aspects of self-identity

Environmentalist, innovator, and social responsibility symbolism of self-identity were expected to load onto separate factors. Instead, we found two factors: environmentalist and social innovator symbolism, supporting H1a, but not H1b.

Innovator and social responsibility may load together due to the fact that both questions tapped a social element, i.e., by asking about being a "trendsetter", and by asking about taking responsible action for societal good, both of which indicate setting a positive example for others in a social group. This aligns with prior suggestions that EVs and hybrids have the potential to embody new combinations of meanings, and in particular it appears they may bridge areas of innovation and social responsibility (Heffner et al., 2007). Hybrids are sometimes seen by their owners as "…symbols of advocating to vehicle manufacturers. By purchasing [a hybrid], households see themselves as providing support to automakers that have developed hybrid technology, and punishing those who have not" (Heffner et al., 2007). This supports the idea that EVs may embody self-identities focused on both innovation as well as feelings of socially responsibility, i.e., that EVs act as symbols for those who want to set socially responsible trends.

Also notable is that seeing driving an EV as "doing the right thing" loaded with environmentalist symbolism in the factor analysis. This highlights that respondents saw performing PEBs as doing the right thing, which may also indicate past exposure to pro-environmental social norms. California has been a leader of environmental policy since the 1960s (Sperling and Eggert, 2014), which has involved conveying various pro-environmental messaging to residents over the years.

4.2 The predictive strength of symbolic attributes reflecting self-identity

Both environmentalist and social innovator symbolism are strong and independent predictors of EV adoption intentions, supporting H2a. This finding expands the literature, which has identified the importance of similar constructs separately but not examined them together (Axsen and Kurani, 2013; Krupa et al., 2014; Noppers et al., 2014). We confirm that environmentalist symbolism in particular is a powerful predictor for EV adoption intentions, and although previous research examining impacts of environmental imagery on hybrids used different analysis methods (Krupa et al., 2014), the greater significance of environmentalist symbolism as predictor in our model may indicate that this symbolic attribute has a greater impact on adoption intentions for EVs compared to hybrids; this possibility should be considered in future studies of low-emissions vehicles.

Additionally, our finding in support of H2b that environmentalist symbolism is the strongest predictor of EV adoption intentions across three dependent variables, over and above EV instrumental attributes as well as demographic and psychological characteristics, emphasizes that this particular type of symbolism should be included in future models. This construct is distinct from the measures of concern about climate change that have often previously been examined (Carley et al., 2013; Egbue and Long, 2012; Krupa et al., 2014; Skippon and Garwood, 2011), and also distinct from constructions of environmental attributes examined previously[5] (Noppers et al., 2014; Schuitema et al., 2013) due to its measurement of

[5] Noppers et al. (2014) examined environmental attributes in terms of "low CO_2 emissions" and "environmentally friendly".

EV reflections of environmentalist self-identity. Environmental self-identity has been linked to feeling a moral obligation to act pro-environmentally, which in turn affects PEBs such as EV adoption (Van der Werff et al., 2013b). The predictive strength (for EV adoption intentions) of seeing EVs to symbolize environmentalist self-identity extends these findings, and may in part be due to desires to show that one has acted on this type of moral obligation.

Providing context for our findings on social innovator symbolism, altruistic signaling can serve as a way to gain social status, particularly if such a signal is costly (costly signaling; Griskevicius et al., 2010). This may explain the significance of innovator symbolism for predicting willingness to lease/buy an EV. Paying additional money to set an environmentally friendly trend may be a new form of altruistic signaling offered by EVs, as suggested by the observation in Heffner et al. (2007) that EV purchases may be made with the intent to reward automakers for providing environmentally-friendly options. This is supported by previous observations that EV symbolism was rated higher by potential early adopters if they perceived instrumental attributes to be lower (Noppers et al., 2015). Additionally, consumers who perceived that EVs were not easy to use had stronger adoption intentions (Peters and Dütschke, 2014), which may indicate another form of "costly" signaling in terms of embracing a technological learning curve alongside additional monetary costs for trendsetting technologies.

There is some indication that decisions to purchase an EV may rest on a temporally-sensitive series of symbolic meanings. Specifically, we find that perceiving EVs as social innovator symbols is a strong predictor of willingness to lease/buy, but a relatively weak or insignificant predictor for impressions and willingness to pay. This suggests a shift in particular aspects of self-identity that are most valuable at different stages of adoption decision-making. Further research is needed to understand the process of EV adoption decision making over time, as well as the role that experience with EVs plays at these various stages.

4.3 Concern about climate change: mediation

Previous literature has found that concern about climate change directly predicts EV adoption intentions (Carley et al., 2013; Egbue and Long, 2012; Krupa et al., 2014; Skippon and Garwood, 2011), but this has not previously been examined alongside seeing EVs as social innovator or environmentalist symbols. Additionally, self-identity has been found to fully mediate the relationship between valuing the environment and actions to alleviate environmental harm (Van der Werff et al., 2013a), so we expected that social innovator and environmental symbolism associated with EVs would mediate the relationship between concern about climate change and EV adoption intentions (H3a and H3b). Our findings confirmed this hypothesis. This extends the literature by uncovering a mediating effect of self-identity symbolism associated with EVs, i.e., that seeing EVs to reflect environmentalist and social innovator self-identities mediates the relationship between concern about climate change and intent to purchase an EV.

On a practical note, our findings indicate that those concerned about climate change value the potential of EVs to reaffirm their environmentalist and social innovator identities. This has implications for EV marketing and uptake strategies. Educating people about the realities of climate change, and explaining why it needs to be mitigated, may not be sufficient to encourage people to take mitigating action if they do not feel that protecting the environment, or being a social innovator, are aspects of their identity. A different approach, perhaps with greater appeal to the ability of EVs to reflect environmentalist or social innovator identities, may be more effective in encouraging adoption.

4.4 Effects of messaging

To our surprise, we did not find any effects of persuasive messaging on adoption intentions, thus H4 was not supported. This may be because social norms of EV ownership were already apparent among our sample of L.A. residents at the time of data collection, even if they did not receive the social norms messaging in our study. California is at the forefront of EV adoption across the U.S. with EVs constituting 1.5% of new vehicle sales in 2014 when data were collected (California New Car Dealers Association, 2014), vs. 0.7% across the U.S. (IEA, 2016). In addition, L.A. is a recognized leader of progressive municipal energy policy (Pincetl et al., 2016). For EV policy in particular, in 2012 L.A. set a target to have 80,000 EVs by 2015, and promoted electric buses and trucks alongside initiatives to increase availability of charging stations, while additionally working with a regional collaborative to promote EVs (IEA, 2012). Thus, L.A. residents are likely to have seen EVs around town, which could plausibly convey positive social norms about them. This could have muted the impact of the social norms messaging, either because the message did not convey new norms, or because the financial group also subscribed to such norms. Alternatively, one brief message may not have been sufficient to influence social norms. It is also possible that the financial messaging had a positive impact on EV adoption intentions on par with effects of social norms messaging, hence failing to produce a distinguishable difference between the two messaging types. Further research should test marketing approaches to encourage EV uptake to discern what strategies work best, and for which consumers.

5 Conclusion

Previous studies have operationalized symbolic attributes broadly in terms of EVs as status symbols, but have not examined the predictive power of EVs reflecting specific aspects of self-identity. We advance this literature by refining the concept of symbolic attributes to include specific reflections of self-identity, examining whether EV adoption intentions are impacted by seeing EVs as symbols for environmentalist and social innovator self-identities. We evaluate the relative importance of these symbolic attributes reflecting specific aspects of self-identity alongside a set of additional variables that prior studies have linked to EV adoption, and find that perceiving EVs to reflect environmentalist self-identity was the strongest and most consistent predictor of EV adoption intentions.

Concern about climate change has previously been found to influence EV adoption intentions, but mechanisms for this concern translating into action have not previously been examined. We find that seeing EVs as environmentalist and social innovator symbols mediates the relationship between concern about climate change and EV adoption intentions. That is, individuals who are concerned about climate change perceive stronger reflections of environmentalist and innovator identities in EVs, and this in turn leads to stronger intent to adopt EVs. This indicates that efforts intended to increase EV adoption should couch EVs as reflections of these aspects of self-identity, not so much as tools to address climate change per se.

6 Limitations and Future Directions

Our findings should be viewed in light of several limitations. First, our study relied on self-report, which is not as strong an outcome as observed behavior. Future work using actual EV purchase data is needed to address these limitations. Second, relative to L.A. County, our sample was older, and included higher proportions of people with higher educational attainment, incomes, and those who identified as

Caucasians. Third, a large number of initial respondents were dropped due to missing data. Drop-out analyses indicated that those retained in the final sample were more favorable towards EVs than those who were dropped, so our results may not capture the full range of variation in EV adoption likelihood. Hence, results may not generalize to all populations or settings. As consumers who are highly educated have been noted to be interested in EVs as early adopters (Carley et al., 2013), results may overestimate adoption willingness of those in later adopter groups (according to diffusion of technology). Additional work in non-early-adopter markets is needed to assess the generalizability of our results.

Fourth, we used a limited number of questions to assess symbolism. A larger number of questions designed to measure a greater spread of distinct symbolic reflections on self-identity could reveal additional clusters of meaning that influence adoption, such as technological or innovator symbolism separate from social and responsibility aspects, or use of EVs to signal anti-war ideologies (Heffner et al., 2007; Noppers et al., 2014). In addition, future work should also assess self-identity to provide further insights into how concern about climate change, self-identity, and symbolism work together to impact EV adoption intentions. Next, our assessment of instrumental attributes was limited in that it only considered estimated range, costs, and charging convenience, whereas previous studies of EVs have assessed additional instrumental attributes such as vehicle performance, comfort, and driving experience (Noppers et al., 2015; Schuitema et al., 2013); future studies would be well advised to consider all of these instrumental factors. Finally, we assessed estimated EV range, rather than asking respondents to report subjective concerns regarding range. Although we found that estimates of EV range, estimates of typical daily driving needs, and the difference between these two variables did not impact EV adoption intentions, it may still be the case that *concerns* regarding EV range could impact adoption intentions. Future work should consider perceptions of EV range limitations as well as associated feelings of anxiety or concern.

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9 Appendix 1

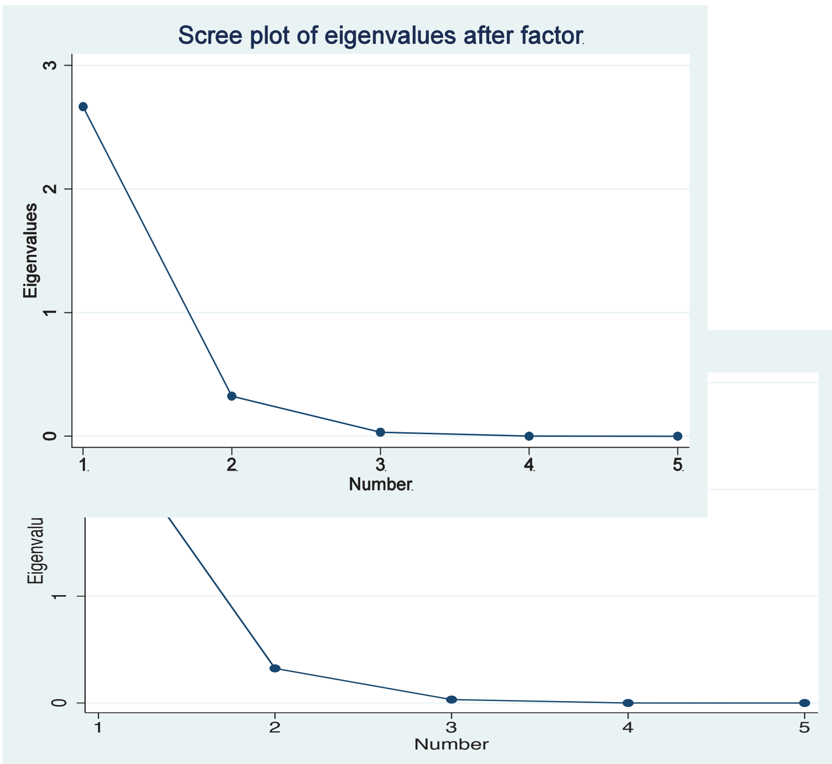
Table A1: Descriptive statistics for key variables among main sample (246 < n < 355 respondents with available demographic data) and sub-sample (n = 224 respondents will full data on demographic variables)

Characteristic	Sample (%)[a]	Sample (%) N = 224	Los Angeles County[b] (%)
Ethnicity	(N = 346)		
African American	2.3	1.8	8.1
Asian / Asian American	11.9	12.1	13.7
Caucasian	67.6	67.4	27.5
Latino	10.7	11.2	47.9
Native American / Pacific Islander	0.6	0.5	0.2
Multiracial	4.9	5.4	2.1
Other	2.0	1.8	0.2
Educational Attainment (>= 25 yrs)	(N = 353)		
Less than High School	1.1	0.9	23.4
High school diploma	4.3	3.13	20.5
Some college / Associate's degree	22.1	18.8	26.5
4-year college degree	37.7	38.4	19.4
Graduate / professional degree	34.8	38.8	10.2
High School diploma or higher	98.9	99.0	76.6
Bachelor's degree or higher	72.5	77.2	29.7
Annual household income	(N = 294)		
<$25,000	9.9	8.9	Median household income: $55,909
$25,001-$50,000	13.6	15.2	
$50,001-$75,000	20.4	21.9	
$75,001-$100,000	13.6	12.5	
>$100,000	42.5	41.5	
Home ownership rate	(N = 355) 60.8	53.1	46.9
Home type	(N = 354)		
Single Family Home	52.8	46.4	49.7
Apartment/Condo	35.9	42.0	34.3
Duplex, Triplex	5.9	6.7	8.0
Townhouse	4.5	4.5	6.5
Mobile Home	0.6	0.5	1.5
Other	0.3	0	
Gender (% male)	(N = 284) 51.8	50.0	49.3
Age (median)	(N = 246) 53	48.0	35.1

[a] Not all respondents answered all demographic questions. Available data for respondents who answered questions is as follows: $N_{ethnicity}$ = 346, $N_{education}$ = 353, N_{income} = 294, $N_{home\ ownership}$ = 355, $N_{home\ type}$ = 354, N_{gender} = 284, N_{age} = 246. [b](U.S. Census Bureau, 2013).

10 Appendix 2

Figure A1: Scree plot for symbolic attributes factor analysis; promax-rotated iterative principal factor analysis constrained to three factors



11 Appendix 3

Table A2: Promax rotated factor loadings and uniqueness of symbolic attributes items based on iterative principal factor analysis constrained to two factors

Question	Factor 1: Environmentalist	Factor 2: Social Innovator	Uniqueness
(1) Owning an EV demonstrates to others that I care about the environment	0.78	0.05	0.37
(2) Changing from a gasoline-powered vehicle to an EV will lessen my impact on the environment	0.84	-0.03	0.32
(3) Driving an EV means that I am doing the right thing	0.72	0.27	0.19
(4) Driving an EV means that I am a trendsetter for environmentally friendly technologies	0.30	0.55	0.42
(5) Driving an EV means that I am socially responsible	-0.04	0.54	0.73
Eigenvalues	2.49	1.61	