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Research Report

Effect of intelligence on consumers' responsiveness to a pro-environmental tax: Evidence from large-scale data on car acquisitions of male consumers☆

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Abstract

Researchers and policy-makers are increasingly interested in the effects of pro-environmental tax incentives on consumer responses. However, it is unknown whether consumers' responsiveness to pro-environmental taxes depends on cognitive ability. We report a natural experiment study, in which a pro-environmental tax was introduced in Finland, providing an economic benefit for cars with lower CO_2 emissions. We examine 140,000 car acquisitions by male consumers, whose intelligence had been tested by Finnish Defense Forces. The results show that the CO_2 emissions of cars acquired by consumers with higher intelligence dropped more after the introduction of the tax than the emissions of cars of consumers with lower intelligence. Specifically, intelligence had both a direct effect on responsiveness to the pro-environmental tax, and an indirect effect via income. The effect was more pronounced for numeric intelligence than verbal and spatial logic intelligence and of equal size as that of income and other demographics. This implies that intelligence is an empirically as well as theoretically relevant variable to study as a moderator to choices that are simultaneously pro-environmental and economical.

Keywords: Intelligence; Tax incentive; Pro-environmental choice; Cognitive flexibility; CO_2 emissions; Cars

To encourage pro-environmental consumption choices, governments are increasingly introducing pro-environmental tax incentives (e.g., Chandra, Gulati, & Kandlikar, 2010; Gallagher & Muehlegger, 2011). However, the challenge with such tax incentives is that they are in essence economic rewards for pro-environmental behavior, and it is well known that consumers may face difficulties in responding to combinations of economic rewards and pro-environmental benefits (Bolderdijk, Steg, Geller, Lehman, & Postmes, 2013; Dogan, Bolderdijk, & Steg, 2014; Evans et al., 2013; Spence, Leygue, Bedwell, & O'Malley, 2014). In the present empirical study, we aim to elucidate this challenge by examining whether the effectiveness of pro-environmental tax incentives is affected by consumers' cognitive abilities. Indeed, research in economics and psychology has indicated that the cognitive salience of tax incentives (or, observability of tax information) affects consumer responses to those incentives (Chetty, Looney, & Kroft, 2009; Finkelstein, 2009; Li, Linn, & Muehlegger, 2012; Rivers & Schaufele, 2012). While focusing on comparing the overall salience of different tax incentives, however previous studies have not examined the influence that consumers' heterogeneous cognitive abilities may have on their reactions to a given tax incentive.

Accordingly, our main focus is to investigate whether consumers with higher vs. lower general cognitive ability, i.e. intelligence, respond differently to one and the same pro-environmental tax incentive. We examine a unique, comprehensive

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dataset of individual intelligence scores obtained from the Defense Forces of Finland, combined with data on the individuals' car acquisitions (n = 140,000) and control variables retrieved from the Finnish Vehicle Administration, Population Register Center, and Tax Authority. In a natural experimental setting, in 2010, Finland changed the annual car ownership tax from being a fixed sum unrelated to environmental concerns, to being based on the car's CO_2 emissions. Our main outcome variable is the CO_2 emission levels of the cars acquired by consumers before vs. after the tax change, while the main predictor variable is the consumer's intelligence score.

Conceptual development

Although prior literature has suggested that intelligence may affect consumer decision-making (e.g., Burroughs & Mick, 2004; Capon & Davis, 1984; Hirschman, 1983), the potential association between consumer intelligence and responsiveness to pro-environmental tax incentives is not straightforward. As we discuss next, intelligence is likely to have direct and indirect effects on the pro-environmentality of consumers' choices per se (main effect), as well as on their responsiveness to pro-environmental tax incentives (moderating effect).

Main effect of intelligence on pro-environmentality of consumer choice

Pro-environmental choices, per se, often involve economic benefits. For instance, fuel-efficient cars have both low CO_2 emissions and enable cost savings through low fuel consumption. Thus, to the extent that intelligence simply involves a greater ability to attend to and calculate the economic benefits of choices (Lia et al., 2015), intelligence should positively correlate with pro-environmental choices that render economic benefits. Second, the aforementioned benefits (e.g., fuel savings, low emissions) tend to accumulate over the long-term use of the product. In turn, intelligence elicits long-term orientation and patience in individuals (Burks, Carpenter, Goette, & Rustichini, 2009; Shamosh & Gray, 2008; Shamosh et al., 2008), which should give further rise to the aforementioned positive correlation. Third, as intelligence has also been shown to correlate with altruistic behaviors (Chen, Chiu, Smith, & Yamada, 2012; Millet & Dewitte, 2007), it may increase consumer preference for pro-environmental attributes over other attributes (e.g., social status) of the choice, partly independent of the economic benefits. Thus, regarding the main effect of intelligence, we hypothesize:

H1. Intelligence increases the pro-environmentality of consumer choice, such that the CO_2 emissions of cars acquired by more (less) intelligent consumers are lower (higher).

Moderating effect of intelligence on the effectiveness of pro-environmental tax

As the focal effect of interest, we also expect intelligence to have a positive moderating influence on the effect of a pro-environmental tax incentive on consumer choice. This is because the pro-environmental tax makes the linkage between the pro-environmental vs. economic benefits of the choice more complex. That is, in addition to the fact that consumers are likely to have difficulties in considering the baseline relationship between the pro-environmental and economic benefits of the choice (e.g., CO_2 emissions vs. fuel-efficiency) (cf. Bolderdijk et al., 2013), the tax incentive introduces an additional, second-order layer of complexity to the decision (e.g., ownership tax based on CO_2 emissions). Processing such complexity, in turn, is likely to be easier for individuals who have higher cognitive flexibility, which general intelligence has been suggested to provide (Duncan et al., 2000, p. 459). In addition, integrating an additional economic reward into the bundle of economic and pro-environmental benefits is likely to require broader mental categorization ability, which is also enhanced by cognitive flexibility (Murray, Sujan, Hirt, & Sujan, 1990). In summary, individuals with higher general intelligence are likely to have greater cognitive flexibility to process the complex integration of economic and pro-environmental benefits, as complicated by the pro-environmental tax incentive, and are therefore likely to respond more favorably to it[1]:

H2. Intelligence increases consumers' responsiveness to a pro-environmental tax incentive, such that the CO_2 emissions of cars acquired by more (less) intelligent consumers drop more (less) following an emissions-based tax incentive.

As further evidence of the proposed mechanism, we examine the differential effects of different types of intelligence: numerical intelligence, verbal intelligence, and spatial logic intelligence. Because the theorized mechanism above is based on the notion that intelligence elicits cognitive flexibility to deal with the dual pro-environmental and economic benefits, the moderating effect of intelligence should be particularly pronounced for numerical intelligence or ability (Gerardi, Goette, & Meier, 2013). This is because the pro-environmental benefits (lower CO_2 emissions) and the economic savings (lower ownership tax), along with their links, primarily represent a numerical challenge for the consumer, rather than a verbal ability or spatial logic challenge. Thus:

H3a. The effect of intelligence on consumer responsiveness to a pro-environmental tax incentive is more pronounced for numerical ability.

To further examine the proposed underlying theoretical mechanism, we examine whether the effect of intelligence on responsiveness to a tax incentive is different for the purchase of large vs. small cars. As pro-environmental tax incentives are usually, as well as in the present case, progressive (i.e., tax cost savings are greater at higher levels of emissions), our theory

[1] This theoretical argument is not based on an assumption about differential attention paid to the tax incentive by more vs. less intelligent consumers. Rather, our theory is that because the tax incentive creates a more complex linkage between the dual economic and pro-environmental benefits of low-emission cars, the cognitive ability to process such duality and complexity, which is elicited by general intelligence, makes higher intelligence consumers more responsive to the tax incentive.

predicts that the effect of intelligence on consumer responsiveness to the tax incentive should be greater for large cars. This is because the progressive nature of the linkage between CO_2 emissions-related economic benefits can be expected to be especially complex to process. This, in turn, means that intelligence is likely to have a greater effect on consumer responsiveness to the tax incentive in the case of larger cars, since the progressive nature of the incentive in such purchases is more pronounced:

H3b. The effect of intelligence on consumers' responsiveness to the pro-environmental tax incentive is more pronounced for larger car acquisitions.

Indirect effects of intelligence via income

In addition to the direct main (H1) and moderating (H2, H3a and H3b) effects hypothesized above, intelligence is likely to have nuanced, indirect effects on consumers' pro-environmental choices as well as on their responsiveness to the pro-environmental tax incentive. In particular, since intelligence is correlated with income (Grinblatt, Keloharju, & Linnainmaa, 2011), indirect effects may occur via income.

As opposed to the positive main effect of intelligence on pro-environmental choice (H1), we expect that the effect of intelligence on pro-environmental choice via income is negative. That is, while intelligence has a positive effect on income (Grinblatt et al., 2011), income, as such, will have a negative effect on the pro-environmentality of one's car. This can be expected because higher-income consumers can afford to buy cars that are larger and consume more gas, on average, meaning that they also produce more emissions.

In contrast, regarding the moderating effect of income on the effectiveness of the tax incentive (per H2), we expect the effect of income to be *positive*, such that higher income consumers are likely to be more responsive to a pro-environmental tax incentive. This is because income is likely to correlate with the consumers' ability to carry out more nuanced financial planning through greater financial literacy. Indeed, previous research shows a correlation between income and financial literacy (Lusardi & Mitchell, 2011; Van Rooij, Lusardi, & Alessie, 2011a, 2011b). Such financial literacy should generally make it easier for higher-income consumers to calculate the financial benefits of responding to the pro-environmental tax incentive. Therefore, we anticipate that the *indirect* influence of intelligence on consumers' responsiveness to the pro-environmental tax incentive via income is positive.

In summary, beyond the main hypotheses on the direct effects of intelligence (H1, H2, H3a and H3b), our empirical expectations about the indirect effects of intelligence via income are as follows: (a) intelligence has a positive effect on income, and (b) income in turn has a negative effect on the pro-environmentality of consumer choice (such that higher income consumers acquire cars producing higher emissions); but (c) income has a positive effect on consumers' responsiveness to the pro-environmental tax (such that the CO_2 emissions of cars acquired by higher-income consumers drop more following the emissions-based tax incentive).

Materials and methods

Focal tax change

The annual car ownership tax was changed in Finland in 2010, from a fixed sum (€127.50) to instead being based on the car's CO_2 emissions (between €20 and €606 for cars with the lowest vs. highest CO_2 emissions). Moreover, the new tax incentive was progressive relative to the level of CO_2 emissions. For instance, 50 g of more CO_2 emissions per kilometer (g/km), from 100 g/km to 150 g/km, would mean €49 more tax per year, whereas an additional 50 g/km increase in emissions from 150 g/km to 200 g/km would mean €66 of more tax.

Data and method

To test the predictions, we compiled register data for a comprehensive census population of male individuals born from 1953 to 92 and residing in the region around Finland's capital city, Helsinki. Intelligence score data for this population were made available by the Finnish Defense Forces, which tests conscripts entering the country's mandatory military service. The final sample comprised 140,293 cars acquired by these individuals in 2007–11, as obtained from the records of the Finnish Vehicle Administration (FVA) (see Methodological detail).

Our main *predictor* variable is the individual's composite intelligence score. In the Defense Forces' test, 120 question items assess intelligence according to cognitive functioning in three domains: (i) numerical, (ii) verbal, and (iii) spatial logic ability. The main *outcome* variable, the car's CO_2 emissions, is measured as average grams of CO_2 generated per 1 km of driving. Data for this variable was retrieved from FVA.

As *control* variables, we include individual-specific variables (age, household size, number of children, work commute costs, disposable income, municipality, language group), from the Population Register Center and Tax Authority, and car registration variables (the individual being the legal owner *vs.* primary holder/user of the car; new vs. used car) from FVA. Beyond these control variables, it would have been relevant to control for the acquisition cost (i.e. sale price) of the cars; however, there is no source of such transaction prices available in Finland.

Results

Descriptive analyses and model-free evidence

The descriptive statistics for the measured variables are reported in Tables A-1, A-2, and A-3 in online Appendix A. To provide model-free evidence of the primary effect of interest (H2), Fig. 1 plots the observed mean CO_2 emissions of cars acquired before and after the pro-environmental tax incentive, as a function of intelligence score. The figure shows that the

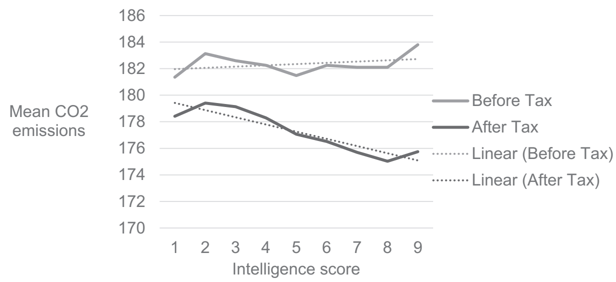

Fig. 1. Model-free evidence: observed CO_2 emissions by intelligence score, before and after the introduction of the pro-environmental tax incentive.

CO_2 emissions of cars acquired by consumers with higher intelligence indeed drop more after the tax incentive, as compared to consumers with lower intelligence.[2]

Effects of intelligence on pro-environmental choice and tax effectiveness

Main and moderating effects of intelligence

Regarding the main effect of intelligence on the pro-environmentality of consumer choice, the results in Table 1 reveal a negative effect by intelligence on the CO_2 emissions of acquired cars (β = −0.63, SE = 0.07, $p < 0.0001$; Model 1). Thus, as hypothesized in H1, intelligence has a positive (negative) main effect on the pro-environmentality (CO_2 emissions) of cars acquired.

Considering the effect of primary interest in the present study, the results in Table 1 (Model 1) further show that the interaction effect of intelligence score and tax incentive (after vs. before) becomes significantly negative (β = −0.61, SE = 0.09, $p < 0.0001$) as well. This supports focal hypothesis H2, suggesting that intelligence increases consumers' responsiveness to a pro-environmental tax incentive. That is, the CO_2 emissions of cars acquired by more intelligent consumers decrease more after the introduction of the tax incentive than those of less intelligent consumers.

Further evidence: different intelligence types and car size

To seek additional evidence for the proposed underlying mechanism to the moderating effect of intelligence to pro-environmental tax effectiveness, we hypothesized in H3a that this effect should be more pronounced for numerical intelligence than for verbal and spatial logic intelligence. To check this, we re-estimated the previous model (Model 1, Table 1) separately for the different intelligent types. The results in Table 2 indicate that the coefficient of the interaction of intelligence and tax incentive is greatest in magnitude with numerical intelligence (β = −0.63, SE = 0.08, $p < 0.0001$), as compared to either verbal intelligence (β = −0.50, SE = 0.09, $p < 0.0001$) or spatial logic intelligence (β = −0.32, SE = 0.09, $p = 0.0002$). In a model with the interaction effects of the tax incentive and all the intelligence types included simultaneously (Table 2, right column), numerical intelligence is the only intelligence type for which the interaction effect remains significant (β = −0.64, SE = 0.12, $p < 0.0001$). Thus, H3a is confirmed, in that the effect of intelligence on responsiveness to a pro-environmental tax incentive is most pronounced for numerical intelligence, rather than verbal or spatial logic intelligence.

For even more evidence to support the mechanism, we examined H3b by considering car size, by adding a three-way interaction effect to the previous model, between intelligence, tax (after-before), and car size. The results show (Table A-4 of Appendix A) that the three-way interaction effect indeed becomes significantly negative (β = −0.002, SE = 0.0007, $p = 0.0007$). This result supports H3b and the theoretical mechanism proposed: because the progressive nature of the CO_2 emissions-related economic benefit is complex to process, intelligence has a greater effect on responsiveness to the tax incentive in acquisitions of larger cars, in which the progressive nature of the incentive is more pronounced.

Indirect effects of intelligence via income

To further examine the expected indirect effects of intelligence on pro-environmental choice through income, we first note a positive correlation between intelligence and disposable income (r = 0.28, $p < 0.0001$; Table A-3). In turn, income has a positive direct effect on the emissions of cars acquired (β = 6.27, SE = 0.24, $p < 0.0001$; Model 1), suggesting a negative main effect by income on the pro-environmentality of the choice. This is as expected: higher-income consumers can afford to acquire larger, higher-emission cars.

To examine the indirect moderating effect of intelligence on tax effectiveness through income, we included the additional interaction term of income and tax incentive into the model. This model (Table 1, Model 2) reveals a significant negative interaction effect between the two (β = −5.77, SE = 0.37, $p < 0.0001$). This result, together with the positive correlation between intelligence and income (r = .28), suggests that intelligence positively affects consumer responsiveness to the pro-environmental tax incentive via income, as well. At the same time, the interaction term of tax incentive and intelligence in this model remains significantly negative, but is attenuated (β = −0.20, SE = 0.089, $p = 0.027$; Model 2) when compared to the previous model without the interaction term of the tax incentive and income (β = −0.61, SE = 0.09, $p < 0.0001$; Model 1). These results, in combination, suggest that income partially—but not fully—mediates the positive effect of intelligence on consumer responsiveness to the pro-environmental tax incentive. In other words, intelligence has a positive moderating effect on the effectiveness of pro-environmental tax incentive both because it provides the

[2] Fig. 1 also indicates certain non-linearity in the relationship between intelligence and CO_2 emissions. However, when adding a squared term of intelligence to a regression model of CO_2 emissions, this squared term is insignificant ($p > 0.10$; see Model 4 below, Table 1). This suggests that the relationship between intelligence and CO_2 emissions can be approximated to be linear, despite the slight "bump" in the plot of the observed CO_2 emissions of individuals' cars as a function of intelligence score (Fig. 1; intelligence scores 2–3).

Table 1
Generalized linear regression models: CO_2 emissions of cars acquired after vs. before the introduction of a tax incentive.

	Model 1			Model 2			Model 3			Model 4		
	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
Intercept	106.98	7.32	<0.0001	138.61	7.64	<0.0001	112.57	7.31	<0.0001	770.02	25.54	<0.0001
Intelligence	−0.63	0.07	<0.0001	−0.40	0.07	<0.0001	−0.51	0.07	<0.0001	−1.24	0.25	<0.0001
Age	0.04	0.02	0.01	0.04	0.02	0.02	−0.10	0.02	<0.0001	0.69	0.12	<0.0001
Ln (household size)	2.19	0.31	<0.0001	2.27	0.31	<0.0001	2.19	0.31	<0.0001	1.24	0.31	<0.0001
Ln (number of children)	0.71	0.19	0.0002	0.69	0.19	0.0003	0.67	0.19	0.0004	0.76	0.19	<0.0001
Ln (income)	6.27	0.24	<0.0001	3.04	0.31	<0.0001	6.17	0.24	<0.0001	−126.27	5.00	<0.0001
Ln (work travel costs)	−0.57	0.02	<0.0001	−0.57	0.02	<0.0001	−0.57	0.02	<0.0001	−0.51	0.02	<0.0001
Holder (vs. owner)	1.51	0.18	<0.0001	1.54	0.18	<0.0001	1.53	0.18	<0.0001	1.73	0.17	<0.0001
New car (vs. used)	−25.28	0.21	<0.0001	−25.26	0.21	<0.0001	−25.28	0.21	<0.0001	−25.98	0.21	<0.0001
After- vs. before-tax	−2.65	0.51	<0.0001	54.20	3.67	<0.0001	6.18	0.88	<0.0001	5.49	0.59	<0.0001
Intelligence * After- vs. before-tax	−0.61	0.09	<0.0001	−0.20	0.09	0.027	−0.40	0.09	<0.0001	−0.65	0.09	<0.0001
Ln(income) * After- vs. before-tax				−5.77	0.37	<0.0001						
Age * After- vs. before-tax							−0.28	0.02	<0.0001			
Intelligence^2										0.02	0.02	0.29
Age^2										−0.009	0.0017	<0.0001
Ln (income)^2										6.68	0.25	<0.0001
Time trend										−3.28	0.12	<0.0001
Location/municipality fixed effects	Yes			Yes			Yes			Yes		
Language group fixed effects	Yes			Yes			Yes			Yes		
n	140,293			140,293			140,293			140,293		
Goodness of fit: QICu	140,590			140,591			140,591			140,593		

Notes. The models were estimated using SAS procedure GENMOD. The goodness of fit statistic QICu (Quasi-likelihood under Independence Model Criterion) is analogous to the AIC (Akaike's Information Criterion) statistic that is often utilized for comparing the goodness of fit of models with likelihood-based methods.

individual with the cognitive flexibility to process the complex bundle of economic rewards and pro-environmental benefits involved (direct moderating effect of intelligence), and because it enhances their financial literacy to consider the pure financial benefits incurred (indirect moderating effect via income). Fig. 2 summarizes these effects.

Table 2
Generalized linear regression models: CO_2 emissions for different intelligence types.

	Model 1: numerical ability			Model 1: verbal ability			Model 1: spatial logic ability			Model 1: all intelligence types		
	β	SE	*p*	β	SE	*p*	β	SE	*p*	β	SE	*p*
Intercept	106.89	7.32	<0.0001	106.29	7.27	<0.0001	107.05	7.30	<0.0001	106.17	7.30	<0.0001
Numerical ability	−0.66	0.07	<0.0001							−0.59	0.10	<0.0001
Verbal ability				−0.64	0.07	<0.0001				−0.40	0.10	<0.0001
Spatial logic ability							−0.27	0.07	0.0002	0.31	0.09	0.0008
Age	0.04	0.02	0.0126	0.04	0.02	0.0085	0.03	0.02	0.0417	0.05	0.02	0.0045
Ln (household size)	2.20	0.31	<0.0001	2.19	0.31	<0.0001	2.13	0.31	<0.0001	2.20	0.31	<0.0001
Ln (number of children)	0.71	0.19	0.0002	0.69	0.19	0.0003	0.73	0.19	0.0001	0.68	0.19	0.0003
Ln (income)	6.30	0.24	<0.0001	6.29	0.24	<0.0001	6.10	0.24	<0.0001	6.33	0.24	<0.0001
Ln (work travel costs)	−0.57	0.02	<0.0001	−0.57	0.02	<0.0001	−0.57	0.02	<0.0001	−0.57	0.02	<0.0001
Holder (vs. owner)	1.50	0.18	<0.0001	1.51	0.18	<0.0001	1.58	0.18	<0.0001	1.50	0.18	<0.0001
New car (vs. used)	−25.26	0.21	<0.0001	−25.27	0.21	<0.0001	−25.33	0.21	<0.0001	−25.24	0.21	<0.0001
After- vs. before-tax	−2.57	0.49	<0.0001	−3.42	0.49	<0.0001	−4.27	0.51	<0.0001	−2.72	0.57	<0.0001
Numerical ability * After- vs. before-tax	−0.63	0.08	<0.0001							−0.64	0.12	<0.0001
Verbal ability * After- vs. before-tax				−0.50	0.09	<0.0001				−0.14	0.12	0.2272
Spatial logic ability * After- vs. before-tax							−0.32	0.09	0.0002	0.17	0.11	0.1283
Location fixed effects	Yes			Yes			Yes				Yes	
Language fixed effects	Yes			Yes			Yes				Yes	
N	140,293			140,293			140,293				140,293	
Goodness of fit: QICu	140,590			140,590			140,590				140,594	

Notes. In the model with all intelligence types included (rightmost column), the effect sign of spatial logic ability changes into positive, from the negative sign observed in the model including spatial logic ability only (third column). Also, the moderating effect of "Spatial logic ability * After-vs-before tax" changes from negative to positive. These sign reversals are, primarily, due to multicollinearity between the three intelligence types, as the three intelligence types are highly correlated (>0.6; see Table A-3) with each other. The reason for the sign reversals being due to this multicollinearity is also reflected in the fact that the effect sign of none of the other predictors changes across the four models in the above table, and in the fact that the model including all intelligence types has a poorer model fit (QICu = 140,594) than any of the models including one intelligence type only (QICu = 140,590). Therefore, the results of the model with all intelligence types included should be treated with caution—and the "real" effect sign of spatial logic intelligence should be interpreted to be negative (as in third column). At any rate, the primary result remains the same even in the model including all intelligence types: the moderating effect of intelligence is most pronounced for numerical ability, rather than verbal and spatial ability.

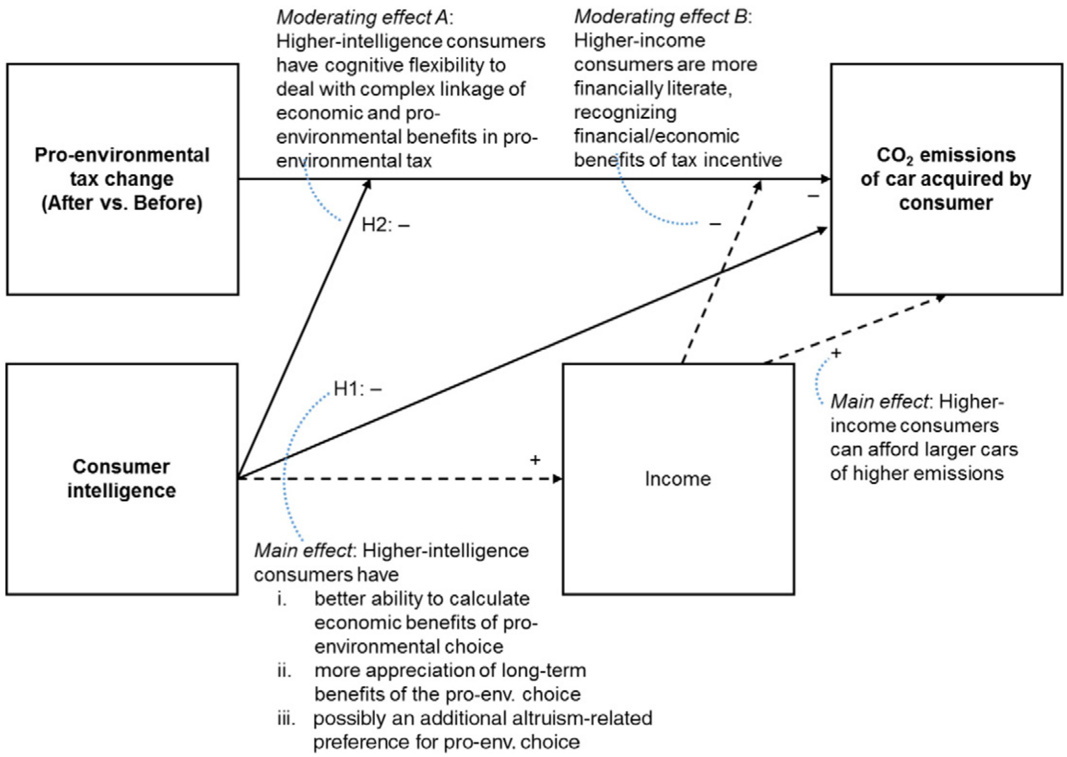

Fig. 2. Summary of results: direct and indirect effects of consumer intelligence on consumers' responsiveness to pro-environmental tax in car acquisitions. Notes: the arrows and signs indicate the hypothesized main, moderated, and mediated effects, which received support in the empirical analyses. Note that the three mechanisms (i–iii) that are assumed to give rise to the *Main effect* of intelligence on the pro-environmentality of one's car choice are distinct from the mechanism driving the *Moderating effect A*. This is because a tax incentive may *not* (i) unilaterally create economic benefits or cost-savings for *all* pro-environmental products (e.g., due to the progressive tax scheme). Moreover, the tax incentive does *not* (ii) unilaterally alter the short-term vs. long-term nature of the choice (e.g., a yearly car ownership tax already existed before the yearly, emission-tied car ownership tax). The tax incentive also does *not* (iii) increase the pro-environmentality of the car's engine per se. Instead, we posit that the *Moderating effect A* is driven by the added complexity of the dual economic/pro-environmental benefits involved in the tax incentive, and the role of cognitive flexibility provided by intelligence in dealing with this complexity. Regarding *Moderating effect B*, note that even if intelligence is also likely to enhance financial literacy and planning ability directly (cf. Gerardi et al., 2013), we presently consider income to be an empirical proxy for financial literacy.

Robustness checks

As a robustness check, we check for the mediating effect of another control variable correlated with intelligence—age—by substituting age for income in the above interaction model. In this model (Table 1, Model 3), however, the interaction term of tax incentive and intelligence does not substantially decrease in magnitude ($\beta = -0.40$, SE = 0.09, $p < 0.0001$). This suggests that unlike income, age does not act as a substantial mediator in the effects. As an additional control model (Table 1, Model 4), we include squared terms of intelligence score, age, and income to the main model, as well as a time trend. The focal interaction effect of intelligence and the tax incentive remains unchanged ($\beta = -0.65$, SE = 0.09, $p < 0.0001$), suggesting that the previous linear models provide a sufficiently good approximation of the focal effects. In yet another model specification (Table A-5 in Appendix A), we include the three-way interaction effect of intelligence, tax incentive, and income. A three-way interaction effect with a moderate-sized negative sign is revealed ($\beta = -0.43$, SE = 0.18, $p = 0.02$), suggesting that cognitive flexibility and financial literacy have a certain mutually reinforcing effect, such that consumers who have both high intelligence and high income are most responsive to the pro-environmental tax incentive (e.g., potentially purchasing expensive, low-emission hybrid cars).

Finally, to address potential omitted variable bias in the above results, we use the instrumental variable approach, utilizing the intelligence score of one's brother as an instrument (Grinblatt et al., 2011).[3] The results (Table A-6) show that the coefficient for the focal effect, the interaction of one's intelligence score and tax incentive, remains negative and statistically significant ($\beta = -0.54$, SE = 0.17, $p = 0.001$) even though the control function residual is included. This suggests that idiosyncratic, unobserved omitted variables, such as education, training, or consumer innovativeness, are unlikely to explain the results.

Comparing the effect sizes

Finally, to permit a comparison of the ability of intelligence vs. other covariates to predict the CO_2 emissions of an individual's car, we log-transform all the predictor variables and outcome variables in a similar manner. This allows for comparing the effects in terms of a percentage change in CO_2 emissions

[3] This is based on the assumption that the intelligence score of one's brother is correlated with one's own intelligence score (due to shared genes), but so not likely to be correlated with one's car choice. We first regress the individual's intelligence score on the intelligence score of his brother as well as on a set of control variables. We then rerun the regression of the CO_2 emissions of the individual's car by adding the control function residual from the first-stage regression as an additional control variable.

Table 3
Generalized linear regression models: CO_2 emissions with comparable log-transformed predictors.

	Model 1: main model			Model 2: main model with tax-income interaction		
	β	SE	p	β	SE	p
Intercept	4.79	0.04	<0.0001	4.97	0.05	<0.0001
Ln (intelligence [numeric])	−0.02	0.00	<0.0001	−0.01	0.00	<0.0001
Ln (age)	0.01	0.00	0.0979	0.00	0.00	0.1864
Ln (household size)	0.01	0.00	<0.0001	0.01	0.00	<0.0001
Ln (number of children)	0.00	0.00	<0.0001	0.00	0.00	<0.0001
Ln (income)	0.03	0.00	<0.0001	0.01	0.00	<0.0001
Ln (work travel costs)	−0.00	0.00	<0.0001	−0.00	0.00	<0.0001
Holder (vs. owner)	0.01	0.00	<0.0001	0.01	0.00	<0.0001
New car (vs. used)	−0.14	0.00	<0.0001	−0.14	0.00	<0.0001
After- vs. before-tax	−0.01	0.00	0.0002	0.30	0.02	<0.0001
Intelligence * After- vs. before-tax	−0.01	0.00	<0.0001	−0.01	0.00	0.015
Income * After- vs. before-tax				−0.03	0.00	<0.0001
Location/municipality fixed effects	Yes			Yes		
Language group fixed effects	Yes			Yes		
n	140,293			140,293		
Goodness of fit: QICu	140,590			140,591		

predicted by percentage change in the predictor variables. The results in Table 3 show that the effect size of intelligence—after the tax incentive (−0.02 − 0.01 = −0.03)—is equivalent to the main effect of income (0.03), and larger than the effects of age (0.01), household size (0.01), number of children (0.004), and work commuting cost/distance (−0.003) *combined*. In absolute terms, the effect of intelligence (nor any of the other covariates) is not large: the average CO_2 emissions drop approximately 3% (from 180 g/km to 175 g/km, see Fig. 1) between individuals with the highest vs. the lowest intelligence (i.e., when intelligence drops 90 percentiles). Nevertheless, the effect is considerable in relative terms, as compared with the other covariates. For instance, a similar percentage decrease in income does not drop emissions more than 3%, either, while a similar percentage decrease in age reduces emissions by only 1%. It is to be noted, as well, that the consumer cannot directly decide the emission levels of their car, since most cars emit CO_2 by the nature of their operation. Thus, even a decrease of 5 g/km (3% above) in emissions is fairly noteworthy, considering that 50% of the cars in the sample had emissions in the relatively narrow inter-quartile range of 43 g/km (with the lower quartile being 156 and the upper quartile 199 g/km; Table A-2).

General discussion

Our empirical results about the effects—and relative effect sizes—of intelligence vs. other predictors on consumers' responsiveness to a pro-environmental tax are noteworthy theoretically. Indeed, the ignorance of the systematic effect of intelligence (i.e., consumers' heterogeneous cognitive abilities) in prior studies of economic psychology may partially explain why these studies have obtained mixed results about whether economic rewards for pro-environmental behavior have positive (e.g., Chandra et al., 2010; Gallagher & Muehlegger, 2011) or negative effects (Bolderdijk et al., 2013; Dogan et al., 2014; Evans et al., 2013; Spence et al., 2014) on consumer choices. In turn, for consumer psychology literature in general, it may not come as a surprise that intelligence (e.g., Burroughs & Mick, 2004; Capon & Davis, 1984; Hirschman, 1983; Langenderfer & Shimp, 2001) affects consumer decision making. Nevertheless, even for consumer research literature in general, it is noteworthy that intelligence seems to impact consumers' pro-environmental choices and responsiveness to tax incentives to an equal extent as the perhaps most important driver of consumption, disposable income—and to a greater extent than the key demographic variables of age and household size combined.

As a further contribution to theory, the present study unpacks and provides empirical evidence of the theoretical mechanisms through which intelligence is likely to affect consumers' pro-environmental choices and responsiveness to pro-environmental tax incentives. Indeed, the empirical results support the theory that intelligence has a positive effect on consumers' responsiveness to pro-environmental tax incentives, because intelligence provides for the cognitive flexibility to process the complex dual combination of pro-environmental benefits and economic benefits. In support of this, the effect was found to be most pronounced for numerical intelligence rather than verbal intelligence or spatial logic intelligence, as well as for larger (vs. smaller) car acquisitions, wherein the complexity of the dual benefits is greater.

Third, the results contribute to the behavioral literature on the salience of tax incentives in particular (Chetty et al., 2009; Finkelstein, 2009). While the existing literature typically focuses on comparing the general cognitive salience of different kinds of tax incentives, the present research contributes by identifying the impact of consumers' cognitive heterogeneity on the effectiveness of one and the same tax incentive. This way, intelligence also seems to serve the purpose of helping consumers to simultaneously achieve "internality" cost-savings of pro-environmental consumption choices and externality benefits on the natural environment (Alcott, Mullainathan, & Taubinsky, 2014; Sunstein, 2013; see also Gneezy, Meier, & Rey-Biel, 2011).

Regarding the practical implications of this study, the key issue is how to boost the effectiveness of pro-environmental tax incentives even among consumer segments with lower cognitive ability. Information that is "easier" to understand, as well as decision support tools, should therefore generally be offered to consumers during the decision making process—alongside an explanation of the tax incentive itself. As the results showed that the dependency of the tax incentive's effectiveness on cognitive abilities is more pronounced in the purchasing of large cars relative to small cars, it is especially important to develop and offer these tools for the use of buyers of large cars (e.g., premium and family cars).

Finally, given the nature of the present study as a short empirical report, a number of important issues remain to be studied in future research. First, since we did not have data on the purchase prices of cars, their role in affecting consumers' pro-environmental choices should be considered a priority in future research efforts. Second, as our data only included data on male consumers, it would be important to investigate whether the results can be replicated with female consumers. Because females tend to be more pro-social, altruistic, and community-oriented than males (e.g., Bem, 1981; Piliavin & Charng, 1990; Winterich, Mittal, & Ross, 2009), it is possible that neither intelligence nor economic tax incentives play the same role in females' pro-environmental choices as they do in those of males. Third, beyond cognitive flexibility or income, intelligence may also have indirect effects on responsiveness to pro-environmental incentives through other mediating or correlating variables, such as creativity and risk/variety-seeking (cf. Benjamin, Brown, & Shapiro, 2013; Burroughs & Mick, 2004). Therefore, studying the relative effects of these variables is yet another task left to be undertaken in future research.

Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.jcps.2017.03.002.

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