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Replication Article

## Is bigger always better? The unit effect in carbon emissions information



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### ABSTRACT

According to Pandelaere et al. (2011), bigger numbers of units in quantitative attribute information lead to greater perceived attribute differences, making it more likely that consumers will choose a higher-attribute option. We replicate this unit effect for the carbon emissions metrics displayed in car advertisements, and extend it to show that highly numerate individuals, who are supposed to be more effective decision-makers, may actually be more prone to numerosity heuristics.

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## 1. Introduction

Quantitative information can be expressed in different units. Pandelaere et al. (2011) show that attribute differences appear larger on expanded scales, which display a higher number of units. The perceived difference between an 84-month and a 108-month warranty is larger than the perceived difference between a 7-year and a 9-year warranty. This unit effect occurs because individuals are overly sensitive to numerosity (the number of units) as a cue for judging quantity (Pelham et al., 1994), and it affects consumer preferences (Burson et al., 2009).

This research replicates the unit effect for carbon emissions metrics. It also shows that highly numerate individuals are, counter intuitively, more susceptible to this bias. This finding calls for a deeper exploration of the reasons why numeracy may alternatively exacerbates or attenuates individual cognitive biases.

## 2. Hypotheses

Research has demonstrated the unit effect across a wide variety of attribute types, including frequencies (e.g., per month vs. per year), units of measure (e.g., euros vs. francs), or arbitrary scales (e.g., 10-point vs. 1000-point scales) (Burson et al., 2009; Pandelaere et al., 2011). Stone et al. (2003) suggest that consumer attention may be drawn to the foreground information (the number of units) at the expense of the background information (the type of unit). For example, in the carbon emissions metric “g of CO<sub>2</sub>/km”, consumers are likely to focus more on the foreground information (g) than the background information (km). In the foreground

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information, expanded scales displaying a higher number of units may lead to a numerosity heuristic, in which individuals can confuse numerosity for quantity and consider bigger numbers as an expression of bigger quantities (Pelham et al., 1994). We therefore expect to find that carbon emissions metrics measured on expanded scales will lead to lower ecological evaluations.

Correlatively, expanded scales are supposed to highlight the difference between choice options, making it easier to discriminate between them than a presentation in contracted scales (Burson et al., 2009; Camilleri & Larrick, 2014; Pandelaere et al., 2011). This enhanced discriminability is likely to shift preferences to the higher alternatives on the expanded scales (Burson et al., 2009). Consistent with this literature, we expect to find that when carbon emissions metrics are presented using expanded scales (vs. contracted scales), consumers will be better able to discriminate in favor of the more ecological option and more willing to choose a more (vs. less) expensive product with lower (vs. higher) carbon emissions.

Going further, we investigate the moderating role of numeracy, defined as the ability to understand and process numbers (Weller et al., 2013), on the unit effect. As shown by Peters et al. (2006), highly numerate individuals are more likely to retrieve and use numerical principles, making them less susceptible to framing effects. Moreover, individuals with lower numeracy are particularly prone to errors in understanding “percentage change” (Mohan et al., 2015). In line with these findings, we expect to see that highly numerate consumers assessing carbon emissions metrics will be less subject to unit effects than less numerate consumers.

### 3. Study 1

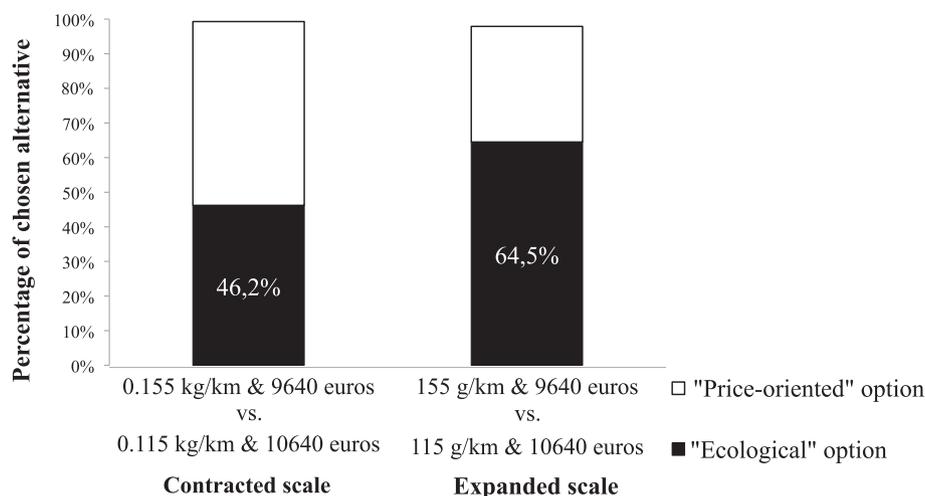
We conducted an online survey presenting fictional vehicles that varied in terms of carbon emissions and price. We manipulated the carbon emissions metrics (expanded scale: “g of CO<sub>2</sub>/km” vs. contracted scales: “kg of CO<sub>2</sub>/km”) for 2 alternatives (the “ecological alternative”: a high price, low carbon emissions vehicle vs. the “price-oriented alternative”: a low price, high carbon emissions vehicle) in a mixed choice experiment (see Appendix A for procedure details). 125 French respondents (56% women, mean age: 38 years) were recruited through the panel of a professional market research institute.

The logistic regression analysis, controlling for gender and age, revealed that carbon emissions metrics have a significant influence on consumers' choices ( $\beta = -.77$ ,  $Wald = 4.38$ ,  $p < .05$ ). As expected, consumers exposed to an expanded scale chose the ecological alternative more frequently than those exposed to a contracted scale (64.5% vs. 46.2%; see Fig. 1). Study 1 therefore replicates Pandelaere et al.'s (2011) unit effect in the case of ecological information. Study 2 focuses on the moderating role of numeracy on this unit effect.

### 4. Study 2

Using similar stimuli as in Study 1, we manipulated the carbon emissions metrics (expanded scale: “135 g of CO<sub>2</sub>/km” vs. contracted scale: “0.135 kg of CO<sub>2</sub>/km”) in a between-subject design. 122 French respondents were recruited from the same panel as for study 1 (57% women, mean age: 38 years). They were first asked to evaluate the vehicle's ecological image using 3 items borrowed from Parguel et al. (2015) 7-point Likert scale (e.g., “This car is environmentally-friendly”;  $\alpha = .72$ ). Then, following Weller et al. (2013), numeracy was measured as the total number of correct responses to 7 items testing numerical processing ( $m = 2.88$ ,  $s.d. = 1.70$ ,  $min = 0$ ,  $max = 7$ ). Using a median-split, we dichotomized participants between those who had answered up to three questions correctly and those who had answered more than three questions correctly.

The ANOVA on ecological image, controlling for gender, age and domain knowledge about carbon emissions (borrowed from Parguel et al., 2015), revealed a significant effect of carbon emissions metrics ( $F(1,116) = 14.27$ ,  $p < .01$ ) and a marginally



**Fig. 1.** Effect of carbon emissions metrics on consumer choice (Study 1) Note: participants were not shown the “price-oriented” and “ecological” labels, only included here for the convenience of description.

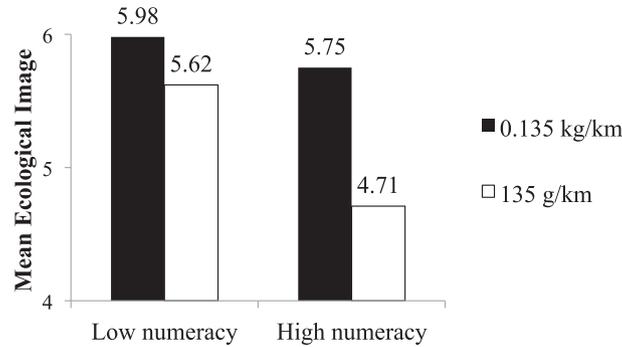


Fig. 2. Effect of carbon emissions metrics on ecological image (Study 2).

significant effect of respondent numeracy ( $p = .09$ ). As expected, we replicate the unit effect such that consumers exposed to an expanded scale perceived the vehicle as less ecological than those exposed to a contracted scale ( $M_{135\text{g}/\text{km}} = 5.22$ ,  $M_{0.135\text{kg}/\text{km}} = 5.90$ ). The interaction between carbon emissions metrics and respondent numeracy was also significant ( $F(1116) = 4.23$ ,  $p < .05$ ); see Fig. 2). However, planned contrasts revealed the opposite to the hypothesized effect: the unit effect only affected highly numerate consumers ( $F(1116) = 13.76$ ,  $p < .01$ ) while there was no significant difference when numeracy was low ( $p = .16$ ). Note that we found the same interaction effect when we kept the numeracy variable quantitative in a floodlight analysis ( $\beta = -.22$ ,  $t = -1.99$ ,  $p < .05$ ). Additional analyses showed that domain knowledge did not moderate the unit effect.

## 5. Discussion

We replicate and extend the “unit effect” (Pandelaere et al. 2011). Surprisingly, we find that highly numerate individuals appear more susceptible to the unit effect than less numerate individuals. This result clearly runs counter to the literature (e.g., Mohan et al., 2015; Peters et al., 2006), which usually considers the framing of numerical information to have greater effects on the less numerate. In line with previous research showing that paying closer attention to a visual stimulus exacerbates rather than attenuates bias (Raghubir, 2008), we believe that highly numerate individuals pay closer attention to numbers, making them both more susceptible to numerosity heuristics, and better able to process numbers. Besides, we extend the unit effect to contracted scales using numbers below 1 while Pandelaere et al. (2011) only manipulated integers. Potential ceiling effects in the unit effect remain to be explored.

Our findings provide interesting implications for public policy makers in terms of health (e.g., health risk, nutrition) and promotion of sustainable consumption (e.g., fuel efficiency, reducing carbon emissions). When consumers face quantitative information expressed in different units, public policy makers can help consumers make better choices by selecting expanded scales, which will make the reader more sensitive to environmental attribute differences. Finally, our surprising result regarding numeracy also calls for more research to reconsider the way numeracy is defined and measured, in order to help public policy makers control relevant indicators and implement adequate types of assistance to help individuals make more ecological decisions.

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## Appendix A. Overview of the two studies.

Study	Results in comparison with Pandelaere et al. (2011)		
Study 1	Replication of the unit effect on consumer choice: an expanded scale leads decision-makers to discriminate between choice options more than a contracted scale.		
– Category: car advertisements			
– DV: consumer choice			
– Framing stimuli:			
	Within-subjects	Choice A: lower CO <sub>2</sub> emission	Choice B: lower price
Between-subjects	Cell 1 (g/km)	115 g/km 10,640 €	155 g/km 9640 €
	Cell 2 (kg/km)	0.115 kg/km 10,640 €	0.155 kg/km 9640 €
		In our case, when carbon emissions metrics involve higher numbers (vs. lower numbers), more consumers are willing to choose the “ecological alternative” (vs. the “price-oriented alternative”).	

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**Appendix A** (continued)

Study	Results in comparison with Pandelaere et al. (2011)
Study 2 – Category: car advertisements – DV: ecological image – Framing stimuli: Between-subjects 0.135 kg/km                      135 g/km	Replication of the underlying mechanism: bigger numbers lower the vehicle's ecological image (numerosity heuristics).  Extension in terms of boundary condition identification: the unit effect is stronger for highly numerate consumers.

**Appendix B. Supplementary data**

Supplementary data to this article can be found online at <http://dx.doi.org/10.1016/j.ijresmar.2015.10.002>.

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