Study on the impact on consumer understanding and purchase decisions of energy labels for lighting products

Final report

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Executive summary

The current study investigates the impact of revisions of the energy label for lighting products on the effectiveness of the label. Effectiveness of the label is defined in terms of understanding (being able to identify the product with the highest energy efficiency class and/or the lowest energy consumption) and choice behaviour (whether consumers choose the most energy efficient product). The study consisted of an online experiment among approximately 1,000 respondents in each of 5 countries (Germany, Italy, Portugal, Romania and Sweden), resulting in 5,015 respondents.

The first research question is whether reducing the **size of the label** reduces its effectiveness. The study included three different sizes of the label (small, smaller, smallest). The second research question pertains to the **colour of the label**. Under current regulations, it is allowed to place a black-and-white version of the label on packages instead of the label in colour. However, it is unclear whether a black-and-white label reduces the effectiveness of the label. To investigate this, the label was either presented in colour or in black-and-white. Finally, in addition to the full label, which is presented on the back of the package, the European Commission proposes to introduce a new smaller label – a **coloured arrow** – for display on the front of the package. The current study provides insight into the added value of adding the smaller label to the package front. On the front of the packages, the label arrow was either absent or present. Moreover, two types of label arrows were investigated: a simple and a more detailed label arrow.

The experiment contained three choice tasks, in which respondents were presented with eight light bulb packages, and were asked to make a choice and to identify the best product in terms of energy class and energy consumption. When respondents clicked on or hovered their mouse over a package front ("turning the package"), they were able to see the back of the package, with the full energy label.

Results revealed that decreasing the size of the label resulted in fewer choices for the light bulb with the highest energy class and a lower understanding of both energy class and energy consumption. Moreover, the *more* the energy label decreased, the more this was the case. There were few differences between the coloured and black-and-white version of the label, and if there were differences, they were small, with the exception of very small labels, for which the coloured version was more effective. However, as long as the energy label does not become very small, there seem to be no large differences between the coloured and the black-and-white version. The presence of a label arrow did not influence respondents' choices, and had a small positive effect on understanding energy class, but also a small negative effect on understanding energy consumption. It seems that respondents confuse energy consumption with energy class, which is worsened by the presence of a label arrow containing the energy class.

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1. Introduction

The Commission proposes a revised energy label for lighting products, which includes[1]:

- the supplier's name or trade mark;
- the supplier's model identifier;
- the energy efficiency class, indicated on a scale from A to G;
- the energy consumption in kWh per 1000 hours;
- a QR code linking to model information on the supplier's website and/or the EU product database.

The purpose of the current study was to inform the European Commission of the impact of a revised energy label for lighting products. The study focused on light sources (specifically, light bulbs); luminaires fall outside the scope of this study.

The QR code is a new element. Because of the typical small size of the packaging of lighting products, the energy label for lighting products should be relatively small. However, when reducing the size of the label, the QR code can become too small and no longer work. The study took this into account by including a small, yet workable QR code[2], which was displayed below the information on energy consumption if there was not enough space on the right side of the label.

The study investigated the impact of revisions of the energy label for lighting products on the effectiveness of the label. Effectiveness of the label was defined in terms of understanding (being able to identify the product with the highest energy efficiency class and/or the lowest energy consumption) and choice behaviour (whether consumers chose the most energy efficient product). Key questions to be answered in this study were:

- How small can the full label be (1) without losing effectiveness and (2) ensuring the workability of the QR-code?
- Is a black-and-white label as effective as a coloured label?
- Is there an added value of adding a small label – a coloured arrow – on the front of packages? Can such a label compensate for any reductions in the effectiveness of the label caused by a black-and-white full label?

The first research question was whether reducing the **size of the label** reduces its effectiveness. The study included three different sizes to identify the smallest possible size while ensuring eligibility, ensuring that the label was as effective as larger-sized labels in promoting energy conscious choice behaviour, and ensuring the workability of the QR code.

[1] Some of these elements may be omitted from the label, however, if they are presented elsewhere on the packaging (http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32012R0874). In the current study, the label will contain the energy class, the energy consumption and a QR code.

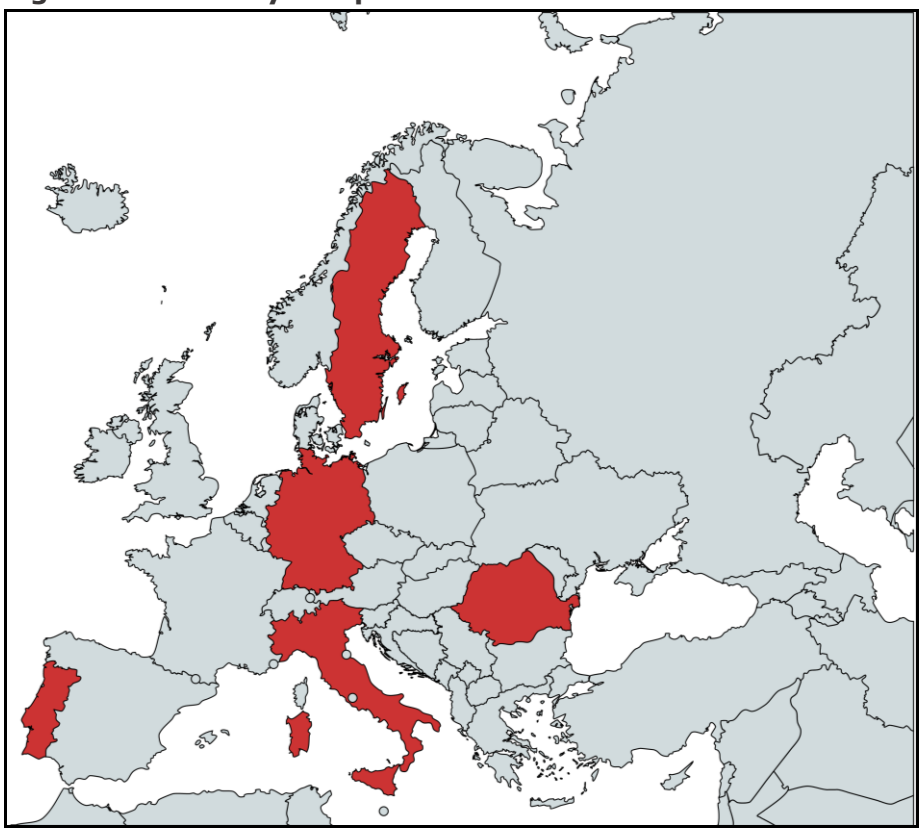
[2] The size of which has been decided after consultation with the European Commission.

The second research question pertained to the **colour of the label**. Under current regulations, it is allowed to place a black-and-white version of the label on packages instead of the label in colour. However, it is unclear whether a black-and-white label reduces the effectiveness of the label. Therefore, the study tested whether (and if so, to what extent) the label's effectiveness was reduced when it was displayed in black-and-white.

Finally, in addition to the full label, which is presented on the back of the package, the European Commission proposes to introduce a new smaller label – a **coloured arrow** – for display on the front of the package. The current study provides insight into the added value of adding the smaller label to the package front. Moreover, we examine whether such a label can compensate for any reductions in the effectiveness of the label caused by a black-and-white full label (relative to the full coloured label) on the back. Two different versions of the small label arrow were included to investigate which type of label would be most effective, a simple arrow or a more detailed arrow.

To answer the specific research questions, an online experiment was conducted among approximately **1,000 respondents in each of 5 countries** (Germany, Italy, Portugal, Romania and Sweden; see Figure 1.1), resulting in a total of 5,015 respondents.

Figure 1.1 Country sample



2. Methodology

2.1. Experiment

The experiment, which took about **10 minutes**, on average, for respondents to complete, consisted of the actual experiment (Part A) and a post-experiment questionnaire (Part B). The full questionnaire can be found in the appendix.

2.1.1. Part A: Experiment

The experiment consisted of three choice tasks (cf. CentERdata/GfK/Ecorys, 2012)[3]. Respondents were asked to imagine that they were looking for new light bulbs. In each choice task, respondents were presented with eight product packages[4] of lighting products (mock-ups developed for this study[5]), and were asked to make a choice ("Please indicate which light bulb you would choose"). In addition, understanding of the labels was assessed by asking respondents to identify best performing product alternatives in terms of energy efficiency ("Please indicate which light bulb, according to you, has the best energy class") and energy consumption ("Please indicate which light bulb, according to you, uses the least amount of energy (results in the lowest energy bill)"). In the choice tasks, respondents were exposed to package fronts (as in reality when standing in front of a shelf), on which the label arrow was either present or absent (depending on the condition the respondent was assigned to, see Table 2.1). When respondents clicked on or hovered their mouse over a package front ("turning the package"), they got to see the back of the package, with the full energy label. For an example of a choice set (with the first package turned around), see Figure 2.1.

[3] https://ec.europa.eu/digital-single-market/en/news/study-effects-consumer-behaviour-online-sustainability-information-displays-final-report-and

[4] Eight packages (two rows of four packages) could be displayed realistically on most computer screens without having to scroll excessively. The experiment was made available on non-mobile computers only.

[5] The packages were developed to look like real product packages, including key information that is typically shown on packages such as average lifetime, light colour, lumen, whether the lamp is dimmable or not, etc. Because the packages and hence the package information other than the label was kept constant across the different experimental conditions, this information did not introduce experimental confounds: It cannot explain any differences in choices and understanding that we observe across the conditions. However, it is important that the product information is chosen carefully: The choice sets may not contain a "dominant product" (a product that is clearly the most attractive for many respondents), as in that case, there is no room for a shift in consumer preferences. Therefore, we conducted a small pre-test (N = 24) of the choice task, which revealed that there were no products in the choice sets that were chosen by a majority of respondents.

Figure 2.1 Example of a choice set

By systematically varying (1) **the size of the full label** (on the back of the package), (2) **the colour of the full label** (on the back of the package), and (3) the **presence (vs. absence) of the small label arrow** on the front of the package, we can measure the individual and combined effects of these factors on understanding and product choice. Respondents were randomly assigned to one of the 10 conditions listed in Table 2.1. All product packages in the choice set that a respondent was presented with carried labels consistent with the experimental condition that the respondent was assigned to. Thus, respondents were exposed to different products with different energy efficiency classes and different levels of energy consumption, but they only saw one "type" of label (or label combination) as listed in Table 2.1. When respondents are randomly assigned to the label conditions[6], any difference in understanding and choices that we observe between the conditions can only be explained by the varied factors (size, colour, and presence of the small label).

[6] Random assignment to experimental groups ensures that the groups are equivalent, provided that sample size is sufficiently large.

Table 2.1 Overview of variants (experimental conditions)

Product package variant:	Size variant	Colour variant	Label arrow
1	Small	Colour	Absent
2	Smaller	Colour	Absent
3	Smallest	Colour	Absent
4	Small	Black-and-white	Absent
5	Smaller	Black-and-white	Absent
6	Smallest	Black-and-white	Absent
7	Small	Colour	Present (simple)
8	Small	Colour	Present (detailed)
9	Small	Black-and-white	Present (simple)
10	Small	Black-and-white	Present (detailed)

Figure 2.2 Example of a light bulb package (backside)

An example of a light bulb package is displayed in Figure 2.2. In total, 24 different light bulb packages (front and back) were developed especially for this study (3 sets of 8 packages). Label size, colour and label arrow variations (as listed in Table 2.1) were then created for each package. The three size variations are displayed in Figure 2.3 (rescaled to fit on the page). One may note that although the size of the energy label varied, the size of the package did not vary. For computer displays with a reasonably large screen size and high resolution, the package images were displayed with a size of 9.5 cm (height) x 5.5 cm (width), which represents a typical light bulb

package. The small label was 6.8 cm (H) x 3.6 cm (W), the smaller label was 4.8 cm (H) x 2.6 cm (W) and the smallest label was 3.7 cm (H)[7] x 1.7 cm (W).

For computer displays with smaller screen sizes and/or lower resolutions, the package images were automatically rescaled.[8] This led to some variation in package sizes (and hence label sizes) *within* conditions, which allowed for a more detailed analysis of effects of label size. In other words, because different respondents saw the packages at slightly different sizes (due to differences in screen size and screen resolution), we were able to compare many more label sizes (see Figure 2.4) and examine in detail at which size the label's effectiveness started to wane.

It is important to note that the variation in package sizes within conditions did not present a threat to the validity of the experiment. Even though there was variation in package sizes *across respondents*[9], randomly assigning respondents to the different experimental conditions ensured that package size did not differ *across conditions*. If package size had been larger in some conditions than in others, other information on the package (including information displayed on the front) could have stood out more or less because it became more or less readable, which could provide an alternative explanation for differences across experimental conditions. This was not the case; the only thing that varied across conditions was the size of the energy label.

[7] For the smallest label, the height was relatively longer (compared to the width) than for the other labels to make room for the QR code, which was placed underneath.
[8] Mobile devices (which have smaller displays) were excluded from the study.
[9] The actual size of the packages depended on browser zoom, screen resolution and screen size. Therefore, we instructed respondents to set their browser zoom at 100%. Moreover, at the start of the study, we asked respondents to measure a line that equaled the width of the package images, which was done by 86.5% of the respondents. The other respondents (who could not find a ruler or measuring tape) estimated the length of the line. If, however, these respondents knew their screen size (we already had information on screen resolution), we tried to find respondents with a similar combination of screen size and screen resolution who had measured the line, and replaced the estimation with a more accurate estimation. We also did this for respondents who reported a line size that varied more than 2 SDs from the mean (e.g., a line size of 0.6 cm may be a typo that should have been 6 cm). On average, the product images approached the size that we intended, as the average line was 5.6 cm (close to the 5.5 cm we intended). We included the line size in our analyses to account for package size differences within conditions.

Figure 2.3 Label size variations

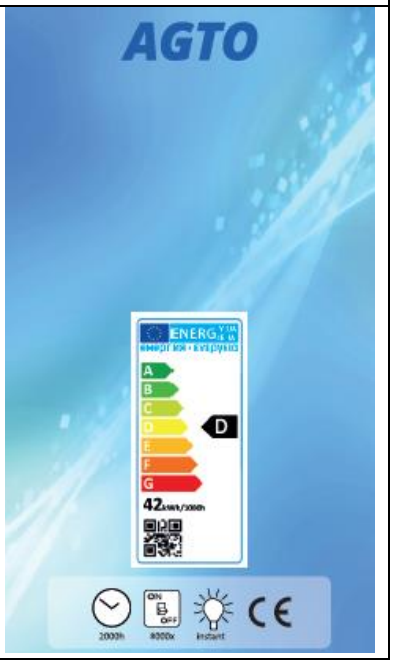
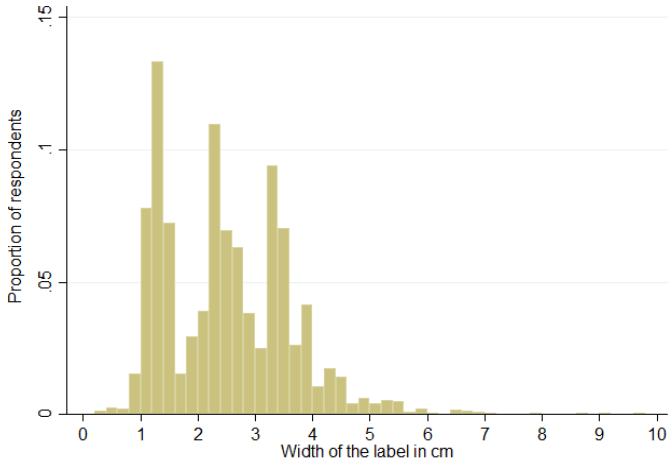
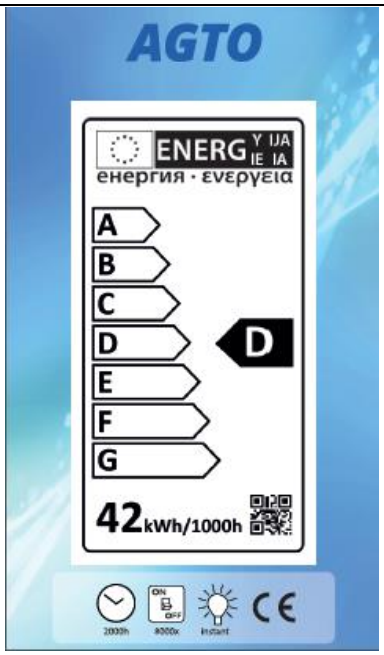
Small	Smaller	Smallest
		

Figure 2.4 Label size variations (actual size)



The two colour variations are displayed in Figure 2.5. For each of the three different sizes of the full label, there was a colour and a black-and-white variant.

Figure 2.5 Colour variations

Colour	Black-and-white
	

Finally, the three small label variations (including one in which this label is absent) are displayed in Figure 2.6.

Figure 2.6 Small label variations

Absent	Present (simple)	Present (detailed)
		

2.1.2. Part B: Post-experiment questionnaire

The experiment was complemented with a post-experiment questionnaire to measure relevant person-related information. This included: (1) experience with buying light bulbs (including how recent the last purchase was), (2) type of store in which the

consumer buys light bulbs (online or regular; lighting, hardware or general store), (3) self-reported use of energy information and reasons thereof, (4) self-reported product category expertise (e.g., "I know a great deal about light bulbs"), (5) concern for the environment (e.g., "In my daily activities, I am conscious about saving energy") and (6) socio-demographics (financial situation, education, work status, gender and age).

2.2. Sampling

2.2.1. Country sample

The experiment was carried out in 5 Member States: Germany, Italy, Portugal, Romania and Sweden. Table 2.2 shows the details per country for relevant country characteristics. This selection included:

- A coverage of **35.7% of the EU-28 population** with adequate geographical spread. The sample included countries from all European **regions**, with one Nordic-European country, one Western-European country, two Southern-European countries, and one Eastern-European country;
- One country with a relatively low level of **consumer concern for the environment**, two with an average level of concern and two with a relatively high level of concern. The selection also included two countries where there has been a big (positive) change in this figure since 2011, one where the change has been around average and two where there has been little or no change since 2011;
- One country with a high percentage of households with **broadband Internet**, two with a low broadband rate and two with an average rate;
- Three countries with low **consumer empowerment** and two countries with a high level of consumer empowerment;
- Two countries with a low **GDP/capita**, one country with an average GDP/capita and two countries with a high GDP/capita.

Table 2.2 Country sample

Country code	Population	Region	Concern for the environment 2014	Change in concern for the environment 2011-2014)	Broadband internet at home (2015)	Consumer empowerment	GDP per capita
	%		Percentage	Percentage	Percentage	Level	Level
DE	15.9%	West	54%	25%	88%	17.3	124
IT	11.8%	South	59%	31%	74%	13.5	96
PT	2.1%	South	42%	0%	69%	13.7	78
RO	4%	East	65%	34%	65%	11.1	55
SE	1.9%	North	56%	16%	83%	17.0	123
EU-28	100%		55%	26%	80%	15.0	100

2.2.2. Respondent sample

The total sample consisted of **5,015 respondents** (approximately 1,000 respondents per country). The sample consisted of members of the general public aged 18-70, nationally representative of each country's population with quotas on age and gender. Sample characteristics are displayed in Table 2.3.

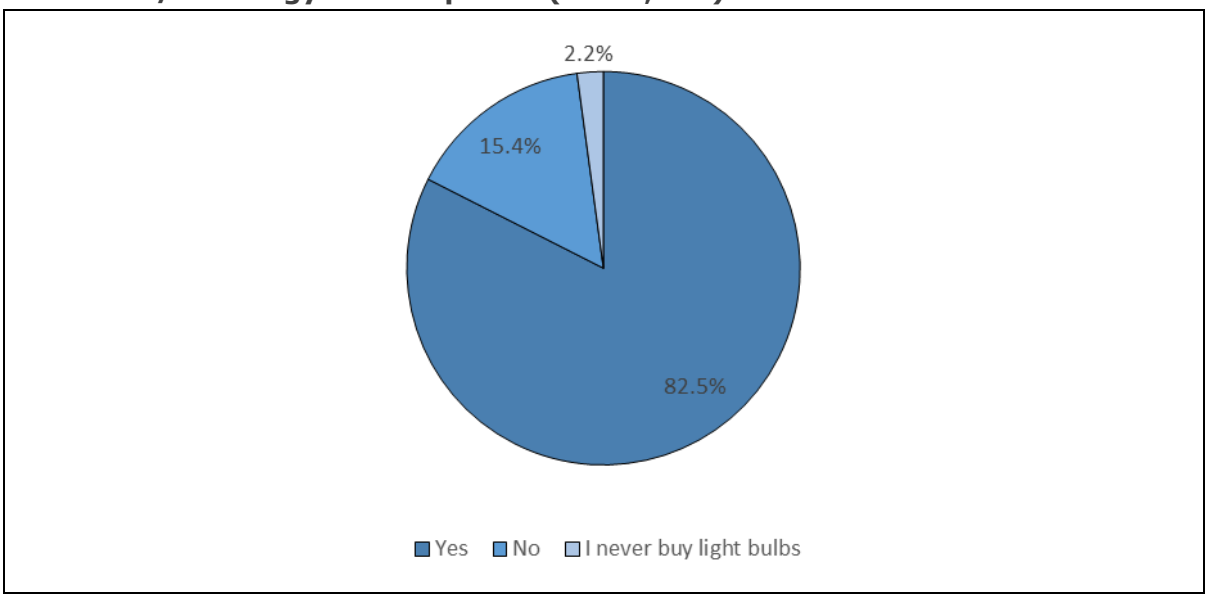
Table 2.3 Sample characteristics

	DE	IT	PT	RO	SE	Total
Male	49.8%	50.7%	50.7%	51.1%	48.5%	50.2%
Female	50.2%	49.3%	49.3%	48.9%	51.5%	49.8%
Age: < 34	27.7%	29.5%	29.0%	26.3%	32.0%	28.9%
Age: 35-54	42.9%	47.7%	45.8%	44.0%	39.0%	43.8%
Age: > 55	29.4%	22.8%	25.3%	29.7%	29.1%	27.3%
Education: elementary school or less	0.3%	3.0%	1.1%	0.4%	7.0%	2.4%
Education: some high school	12.3%	6.1%	5.8%	1.2%	7.0%	6.5%
Education: graduated from high school	44.3%	50.3%	37.7%	30.8%	38.7%	40.4%
Education: graduated from college / university	30.3%	31.2%	36.3%	44.6%	30.1%	34.5%
Education: post-graduate degree	8.1%	6.3%	15.5%	21.3%	9.0%	12.0%
Education: other	4.7%	3.1%	3.6%	1.7%	8.1%	4.2%
Financial situation[10]	4.0	4.2	3.8	3.4	4.8	4.03
Product category expertise[11]	3.8	4.5	3.9	4.4	3.2	4.0
Concern for the environment[12]	5.3	5.7	5.7	5.8	4.7	5.4

Most respondents had experience with buying light bulbs, as only 2.2% (*n* = 108) indicated that they never bought light bulbs. Out of all 5,015 respondents, 82.5% indicated that when buying light bulbs, they paid attention to energy class and/or energy consumption (see Figure 2.7). The main reason for this was to save money on the energy bill (72.0%), followed by wanting to protect the environment (26.1%). Out of the 4,907 respondents who had experience with buying light bulbs, 34.9% had last bought a light bulb less than a month ago, 54.6% between a month and a year ago and 10.6% more than a year ago. As to where respondents bought light bulbs, 13.9% indicated doing so in an online store and 90.3% in a regular store.[13] The type of store was a lighting store for 34.8% of respondents, a hardware store for 31.8% of respondents and a general store (e.g., supermarket) for 57.0% of respondents.[14]

[10] Financial situation ("Thinking about your household's financial situation, would you say that making ends meet every month is…") was measured on a 5-point scale ranging from 1 = *very difficult* to 5 = *very easy*.
[11] Product category expertise ("I know a great deal about light bulbs" and "I know more about light bulbs than most other people", correlation = .83) was measured on a 7-point scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*.
[12] Concern for the environment ("In my daily activities, I am conscious about saving energy" and "I am worried about the environment", correlation = .55) was measured on a 7-point scale ranging from 1 = *strongly disagree* to 7 = *strongly agree*.
[13] Multiple answers possible (so respondents could also indicate buying light bulbs in both online and regular stores).
[14] Multiple answers possible.

Figure 2.7 When buying a new light bulb, do you pay attention to energy class and/or energy consumption? (*N* = 5,015)



3. Results and recommendations

In this chapter, we first take a brief look at the choice shares for the light bulbs per choice set. Next, we describe the results of the main analyses, in which we examined whether there were differences across the size, colour and arrow conditions in choice and understanding. We divided the analyses in two parts. First, we examined effects of the size and colour of the label. Next, we examined effects of the label arrow, including whether this label would compensate for any reductions in the effectiveness of the label caused by a black-and-white full label. The chapter ends with conclusions and recommendations.

Table 3.1 provides an overview of the responses per choice set. It shows that in each set, between 23-29% of respondents chose the light bulb with the highest energy class out of eight light bulbs. Moreover, when explicitly asked to identify the light bulb with the highest energy class, a majority of respondents (70-73%) was able to do so. The same conclusion could not be drawn for energy consumption, however. When asked to identify the light bulb with the lowest energy consumption, only 25-33% of respondents was able to do so in choice sets 1 and 2. Instead, the largest group (40-42%) chose the light bulb with the highest energy class. Set 3 was an exception, as the light bulb with the lowest energy consumption was also the light bulb with the highest energy class, which may be why a majority of respondents (66.4%) was able to identify the correct light bulb in that set. Thus, when asked to identify the "best" light bulb in terms of energy *consumption*, many respondents chose the "best" light bulb in terms of energy *class*. These results suggest that for many consumers, it is difficult to understand the difference between energy class and energy consumption. They seem to equate a high energy class to a low energy consumption.

Table 3.1 Responses per choice set (*N* = 5,015)

	Choice	**Understanding energy class**	**Understanding energy consumption**	
	% that chose light bulb with best energy class	% that selected light bulb with best energy class (correct answer)	% that selected light bulb with lowest energy consumption (correct answer)	% that selected light bulb with best energy class (false answer)
Choice set 1	26.8%	70.9%	33.0%	41.3%
Choice set 2	23.5%	70.4%	25.8%	40.9%
Choice set 3	28.6%	72.4%	66.4%*	66.4%*

*Same light bulb (in set 3, the light bulb with the lowest energy consumption was also the light bulb with the highest energy class).

3.1. Size and colour of the label

To investigate effects of the size and colour of the label, we focused on 3 size variations (small, smaller, smallest) × 2 colour variations (colour, black-and-white).[15]

[15] Conditions 1-6 in Table 2.1. In the main analyses, we accounted for the nested structure of the data (sets within respondents within countries).

We first examined effects of the size and colour variations on choice. Percentages of respondents choosing the light bulb with energy class A are displayed in Table 3.2. There were significant differences in choice across the three size variations.[16] When the size of the energy label was small, 27.8% of respondents chose the light bulb with energy class A. However, when the size of the energy label became smaller, fewer respondents chose the light bulb with energy class A[17] (25.5% for the smaller variation and 19.6% for the smallest variation, also a significant difference[18]). Thus, decreasing the size of the label resulted in fewer choices of the light bulb with energy class A, and the *more* the size decreased, the fewer respondents chose the light bulb with the highest energy class.

As for the colour of the label, there was only a marginally significant difference. Compared to the coloured label (25.3%), slightly fewer respondents chose the light bulb with the highest energy class when the label was presented in black-and-white (23.3%).[19] The effect of the colour of the label did not depend on the size of the label.[20] In other words, the effect of the colour of the label was similar for the three label sizes (small, smaller, smallest).

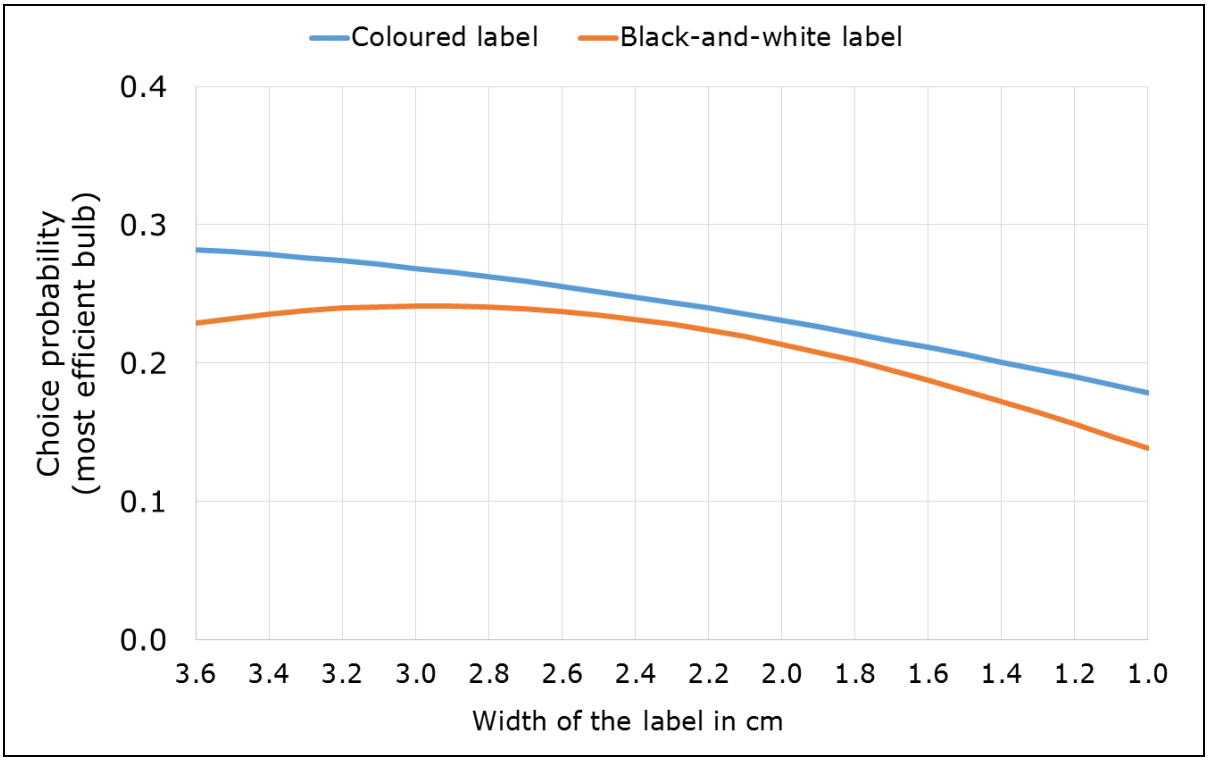
Table 3.2 Choice: Percentages of respondents choosing the light bulb with energy class A (*N* = 9,015 observations)

	Colour	Black-and-white	Total
Small	28.5%	27.0%	27.8%
Smaller	26.9%	24.0%	25.5%
Smallest	20.5%	18.8%	19.6%
Total	25.3%	23.3%	24.3%

Because we also had information on the exact size in which respondents had seen the product packages (see footnote 9) – from which we could derive the size of the energy label – we repeated the analysis with the actual label size as a predictor instead of the three size categories (Figure 3.1). We examined linear as well as curvilinear (quadratic) effects of actual label size, to allow for the possibility that effectiveness of the label remains stable with initial decreases in sizes to eventually fall with further decreases in size. The analysis revealed a similar effect of label size: The more size decreased, the fewer respondents chose the light bulb with the highest energy class. The energy label lost effectiveness with each reduction in size, starting from the current standard label width of 3.6 cm (linear downward trend) [21]. This time, there was no significant effect of the colour of the label, nor did the effect of colour of the label depend on the size of the label.[22]

[16] $p < .001$ (p-value of the main effect of size)
[17] $p < .001$ (p-value of contrast 1: small vs. two smaller size variants)
[18] $p < .001$ (p-value of contrast 2: smaller vs. smallest)
[19] $p = .091$ (p-value of the main effect of colour)
[20] $p = .899$ (p-value of the size × colour interaction effect)
[21] $p < .001$ (p-value of the main effect of actual label size as a continuous predictor); there was no quadratic effect of label size: $p = .122$.
[22] $ps > .427$ (p-values of the main effect of colour and the interactions with label size (both linear and quadratic))

Figure 3.1 Choice: Results with actual label size as a predictor



Next, we examined effects of size and colour of the energy label on understanding. First, we measured whether respondents were able to identify the light bulb with the highest energy class. Percentages of respondents being able to do so are displayed in Table 3.3. There were significant differences in understanding across the three size variations.[23] When the size of the energy label was small, 72.5% of respondents correctly selected the light bulb with the highest energy class. However, when the size of the energy label became smaller, fewer respondents were able to identify the correct light bulb[24] (69.6% for the smaller variation and 63.4% for the smallest variation, also a significant difference[25]). Thus, decreasing the size of the label resulted in a lower understanding, and the *more* the size decreased, the fewer respondents were able to identify the light bulb with the highest energy class.

There was no significant effect of the colour of the label on understanding of the energy efficiency class.[26] Thus, for understanding, it did not seem to matter whether the label was presented in colour or in black-and-white. However, the effect of the colour of the label depended on the size of the label.[27] When the label was small (the typical label), understanding was not influenced by whether the label was presented in colour (73.6%) or in black-and-white (71.3%).[28] Contrary to expectations, when the label was smaller, understanding was marginally significantly higher when the label was presented in black-and-white (71.8%) than when it was presented in colour

[23] $p < .001$ (p-value of the main effect of size)
[24] $p < .001$ (p-value of contrast 1: small vs. two smaller size variants)
[25] $p < .001$ (p-value of contrast 2: smaller vs. smallest)
[26] $p = .244$ (p-value of the main effect of colour)
[27] $p = .003$ (p-value of the size × colour interaction effect)
[28] $p = .225$ (p-value of the (simple) effect of colour for the small label size)

(67.4%).[29] However, for the smallest label, understanding was significantly lower when the label was presented in black-and-white (60.2%) than when it was presented in colour (66.5%).[30] Thus, only for the smallest label did we find that understanding was lower when the label was presented in black-and-white compared to colour. A potential reason for this is that on the smallest label, it is difficult to read the letter on the arrow. However, apart from the letter on the arrow (and the position of the arrow), the *colour* also indicates the energy class of the light bulb. When respondents could rely less on reading the letter indicating the energy class, they may have relied more on the colour, which they could do when the label was presented in colour (but not when it was presented in black-and-white).

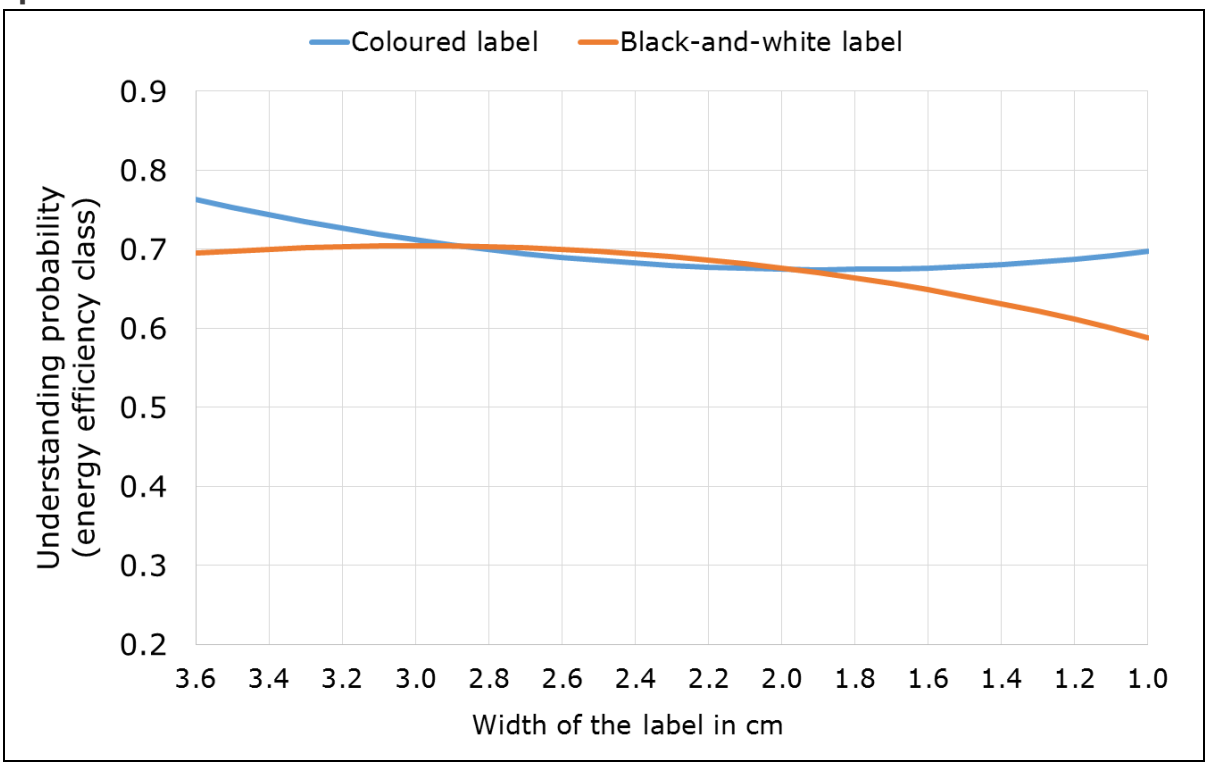
Table 3.3 Understanding: Percentages of respondents correctly identifying the light bulb with the highest energy class (*N* = 9,015 observations)

	Colour	Black-and-white	Total
Small	73.6%	71.3%	72.5%
Smaller	67.4%	71.8%	69.6%
Smallest	66.5%	60.2%	63.4%
Total	69.2%	67.8%	68.5%

Again, we repeated the analysis with the actual label size as predictor (Figure 3.2). In line with the previous results, the analysis revealed a significant effect of label size: The more the label decreased, the fewer respondents were able to identify the light bulb with the highest energy class (linear downward trend[31]). Again, there was no significant effect of the colour of the label[32], but the effect of colour did depend on label size[33]. For most sizes, there was no difference between the coloured and black-and-white version of the energy label on understanding. However, as in the previous analysis, for very small sizes (below 1.6 cm[34]), understanding was significantly lower when the label was presented in black-and-white than when it was presented in colour.

[29] p = .051 (p-value of the (simple) effect of colour for the smaller label size). However, this effect was not repeated in the analysis with actual label size as a predictor (see Figure 3.2), where this difference remained nonsignificant.
[30] p = .006 (p-value of the (simple) effect of colour for the smallest label size)
[31] p = .001 (p-value of the main effect of actual label size as a predictor); there was no quadratic effect of label size: p = .952.
[32] p = .690
[33] That is, the quadratic effect of label size interacted with colour of the label: p = .046; p-value of the interaction effect of colour with the linear effect of label size: p = .285.
[34] 1 cm was an exception, possibly caused by too few observations of 1 cm.

Figure 3.2 Understanding energy class: Results with actual label size as predictor



Another measure of understanding pertained to the energy consumption part on the label. Percentages of respondents correctly identifying the light bulb with the lowest energy consumption are displayed in Table 3.4. There were significant differences in understanding across the three size variations.[35] When the size of the energy label was small, 46.1% of respondents correctly identified the light bulb with the highest energy class. However, when the size of the energy label became smaller, fewer respondents were able to identify the correct light bulb[36] (39.5% for the smaller variation and 36.8% for the smallest variation, a marginally significant difference[37]). Again, decreasing the size of the label resulted in a lower understanding.

There was no significant effect of the colour of the label understanding.[38] This time, the effect of colour also did not depend on the size of the label.[39] Thus, for being able to identify the product with the lowest energy consumption, it did not matter whether the label was presented in colour or in black-and-white.

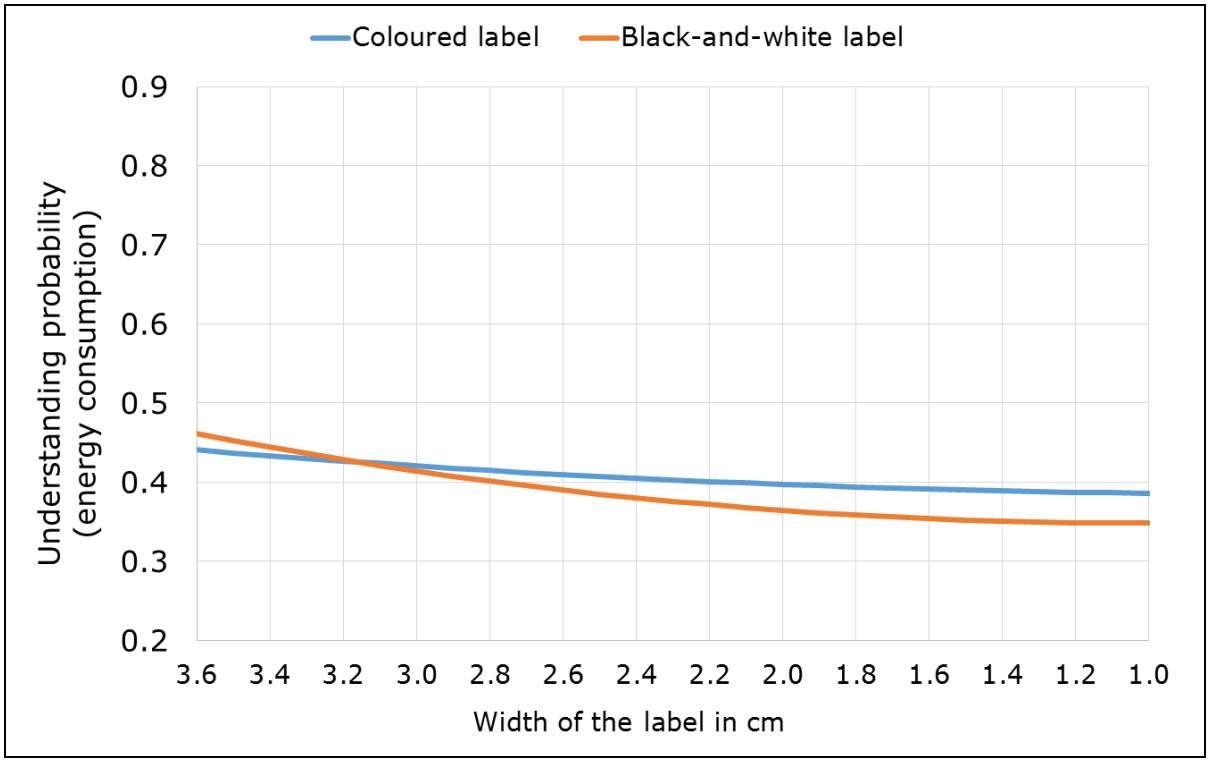
[35] $p < .001$ (p-value of the main effect of size)
[36] $p < .001$ (p-value of contrast 1: small vs. two smaller size variants)
[37] $p = .077$ (p-value of contrast 2: smaller vs. smallest)
[38] $p = .323$ (p-value of the main effect of colour)
[39] $p = .402$ (p-value of the size × colour interaction effect)

Table 3.4 Understanding: Percentages of respondents correctly identifying the light bulb with the lowest energy consumption (*N* = 9,015 observations)

	Colour	Black-and-white	Total
Small	46.3%	45.8%	46.1%
Smaller	39.2%	39.8%	39.5%
Smallest	38.4%	35.2%	36.8%
Total	41.3%	40.3%	40.8%

Again, we repeated the analysis with the actual label size (linear and curvilinear trends) rather than the three size categories as predictor (Figure 3.3). In line with the previous results, the analysis revealed a significant effect of label size: The more the label decreased, the fewer respondents were able to identify the light bulb with the lowest energy consumption (linear downward trend[40]). Also in line with the previous results, there was no significant effect of the colour of the label, nor did the effect of colour of the label depend on the size of the label.[41]

Figure 3.3 Understanding energy consumption: Results with actual label size as predictor



Finally, we investigated whether respondents' (self-reported) expertise with the product as well as respondents' environmental concern influenced effects on choice. The analyses revealed that, as might be expected, respondents with a higher self-reported expertise with the product[42] and respondents with a higher environmental

[40] p = .001 (p-value of the main effect of actual label size as a predictor); there was no quadratic effect of label size: p = .395.
[41] ps > .210 (p-values of the main effect of colour and the interactions with label size (both linear and quadratic))
[42] p < .001 (p-value of the main effect of expertise with the product)

concern[43] were more likely to choose the product with the highest energy efficiency class. However, none of the effects (size, colour and size × colour) was influenced by expertise and/or environmental concern.[44]

3.2. Label arrow and colour of the label

To investigate effects of the label arrow and colour of the label, we focused on 3 label arrow variations on the front of the package (absent, simple, detailed) × 2 colour variations of the full label on the back (colour, black-and-white).[45]

We first examined effects of the label arrow and colour of the energy label on choice. Percentages of respondents choosing the light bulb with energy class A are displayed in Table 3.5. There was no significant effect the presence and type of label arrow on choice.[46] There was also no significant effect of the colour of the label on choice[47], nor did the effect of colour on choice depend on the presence and type of label arrow.[48] Thus, for respondents' choices, it did not matter whether the front of the package contained a label arrow and/or whether the label on the back of the package was presented in colour or in black-and-white.

Table 3.5 Choice: Percentages of respondents choosing the light bulb with energy class A (*N* = 9,048 observations)

	Colour	Black-and-white	Total
Label arrow absent	28.5%	27.0%	27.8%
Simple label arrow	29.6%	30.8%	30.2%
Detailed label arrow	28.7%	27.9%	28.3%
Total	28.9%	28.6%	28.8%

Next, we examined effects of the label arrow and colour of the energy label on understanding. First, we measured whether respondents were able to identify the light bulb with the highest energy class. Percentages of respondents being able to do so are displayed in Table 3.6. There were marginally significant differences in understanding across the three label arrow variations.[49] When the label arrow was absent, 72.5% of respondents correctly identified the light bulb with energy class A. However, when a label arrow was present on the front of the package, understanding significantly increased.[50] The type of label did not influence understanding (75.3% for the simple label and 75.4% for the detailed label).[51] Thus, the presence of a label arrow on the front of the package allowed for a slightly better understanding of which light bulb contained the highest energy class.

[43] $p < .001$ (p-value of the main effect of environmental concern)
[44] That is, these variables did not interact with size and/or colour and there was also no three-way interaction effect (size × colour × expertise / environmental concern), all *p*s > .10.
[45] Conditions 7-10 as well as 1 and 4 (these last two were also used in the previous analyses) in Table 2.1. In the main analyses, we accounted for the nested structure of the data (sets within respondents within countries).
[46] $p = .291$ (p-value of the main effect of label arrow)
[47] $p = .758$ (p-value of the main effect of colour)
[48] $p = .604$ (p-value of the label arrow × colour interaction effect)
[49] $p = .080$ (p-value of the main effect of label arrow)
[50] $p = .025$ (p-value of contrast 1 (presence): label arrow absent vs. present)
[51] $p = .991$ (p-value of contrast 2 (type): simple vs. detailed label arrow)

There was a marginally significant effect of the colour of the label on understanding of the energy efficiency class.[52] Respondents were slightly worse at identifying the light bulb with the highest energy class when the energy label on the back of the package was presented in black-and-white (73.4%) than when it was presented in colour (75.4%). However, the effect of colour on understanding marginally significantly depended on the label arrow variations.[53] Only when the label arrow was detailed did understanding lower when the energy label on the back of the package was presented in black-and-white (72.6%) compared to when it was presented in colour (78.2%).[54] When the label arrow was absent[55] or simple[56], the colour of the full label did not influence understanding. It is not clear what caused this difference. Possibly, the presence of the same (but much smaller) energy scale on the detailed label arrow as on the coloured full energy label on the back of the package reminded respondents to take a look at the full energy label. They may have only looked in more detail when this scale indeed turned out to be the (same) coloured scale.

Table 3.6 Understanding: Percentages of respondents correctly identifying the light bulb with the highest energy class (*N* = 9,048 observations)

	Colour	Black-and-white	Total
Label arrow absent	73.6%	71.3%	72.5%
Simple label arrow	74.3%	76.3%	75.3%
Detailed label arrow	78.2%	72.6%	75.4%
Total	75.4%	73.4%	74.4%

Another measure of understanding pertained to the energy consumption part on the label. Percentages of respondents correctly identifying the light bulb with the lowest energy consumption are displayed in Table 3.7. There were marginally significant differences in understanding across the three label arrow variations.[57] When the label arrow was absent, 46.1% of respondents correctly identified the light bulb with the lowest energy consumption. However, when a label arrow was present on the front of the package, understanding significantly *decreased*.[58] The type of label did not influence understanding (43.0% for the simple label and 43.4% for the detailed label).[59] A potential reason for the decrease in understanding is that the arrow label contains the energy *class* (energy efficiency), not the energy consumption. This may have moved respondents to choose the light bulb with energy class A instead of looking at the full label on the back of the package, which contains the energy consumption. Indeed, at the start of the results chapter we already saw that the largest group of respondents was inclined to incorrectly choose the light bulb with the highest energy efficiency when asked to choose the light bulb with the highest energy consumption. The presence of a label arrow that matches this inclination may have inadvertently moved respondents further in the wrong direction.

[52] p = .062 (p-value of the main effect of colour)
[53] p = .053 (p-value of the label arrow × colour interaction effect)
[54] p = .007 (p-value of the (simple) effect of colour for the detailed label arrow)
[55] p = .209 (p-value of the (simple) effect of colour for the label arrow absent)
[56] p = .474 (p-value of the (simple) effect of colour for the simple label arrow)
[57] p = .093 (p-value of the main effect of label arrow)
[58] p = .030 (p-value of contrast 1 (presence): label arrow absent vs. present)
[59] p = .870 (p-value of contrast 2 (type): simple vs. detailed label arrow)

There was no significant effect of the colour of the label on understanding of the energy consumption.[60] The effect of colour also did not depend on the presence and type of the label arrow.[61] Thus, for being able to identify the product with the lowest energy consumption, it did not matter whether the full energy label was presented in colour or in black-and-white.

Table 3.7 Understanding: Percentages of respondents correctly identifying the light bulb with the lowest energy consumption (*N* = 9,048 observations)

	Colour	Black-and-white	Total
Label arrow absent	46.4%	45.8%	46.1%
Simple label arrow	42.1%	44.0%	43.0%
Detailed label arrow	43.8%	42.9%	43.4%
Total	44.1%	44.2%	44.2%

Finally, we investigated whether respondents' (self-reported) expertise with the product as well as respondents' environmental concern influenced effects on choice. The analyses again revealed that respondents with a higher self-reported expertise with the product[62] and respondents with a higher environmental concern[63] were more likely to choose the product with the highest energy efficiency class. However, none of the effects (label arrow, colour and label arrow × colour) was influenced by expertise and/or environmental concern.[64]

3.3. Conclusions and recommendations

We investigated effects of size, colour and the presence of a label arrow on choice and understanding. Below, we discuss the conclusions and recommendations per research question.

RQ1. How small can the full label be (1) without losing effectiveness and (2) ensuring the workability of the QR-code?

We investigated the size of the energy label in two ways. First, we varied the size of the label, showing respondents one of three size variations (small, smaller, smallest). Because the actual size in which respondents saw the energy label also depended on screen size and resolution, we controlled for this in our analyses (see footnote 9). Second, we computed the actual size in which respondents had seen the energy label, and repeated the analyses with the actual label size instead of the three label variations. Both types of analyses revealed the same conclusions: Decreasing the size of the label resulted in fewer choices for the light bulb with the highest energy class and a lower understanding of both energy class and energy consumption. The energy label instantly started losing effectiveness when the size of the label became smaller

[60] p = .931 (p-value of the main effect of colour)
[61] p = .578 (p-value of the label arrow × colour interaction effect)
[62] p < .001 (p-value of the main effect of expertise with the product)
[63] p < .001 (p-value of the main effect of environmental concern)
[64] That is, these variables did not interact with label arrow and/or colour and there was also no three-way interaction effect (label arrow × colour × expertise / environmental concern), all ps > .10.

than the current minimum size of 6.2-7.5 cm (H) x 3.6 cm (W). We therefore recommend to not decrease the size of the energy label on light bulb packages.

RQ2. Is a black-and-white label as effective as a coloured label?

For the colour of the label, the results were less straightforward. In some analyses, we found a difference between the coloured and the black-and-white label (with the coloured label usually being more effective); in others, we did not. However, *if* there was a difference, it was very small and usually only marginally significant. Moreover, such differences were often not replicated in the analyses with actual label size (see previous paragraph). There was only one difference that was actually significant (not marginally significant) and found in *both* types of analyses with label size: We found that only for very small energy labels (with a width in the range of 1.0 to 1.6 cm), respondents were better able to identify the light bulb with the highest energy class when the label was presented in colour than when the label was presented in black-and-white. A potential reason for this is that on very small labels, it is difficult to read the letter in the arrow on the energy label. It is, however, still possible to see the colour of the arrow, and the colour also indicates the energy class. We advise against using such very small energy labels, though (see previous paragraph), and as long as the energy label does not become very small, there seem to be no large differences between the coloured and the black-and-white version. Thus, if the energy label is not reduced, we see no reason to advise against the use of the black-and-white version that is currently allowed.

RQ3. Is there an added value of adding a small label – a coloured arrow – on the front of packages? Can such a label compensate for any reductions in the effectiveness of the label caused by a black-and-white full label?

Finally, we examined effects of adding a small label arrow on the front of the package. Apart from the presence (vs. absence) of this label arrow, we compared two different types: a simple and a more detailed label arrow. Contrary to expectations, the presence of a label arrow did not influence respondents' choices. Thus, presenting the energy class on the front of the package did not result in more choices for the light bulb with the highest energy class. The presence of the label arrow did have small effects on understanding. When asked to identify the light bulb with the highest energy class (that is, with energy class A), slightly more respondents were able to do so when the label arrow was present. However, when asked to identify the light bulb with the lowest energy consumption (that is, with the lowest kWh/1000h), slightly *fewer* respondents were able to do so when the label arrow – containing the energy *class* – was present. It seems that respondents confuse energy consumption with energy class, which is worsened by the presence of a label arrow containing the energy class. Overall, it seems that including a label arrow containing the energy class on the front of the package has no large beneficial effects but also no large detrimental effects. The only side effect seems to be that it focuses consumers more on the energy efficiency class (which is understood better), at the expense of energy consumption (which is understood worse).

Appendix: Questionnaire

Factors

The experiment contains three factors (F1, F2 and F3). Factor 1 consists of three levels, factor 2 consists of two levels and factor 3 consists of three levels. However, not all combinations of these three factors exist. In total, there are 10 combinations / conditions (see "hidden variables", X1).

Value of F1	Back of package: Size of the label
1	Typical
2	Smaller
3	Smallest

Value of F2	Back of package: Colour of the label
1	Colour
2	Black-and-white

Value of F3	Front of package: Label arrow
1	Absent
2	Type 1 (simple)
3	Type 2 (detailed)

Hidden variables

Information for programmer:
In total, there are 10 variants / conditions, which are shown under X1. Respondents are randomly assigned to one of these conditions. Importantly, respondents always stay in the same condition, so the condition only has to be assigned once.

Value of X1	Condition		
	F1 (Size)	F2 (Colour)	F3 (Label arrow)
1	1 (Typical)	1 (Colour)	1 (Absent)
2	2 (Smaller)	1 (Colour)	1 (Absent)
3	3 (Smallest)	1 (Colour)	1 (Absent)
4	1 (Typical)	2 (Black-and-white)	1 (Absent)
5	2 (Smaller)	2 (Black-and-white)	1 (Absent)
6	3 (Smallest)	2 (Black-and-white)	1 (Absent)
7	1 (Typical)	1 (Colour)	2 (Type 1 (simple))
8	1 (Typical)	1 (Colour)	3 (Type 2 (detailed))
9	1 (Typical)	2 (Black-and-white)	2 (Type 1 (simple))
10	1 (Typical)	2 (Black-and-white)	3 (Type 2 (detailed))

Information for programmer:
In the experiment, respondents see three different sets with products. The order in which they see the three sets should be randomized (X2).
There are also two sets of screens for which the order needs to be randomized (X3).

Value of X2	Order of the choice sets
1	Set 1, set 2, set 3
2	Set 1, set 3, set 2
3	Set 2, set 1, set 3
4	Set 2, set 3, set 1
5	Set 3, set 1, set 2
6	Set 3, set 2, set 1

Value of X3	Order of screens 3 and 4
1	Screens 3 first
2	Screens 4 first

Questionnaire

All respondents:
Screen 1 (general introduction)
This questionnaire is about the purchase of light bulbs. The questionnaire starts with questions on purchasing light bulbs, followed by more general questions.

All respondents:
Screen 2 (choice task)
Imagine that one of the light bulbs in the hallway of your house breaks. You find out that there are no replacements at home, and are now looking for new light bulbs for your hallway and to have in stock. You visit a regular store that sells all kinds of light bulbs. On the next screens, you will see a number of light bulbs that are available in this store (all with the type of fitting that you are looking for). On each screen, you will see eight light bulb packages, and are asked to indicate which of these packages you would choose. As in a real store, you will be able to turn around each package and inspect its back.

Information for programmer:
- *Which images are shown depends on the value of **X1**.*
- *Screens 2a-2c should be randomized, and which order is shown should be saved under **X2**.*

Screen 2a – set 1
Q1a. Please indicate which light bulb you would choose.
Click on the image to see the back of the package.

<set 1 – product 1>	*<set 1 – product 2>*	*<set 1 – product 3>*	*<set 1 – product 4>*
<set 1 – product 5>	*<set 1 – product 6>*	*<set 1 – product 7>*	*<set 1 – product 8>*

Screen 2b – set 2
Q1b. Please indicate which light bulb you would choose.
Click on the image to see the back of the package.

<set 2 – product 1>	*<set 2 – product 2>*	*<set 2 – product 3>*	*<set 2 – product 4>*
<set 2 – product 5>	*<set 2 – product 6>*	*<set 2 – product 7>*	*<set 2 – product 8>*

Screen 2c – set 3
Q1c. Please indicate which light bulb you would choose.
Click on the image to see the back of the package.

<set 3 – product 1>	*<set 3 – product 2>*	*<set 3 – product 3>*	*<set 3 – product 4>*
<set 3 – product 5>	*<set 3 – product 6>*	*<set 3 – product 7>*	*<set 3 – product 8>*

Information for programmer:
- *Screens 3 (3a, 3b, 3c) belong together and screens 4 (4a, 4b, 4c) belong together, but the order of screens 3 and 4 should be randomized. So, half of the respondents start with all the screens under "screen 3", and thereafter receive all the screens under "screen 4". The other half first receives all the screens under "screen 4", followed by all the screens under "screen 3". The order should be saved under **X3**.*
- *X1 and X2 stay the same across screens:*
  - *So, the images stay the same (X1 stays the same):*
    - *For screens 3a-3c, the exact same images should be shown as for screens 2a-2c.*
    - *For screens 4a-4c, the exact same images should be shown as for screens 2a-2c and 3a-3c.*
  - *And the order of the subscreens stays the same (X2 stays the same):*
    - *Screens 3a-3c should be shown in the same order as screens 2a-2c.*
    - *Screens 4a-4c should be shown in the same order as screens 2a-2c and 3a-3c.*

All respondents:
Screen 3 (understanding energy efficiency)
On the next screens, you will again see all the light bulbs. You will see eight light bulb packages on each screen, and will be asked to indicate which light bulb, according to you, has the best energy class.

Screen 3a – set 1
Q2a. Please indicate which light bulb, according to you, has the best energy class.
Click on the image to see the back of the package.

<set 1 – product 1>	*<set 1 – product 2>*	*<set 1 – product 3>*	*<set 1 – product 4>*
<set 1 – product 5>	*<set 1 – product 6>*	*<set 1 – product 7>*	*<set 1 – product 8>*

Screen 3b – set 2
Q2b. Please indicate which light bulb, according to you, has the best energy class.
Click on the image to see the back of the package.

<set 2 – product 1>	*<set 2 – product 2>*	*<set 2 – product 3>*	*<set 2 – product 4>*
<set 2 – product 5>	*<set 2 – product 6>*	*<set 2 – product 7>*	*<set 2 – product 8>*

Screen 3c – set 3
Q2c. Please indicate which light bulb, according to you, has the best energy class.
Click on the image to see the back of the package.

<set 3 – product 1>	*<set 3 – product 2>*	*<set 3 – product 3>*	*<set 3 – product 4>*
<set 3 – product 5>	*<set 3 – product 6>*	*<set 3 – product 7>*	*<set 3 – product 8>*

All respondents:
Screen 4 (understanding energy consumption)
On the next screens, you will again see all the light bulbs. You will see eight light bulb packages on each screen, and will be asked to indicate which light bulb, according to you, uses the least amount of energy. In other words, which light bulb would result in the lowest energy bill?

Screen 4a – set 1
Q3a. Please indicate which light bulb, according to you, uses the least amount of energy (results in the lowest energy bill).
Click on the image to see the back of the package.

<set 1 – product 1>	*<set 1 – product 2>*	*<set 1 – product 3>*	*<set 1 – product 4>*
<set 1 – product 5>	*<set 1 – product 6>*	*<set 1 – product 7>*	*<set 1 – product 8>*

Screen 4b – set 2
Q3b. Please indicate which light bulb, according to you, uses the least amount of energy (results in the lowest energy bill).
Click on the image to see the back of the package.

<set 2 – product 1>	*<set 2 – product 2>*	*<set 2 – product 3>*	*<set 2 – product 4>*
<set 2 – product 5>	*<set 2 – product 6>*	*<set 2 – product 7>*	*<set 2 – product 8>*

Screen 4c – set 3
Q3c. Please indicate which light bulb, according to you, uses the least amount of energy (results in the lowest energy bill).
Click on the image to see the back of the package.

<set 3 – product 1>	*<set 3 – product 2>*	*<set 3 – product 3>*	*<set 3 – product 4>*
<set 3 – product 5>	*<set 3 – product 6>*	*<set 3 – product 7>*	*<set 3 – product 8>*

All respondents:
Screen 5 (self-reported use of energy information and experience with purchasing light bulbs)
Q4. When buying a new light bulb, do you pay attention to energy class and/or energy consumption?
1 Yes
2 No
3 I never buy light bulbs

If Q4 = 1 (Yes):
Screen 6 (reason for paying attention to energy efficiency/energy consumption)
Q5. There are various reasons why people pay attention to energy class and/or energy consumption when buying a new light bulb. What would be the most important reason for you, personally?
1. I want to save money (a lower energy bill)
2. I want to help protect the environment and combat climate change
3. Other, namely…
4. I really don't know

If Q4 is NOT 3 (I never buy light bulbs):
Screen 7 (how recent they purchased a light bulb)
Q6. When was the last time you purchased a light bulb?
1. Less than a month ago
2. Between a month and one year ago
3. More than a year ago

If Q4 is NOT 3 (I never buy light bulbs):
Screen 8 (online vs. regular store)
Q7. Where do you buy light bulbs?
Multiple answers possible.
1. In an online store
2. In a regular store

If Q4 is NOT 3 (I never buy light bulbs):
Screen 9 (online vs. regular store)
Q8. In what type of store do you buy light bulbs?
Multiple answers possible.
1. In a lighting store
2. In a hardware store
3. In a general store (such as a supermarket)
4. Other, please specify: _____

All respondents:
Screen 10 (self-reported product category expertise and pro-environmental self-identity / environmental concern)
Q9. Please indicate how much you agree or disagree with the following statements.

		Strongly disagree						Strongly agree
Q9a	I know a great deal about light bulbs.	1	2	3	4	5	6	7
Q9b	I know more about light bulbs than most other people.	1	2	3	4	5	6	7
Q9c	In my daily activities, I am conscious about saving energy.	1	2	3	4	5	6	7
Q9d	I am worried about the environment.	1	2	3	4	5	6	7

All respondents:
Screen 11 (financial situation)
Q10. Thinking about your household's financial situation, would you say that making ends meet every month is:
1. Very difficult
2. Fairly difficult
3. Neither easy nor difficult
4. Fairly easy
5. Very easy
99. Don't know

All respondents:
Screen 12 (socio-demographics)
Q11. At what stage did you complete your full-time studies?
1. Elementary (primary) school or less
2. Some high (secondary) school
3. Graduation from high (secondary) school
4. Graduation from college, university or other third-level institute
5. Post-graduate degree (Masters, PhD) beyond your initial college degree
6. Still studying full-time
7. Other qualification
8. Refusal

Q12. Which of these best describe your current work status?
1. Self-employed
2. Manager
3. Other white collar
4. Blue collar
5. Student
6. House-person and other not in employment
7. Seeking a job
8. Retired

Q13. What is your gender?
1. Man
2. Woman

Q14. How old are you?