NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Using augmented reality to inform environmental decision making

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Contributors

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What is Augmented Reality?

"Augmented reality allows the user to see the real world, with virtual objects super-imposed upon or composited with the real world"[1]

"MediatedReality on iPhone2009 07 13 21 33 39" by Glogger - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - https://commons.wikimedia.org/wiki/File:MediatedReality_on_iPhone2009_07_13_21_33_39.jpg#/media/File:MediatedReality_on_iPhone2009_07_13_21_33_39.jpg

"Microsoft Windows Holographic" by Source (WP:NFCC#4). Licensed under Fair use via Wikipedia - https://en.wikipedia.org/wiki/File:Microsoft_Windows_Holographic.png#/media/File:Microsoft_Windows_Holographic.png

Smartphone App

1. Azuma, Ronald T. 1997. "A Survey of Augmented Reality." *MIT Presence* 6 (4): 355–85.

Why Did We Choose Augmented Reality?

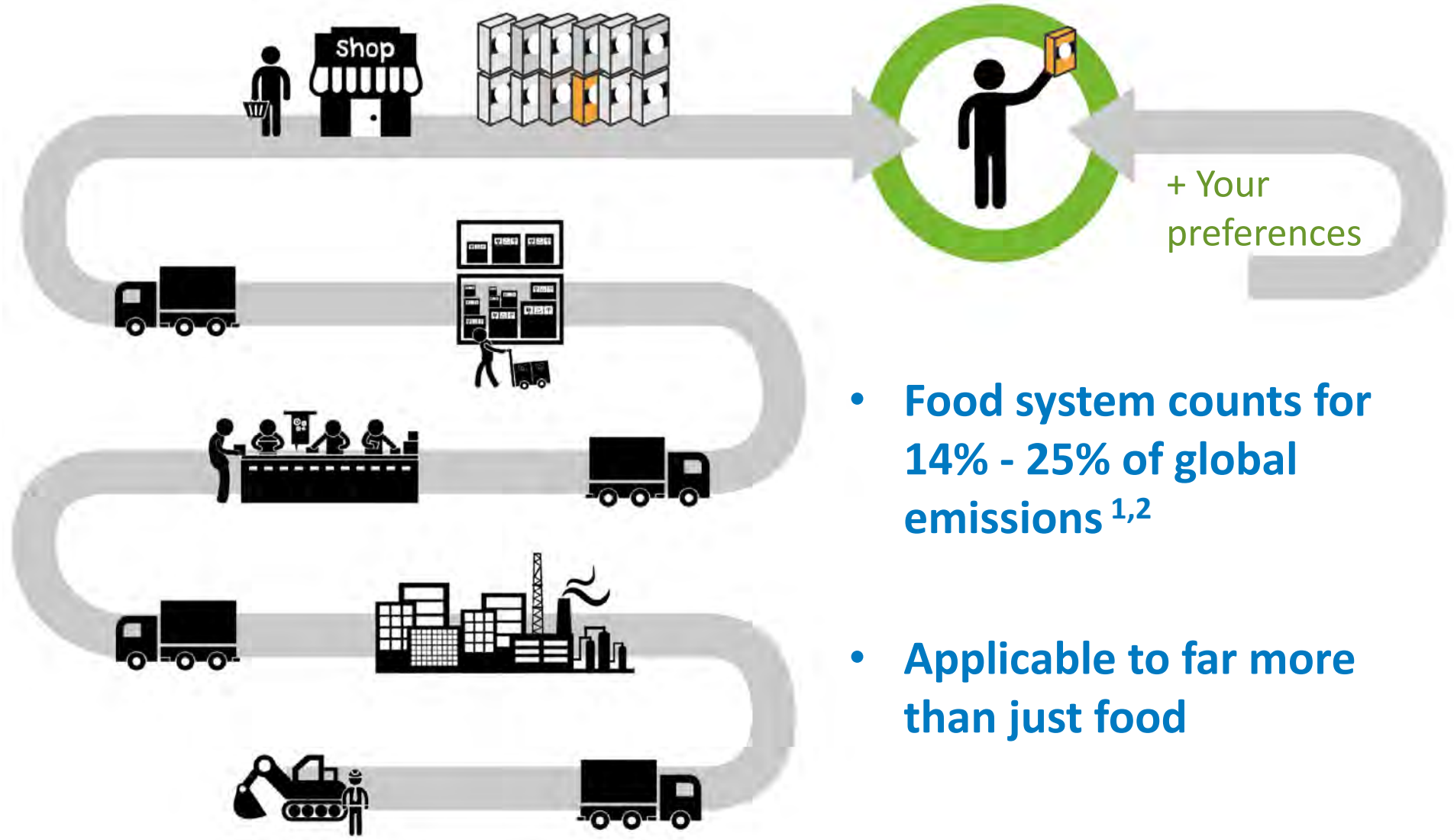
Addresses Limitations of…

- Information
- Cognition
- Time

New Capabilities…

- Contextual
- Personalized
- Consumer-Focused

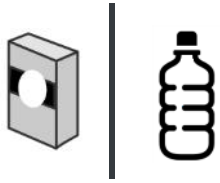
Each product has a unique supply chain

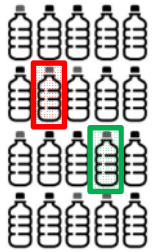


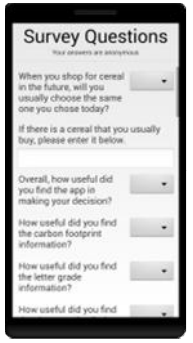
- **Food system counts for 14% - 25% of global emissions [1,2]**
- **Applicable to far more than just food**

1. IPCC 4th Assessment Report
2. Cook et al. 2014. "Standing on the Sidelines." *Oxfam Briefing Paper*.

Experimental Details







Recruitment	Randomization	Preference Elicitation	Non-AR Product Choice	AR Product Choice	Finish
• Actual shoppers • 126 people (54% female) • 9 days • Avg Age: 40	• Randomized to use app on <u>water</u> OR <u>cereal</u> • BUT, had to choose one of each	• Included 17 cereal and 5 water attributes • Carbon footprint always included	• Makes non-augmented reality choice first • Serves as control group	• Uses app to make next product choice	• Survey, 25 questions • $20 payment • Had to purchase goods

App Demonstration Movie

NREL's Augmented Reality App Screen Capture

Cereal Demonstration

Display Design

Far View – General
(scanning from greater than 2 ft.)

Near View – Specific
(scanning from less than 2 ft.)

Water Results

Outcome	Selected	Change	p value
Carbon	-	-24.0%	**0.009***
Price per Liter	51%	-1.0%	0.892
Bottle Size	56%	0.2%	0.948

Large change in Carbon

No change in other attributes

Participants chose much lower carbon intensity products

Cereal Results

Outcome	Selected	Change	p value
Fiber	59%	47%	**0.014***
Sugar	54%	-32%	**0.0003***
Fat	37%	-15%	**0.023***
Ingredients	32%	-15%	**0.012***
Calories	43%	-11%	0.052
Sodium	40%	-9.8%	**0.037***
Price per Serving	40%	7.1%	0.24
Protein	59%	4.8%	0.66
Carbon	-	-3.5%	0.44

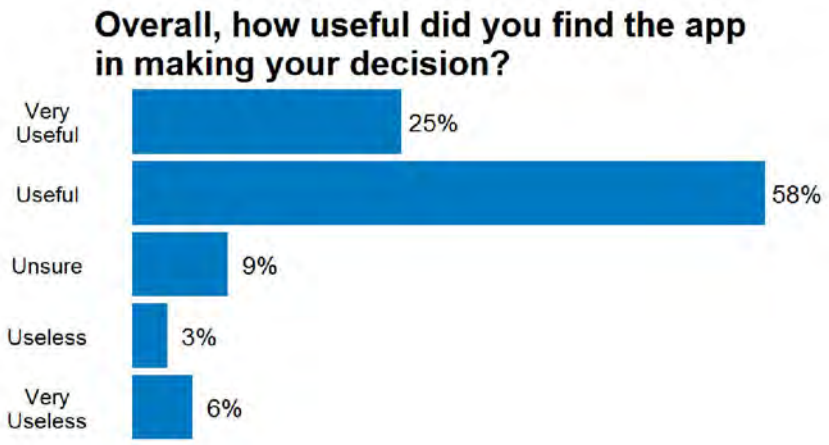
Large changes in Fiber, Sugar, Sodium, Fat and Ingredient Count

Marginal change in Calories

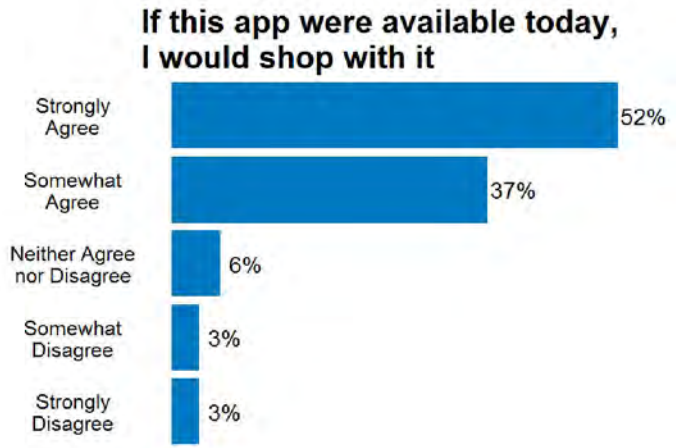
No change in Carbon

Participants chose nutrition over carbon for cereal

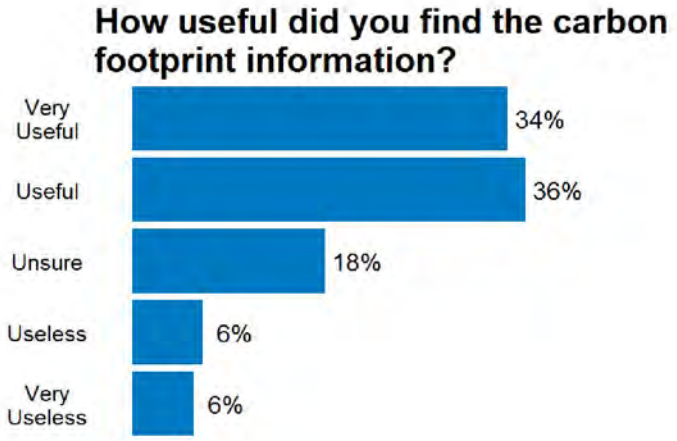
Select Survey Results



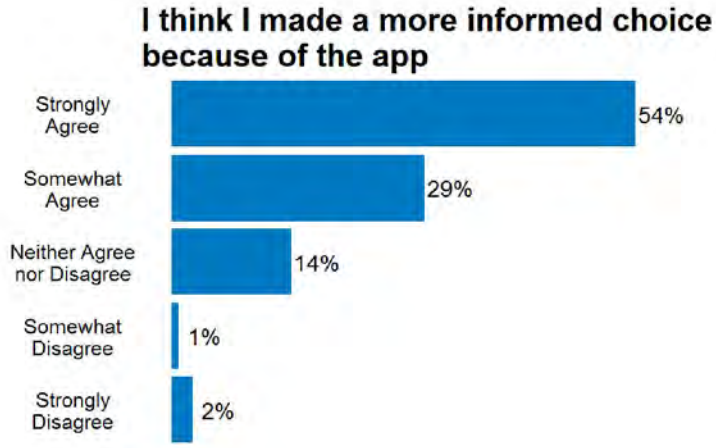
83% found the app useful



89% said they would shop with the app



70% found the carbon information useful



83% made a more informed choice

Summary

Questions?
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Find me afterwards to:

- Try the app yourself
- Learn more about how we designed the near/far displays
- See more data

How It Works

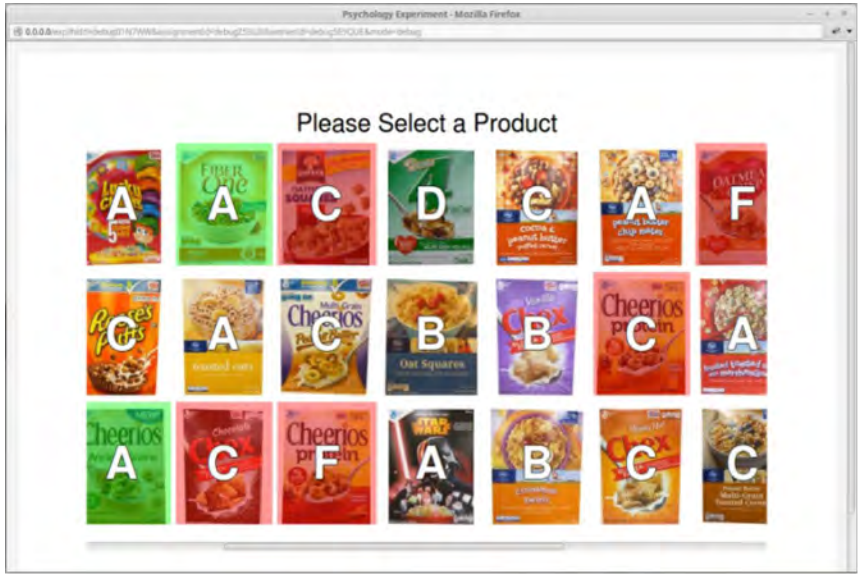
- Uses the Vuforia Augmented Reality library for object recognition
- OpenGL ES for drawing displays

Designing the Far View Display

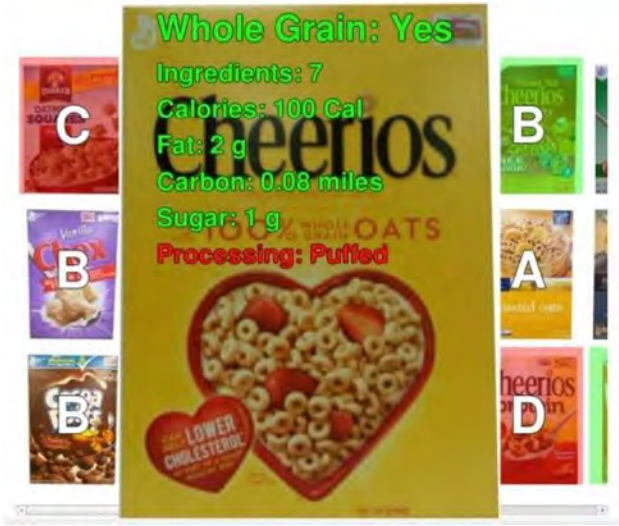
6 different display types

Avg. Carbon Intensity (g/serving)	33.5	32.3	29.9	29.5	29.3	28.3
						-16%

amazon mechanical turk
Artificial Artificial Intelligence

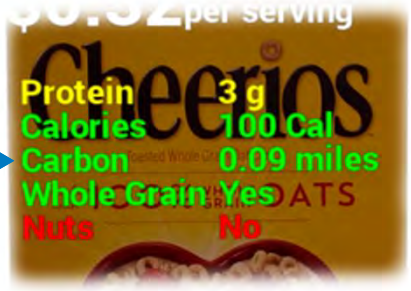


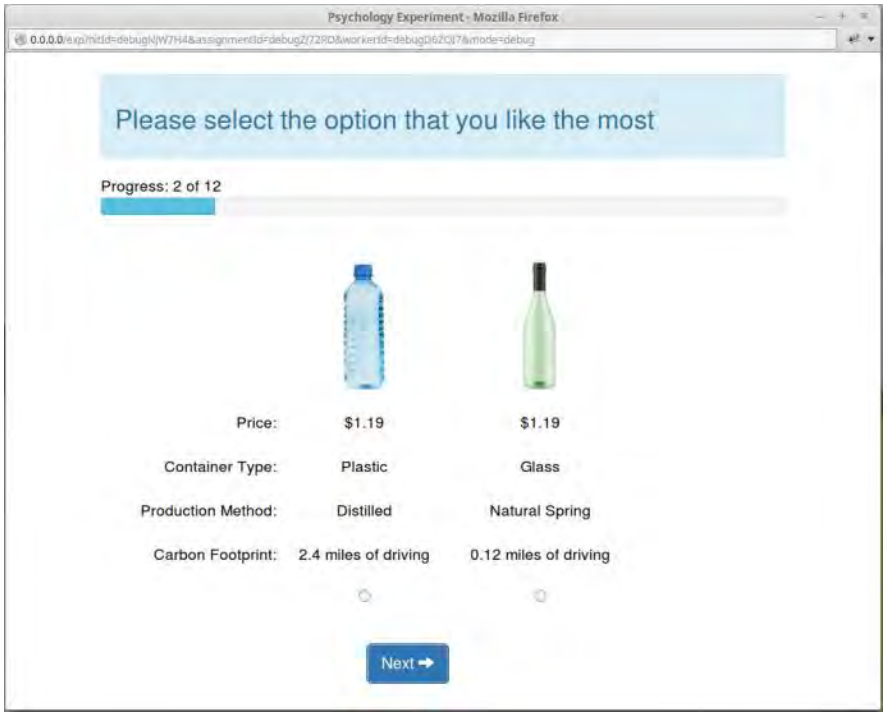
On Click

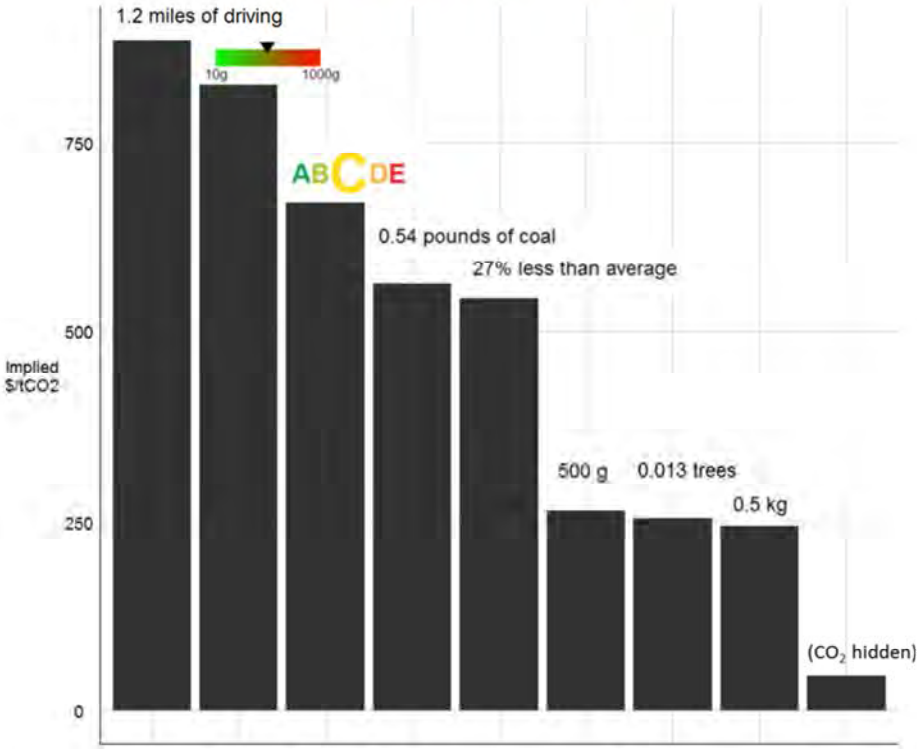


Designing the Near View Display

Why did we express carbon in “miles driven”?



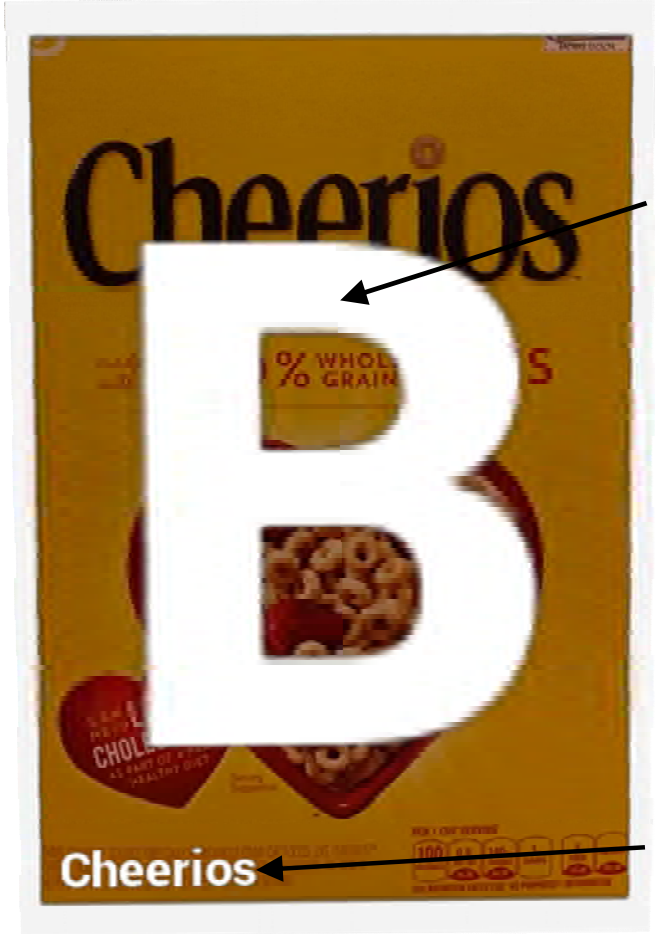




Source code available upon request

Final Display

Far View -> General



Personalized letter grade

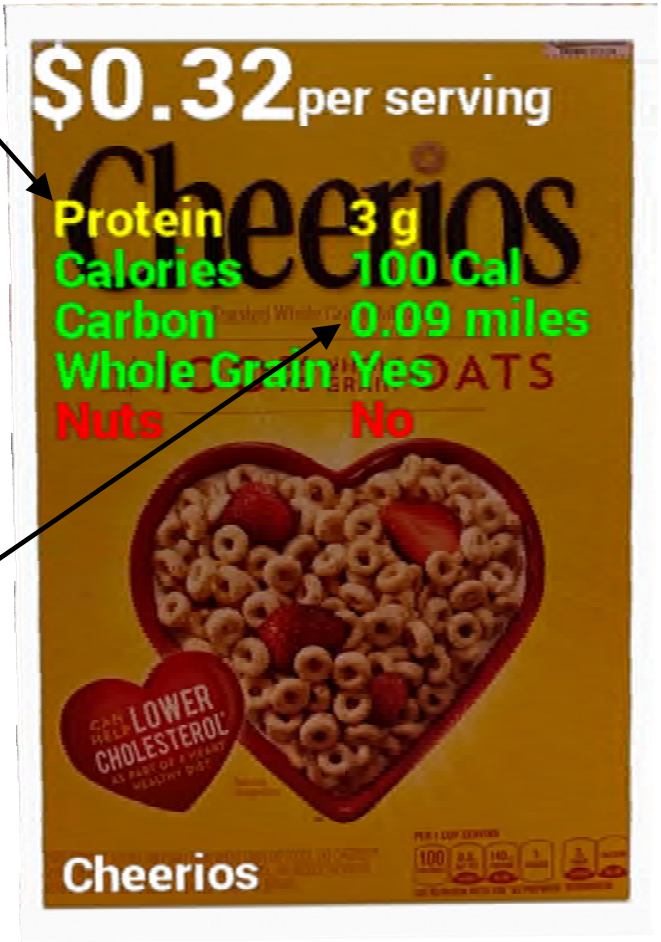
Product name shown for credibility

Near View -> Specific

Color denotes value relative to alternatives

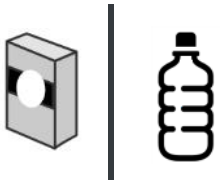
Attributes chosen and ranked from preference survey

Carbon translated to "miles driven"



What Did We Do?

Field Experiment, Major Grocer



Cereal and Water

Personalized Display

Included Carbon Footprint

Preference Elicitation

"SMARTER" Technique for Eliciting Preferences (Edwards & Barron 1994)

1 2 3

Attribute Selection Results

Cereal Attributes

Attribute	Selected	Median	% +
Fiber	59%	3.0	95%
Protein	59%	4.0	100%
Sugar	54%	3.0	5.9%
Grain	52%	5.0	-
Whole Grain	49%	4.0	-
Calories	43%	3.0	11%
Price per Serving	40%	3.0	0%
Sodium	40%	3.0	0%
GMO	40%	3.0	-
Fat	37%	5.0	0%
Ingredients	32%	3.5	0%
Fruit	24%	5.0	-
Gluten	17%	5.0	-
Nuts	16%	6.5	-
Processing	16%	4.5	-
Chocolate	13%	8.5	-
Soy	6.3%	6.5	-

Water Attributes

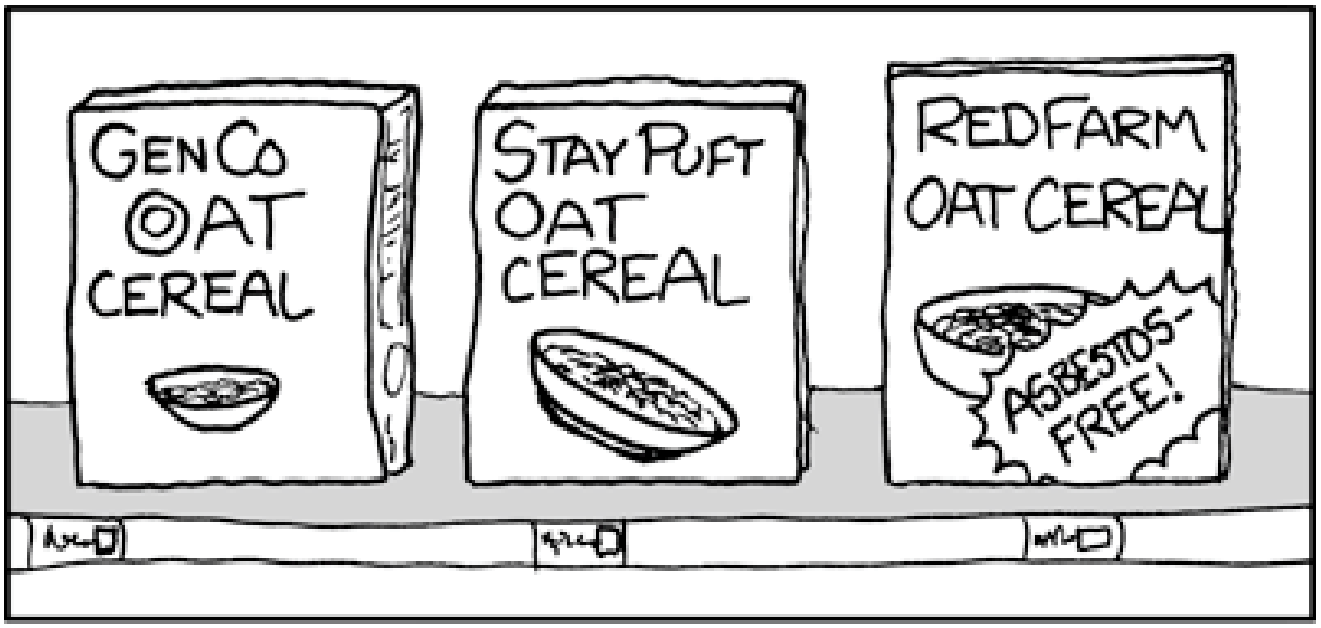
Attribute	Selected	Median	% +
Source	62%	2	-
Bottle Size	56%	2	66%
Price per Liter	51%	2	0%
Bottle Material	44%	2	-
Cap	21%	3	-

Average number of attributes chosen:

- Cereal: 6.4
- Water: 2.9

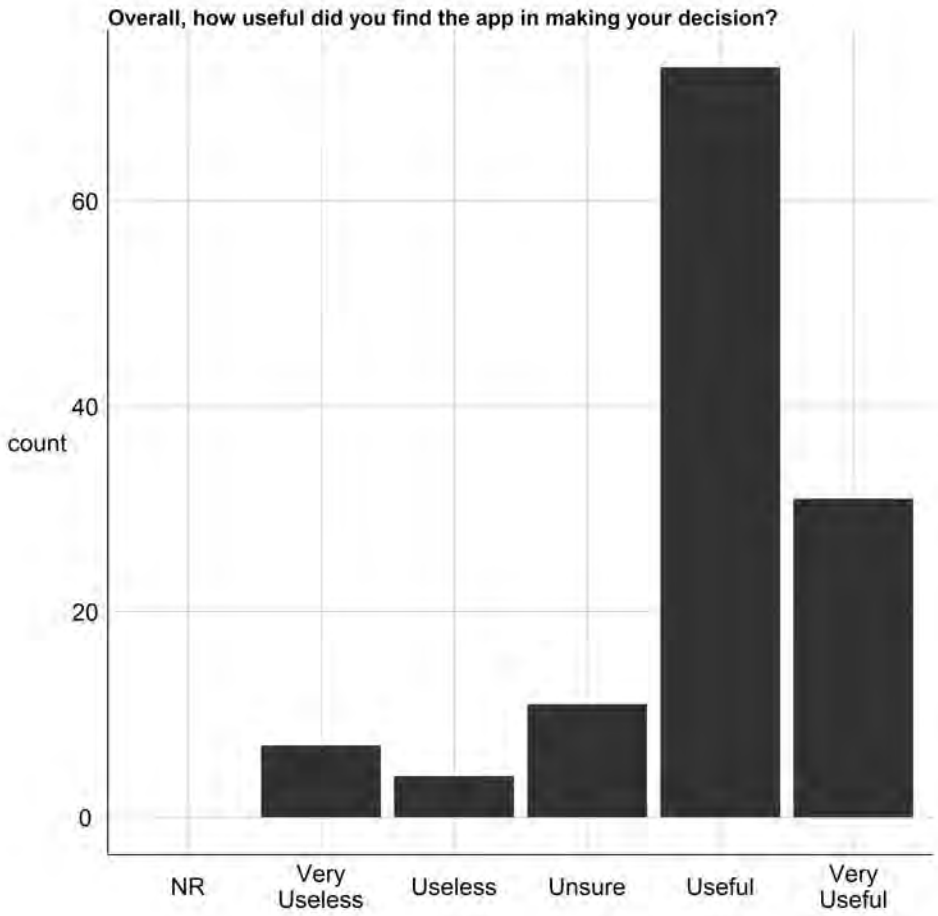
- %+ is the percent of participants who chose the item and wanted a larger value
- Median is median rank for the attribute when it was chosen

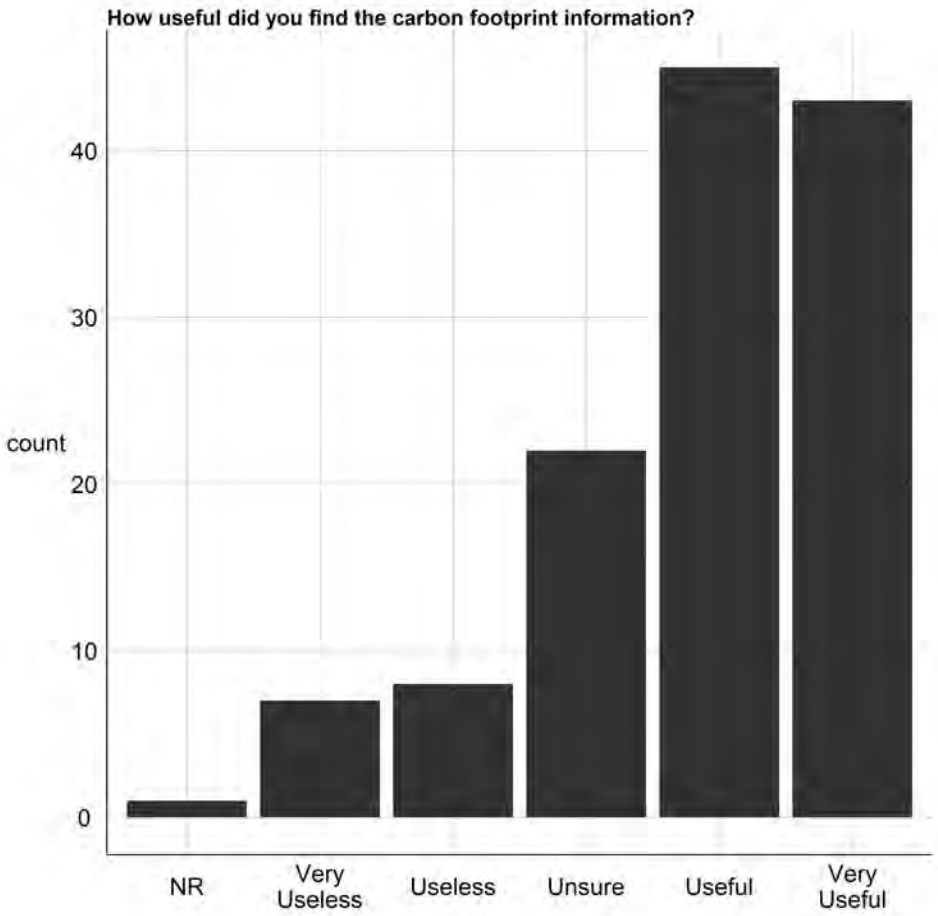
Consumer-Focused vs. Producer-Focused

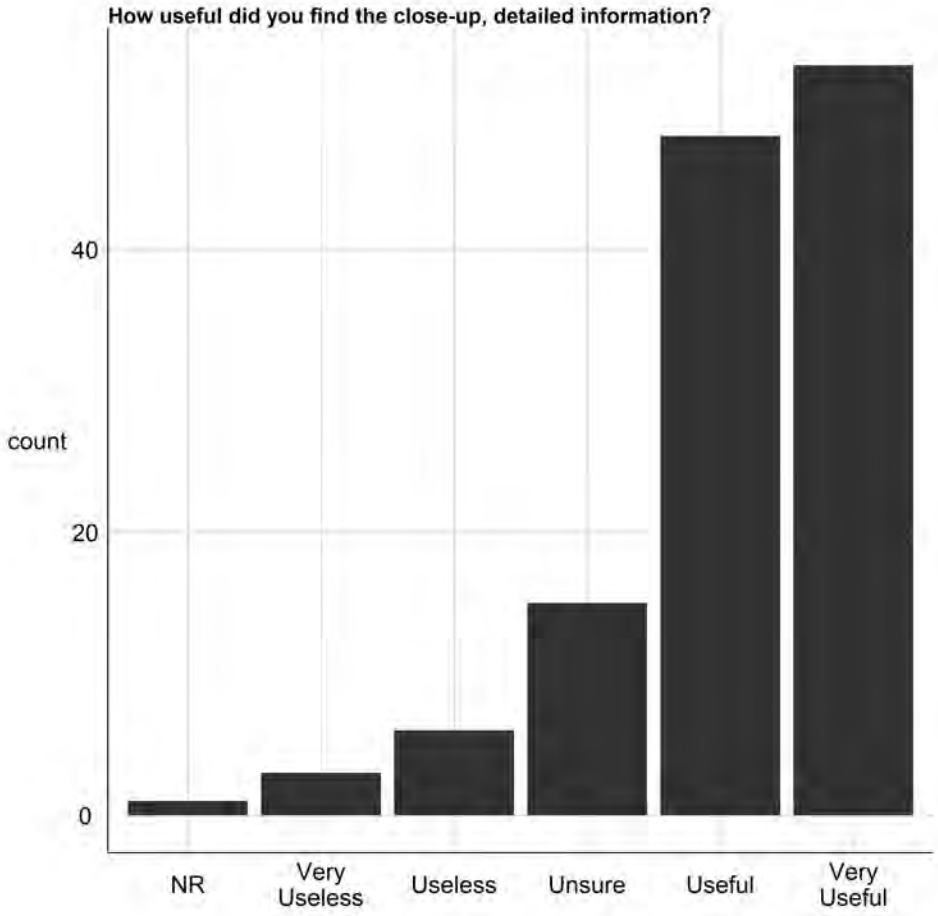


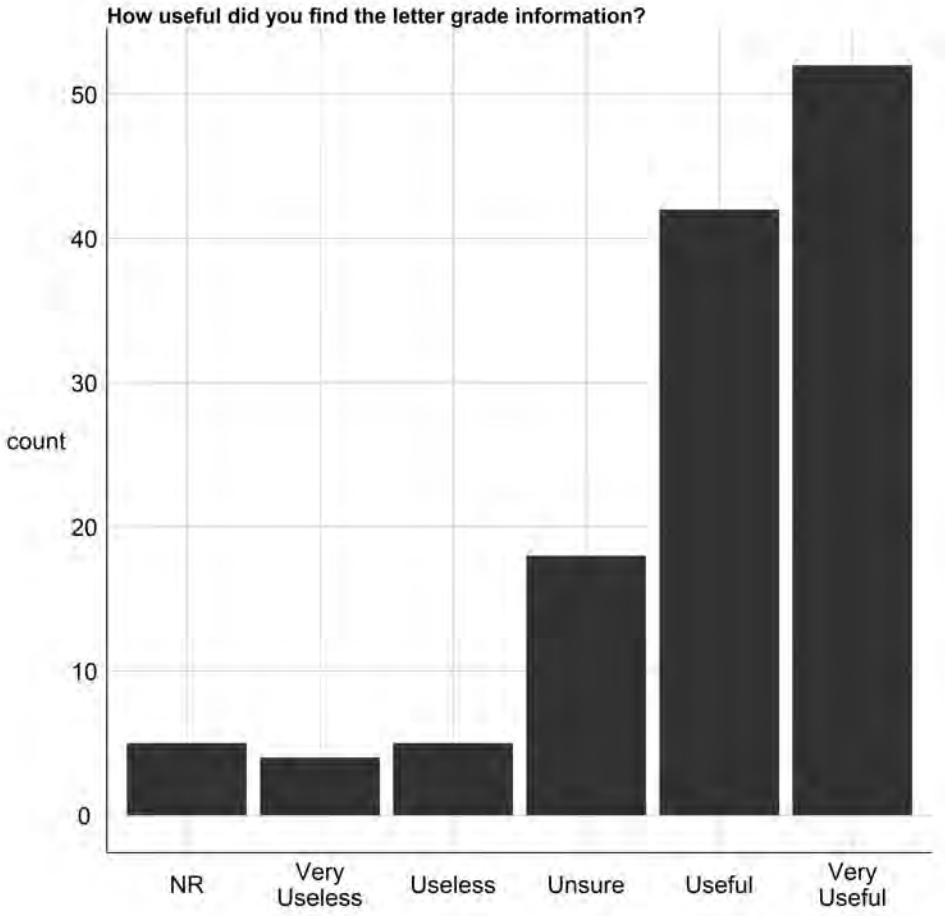
I HATE WHATEVER MARKETER FIRST REALIZED YOU COULD DO THIS.

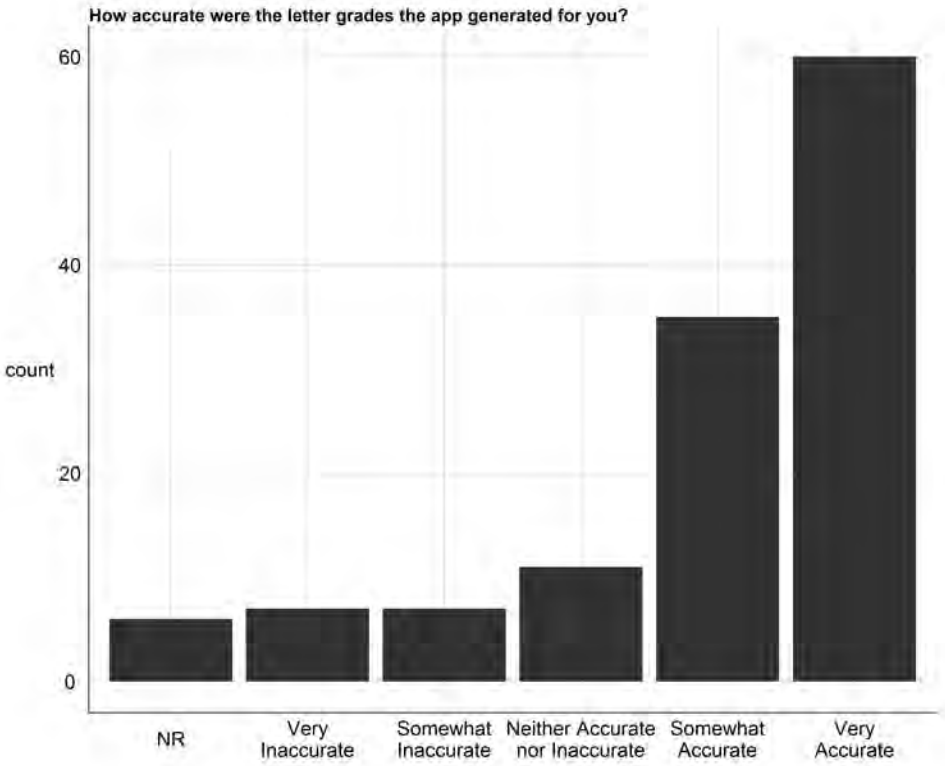
http://xkcd.com/641/

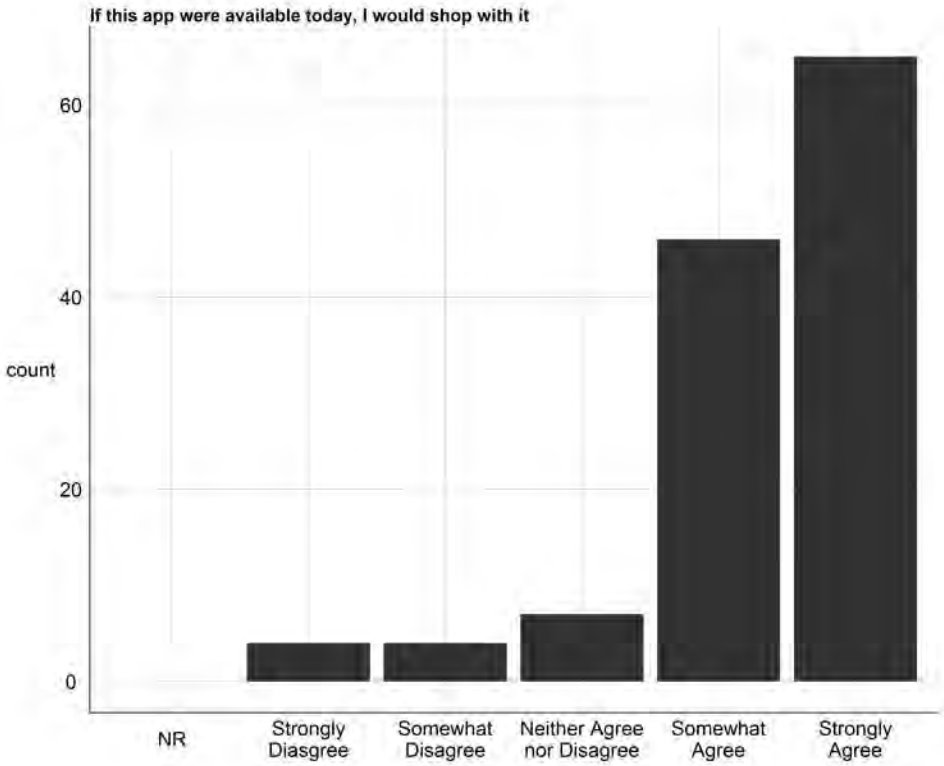

Overall, how useful did you find the app in making your decision?
count
60
40
20
0
NR
Very Useless
Useless
Unsure
Useful
Very Useful

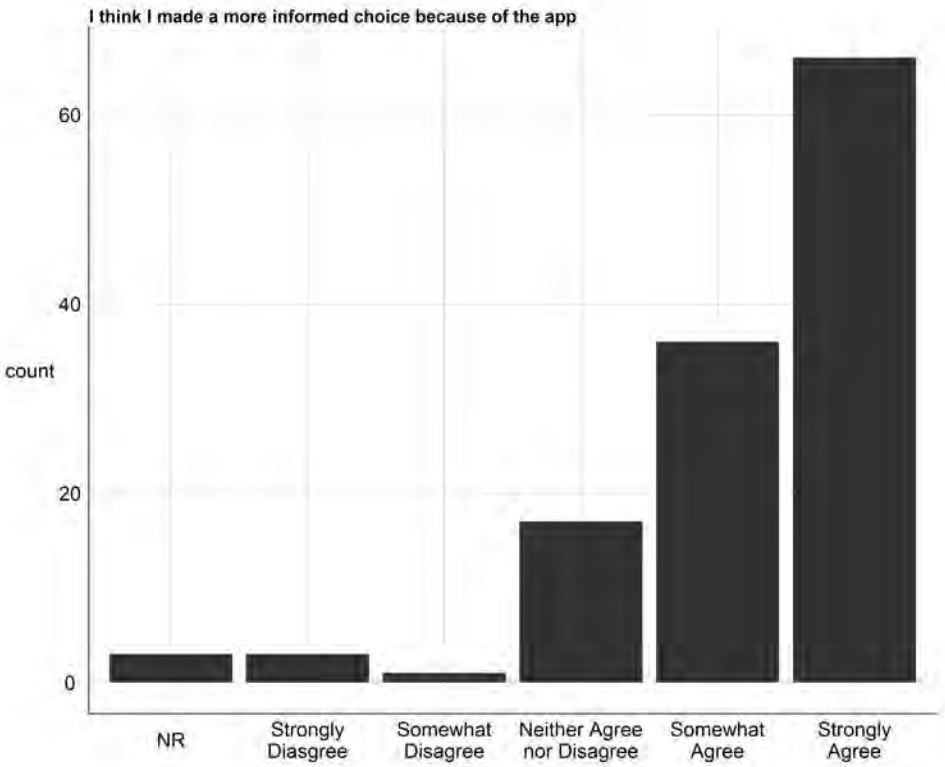

How useful did you find the carbon footprint information?
count
40
30
20
10
0
NR
Very Useless
Useless
Unsure
Useful
Very Useful

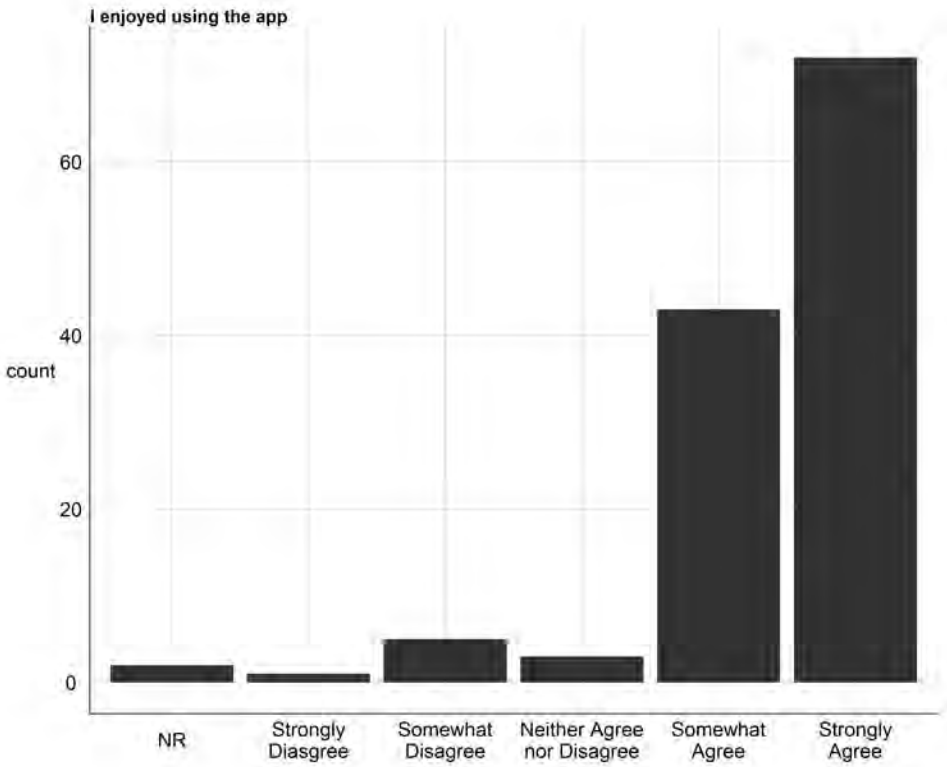

How useful did you find the close-up, detailed information?
count
0
20
40
NR
Very Useless
Useless
Unsure
Useful
Very Useful

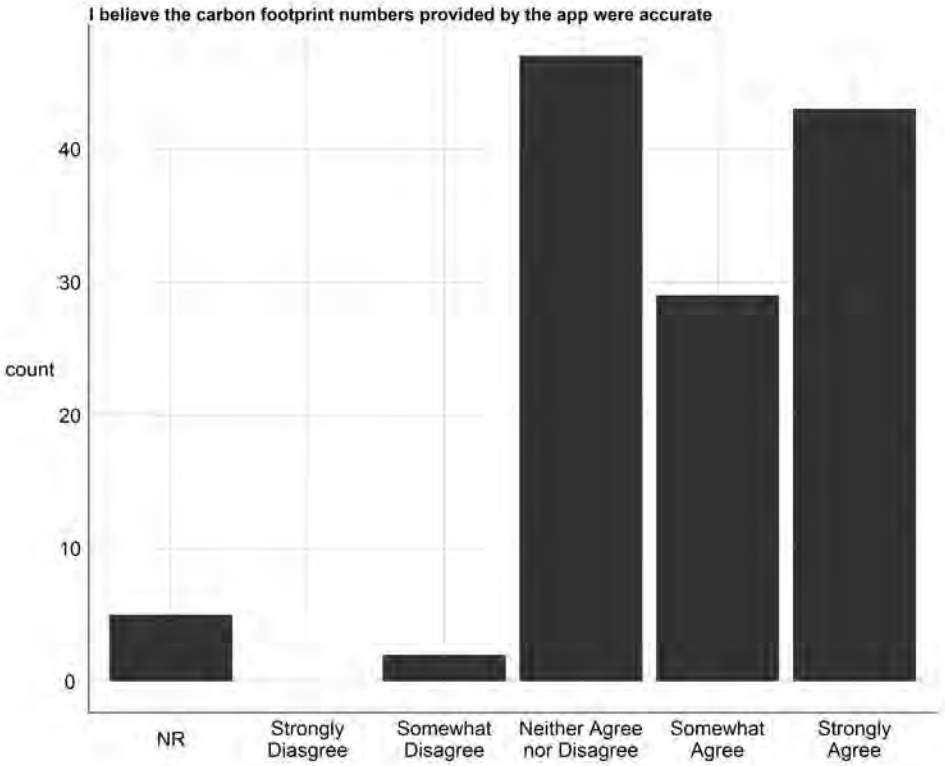

How useful did you find the letter grade information?
count
0
10
20
30
40
50
NR
Very Useless
Useless
Unsure
Useful
Very Useful

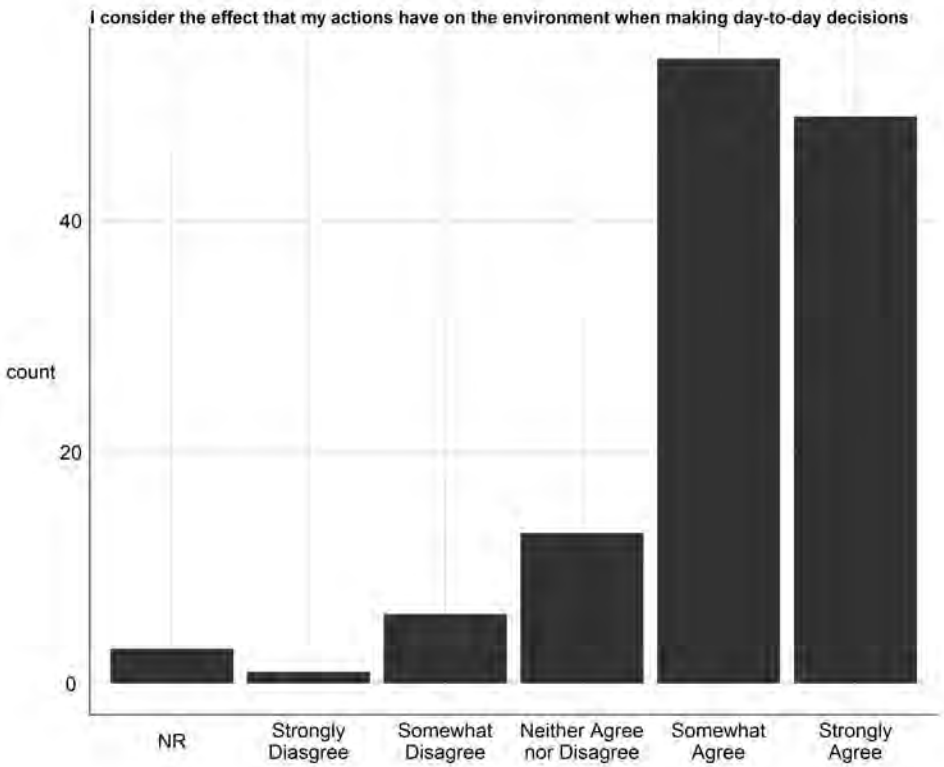

How accurate were the letter grades the app generated for you?
count
60
40
20
0
NR
Very Inaccurate
Somewhat Inaccurate
Neither Accurate nor Inaccurate
Somewhat Accurate
Very Accurate

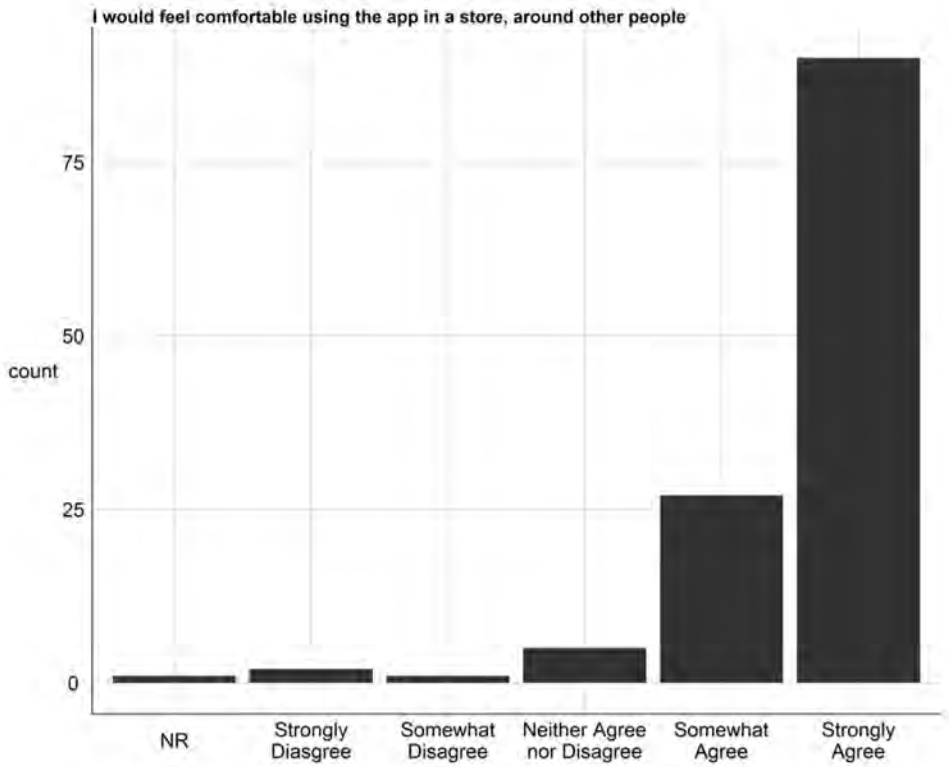

If this app were available today, I would shop with it
count
60
40
20
0
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

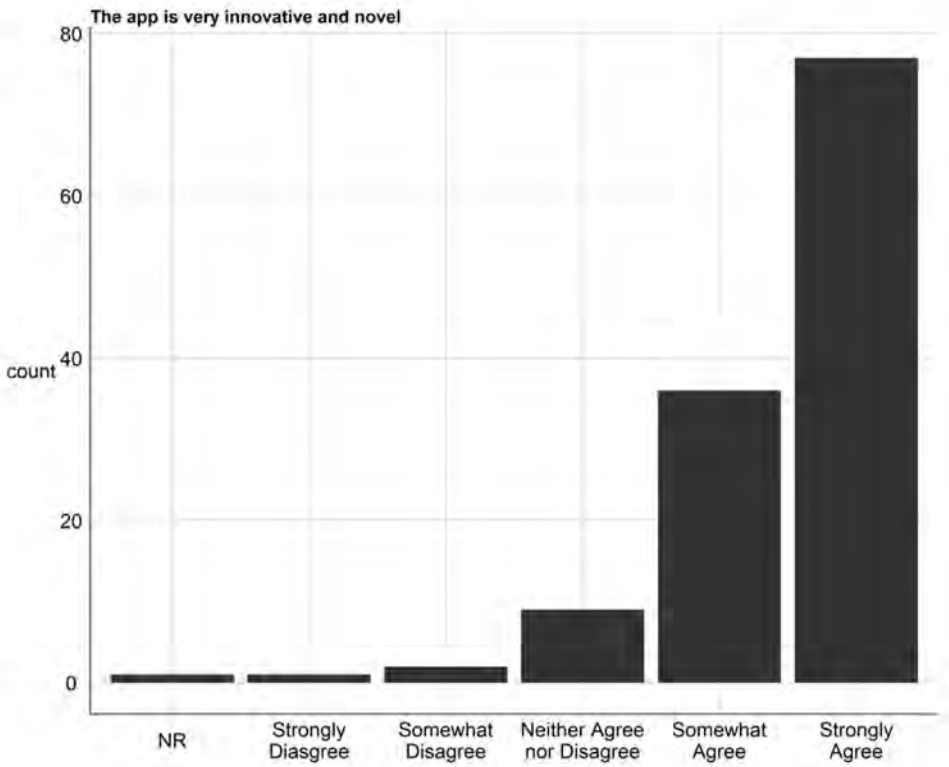

I think I made a more informed choice because of the app
count
60
40
20
0
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

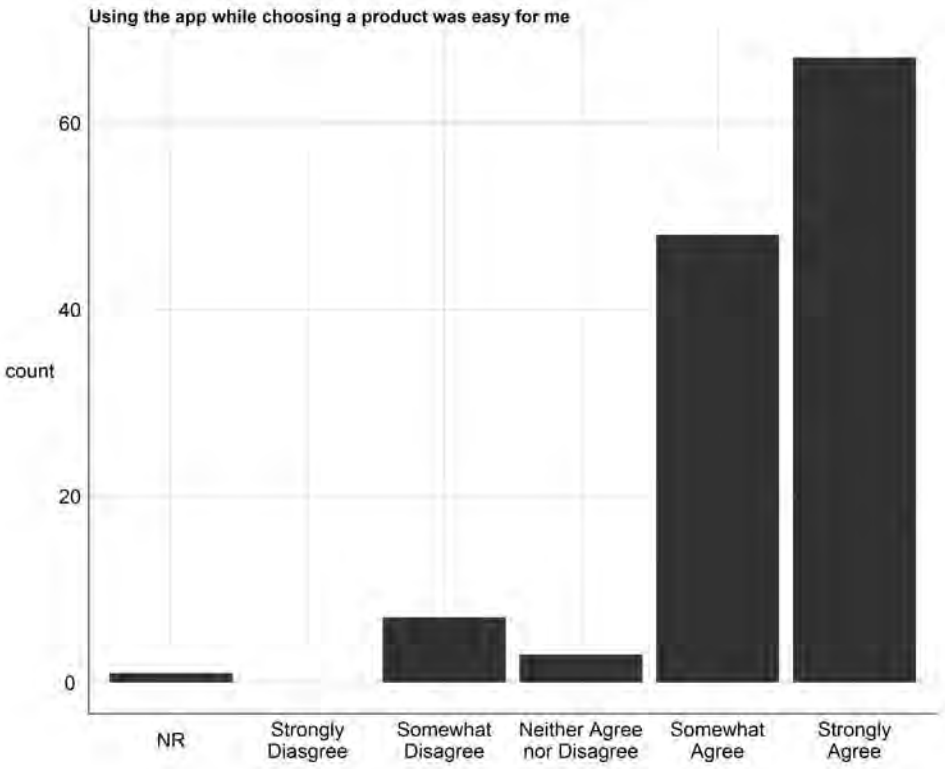

I enjoyed using the app
count
60
40
20
0
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

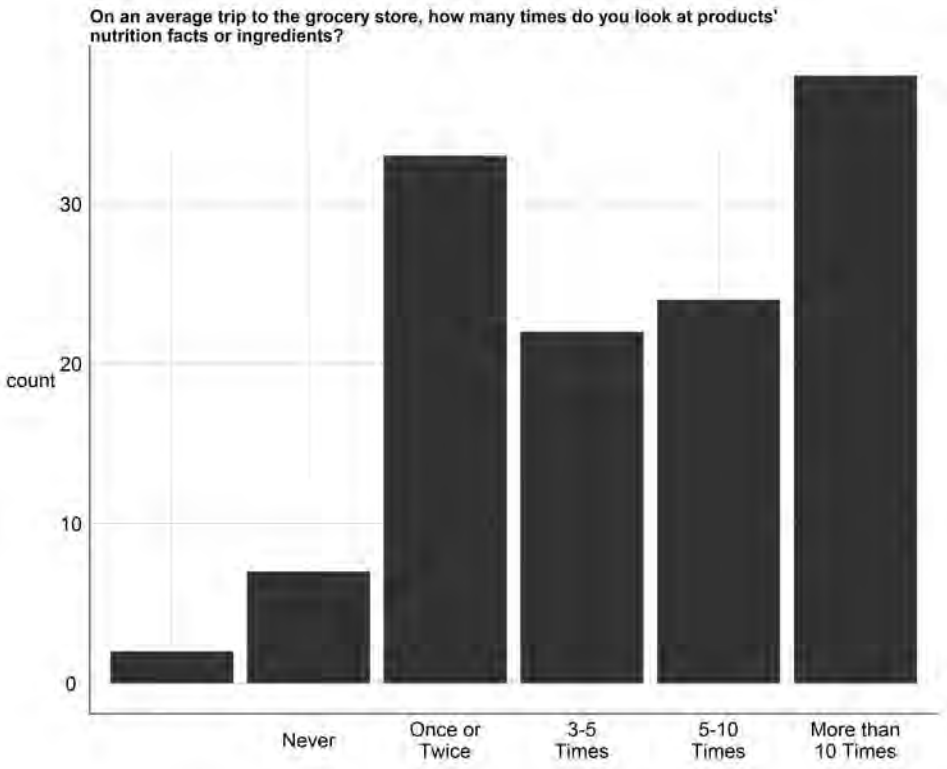

I believe the carbon footprint numbers provided by the app were accurate
count
0
10
20
30
40
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

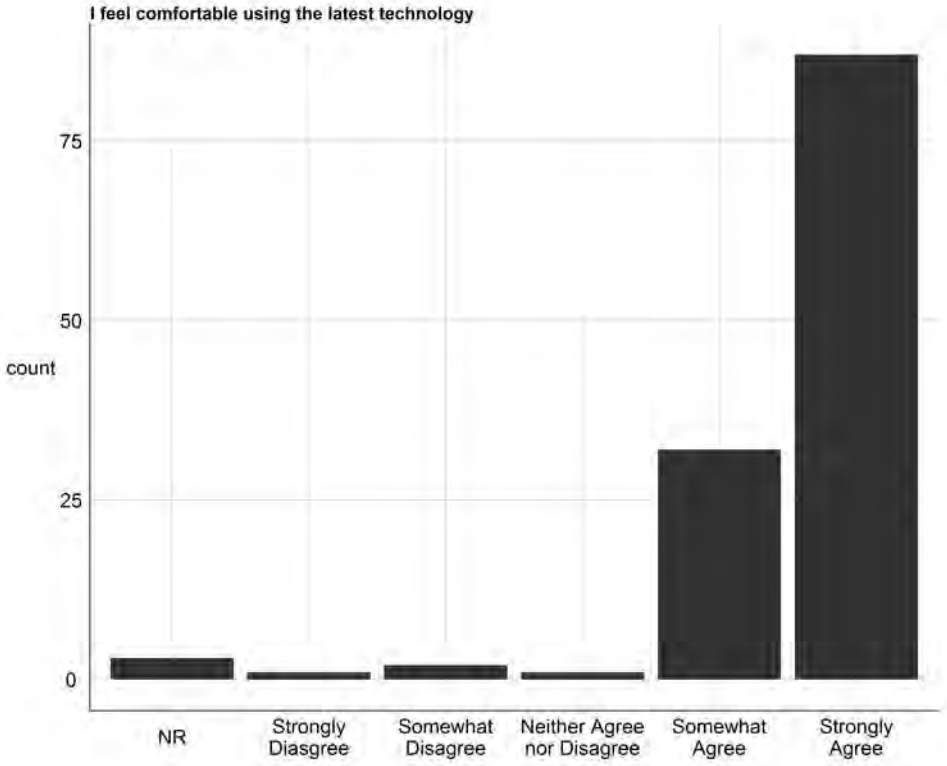

I consider the effect that my actions have on the environment when making day-to-day decisions
count
0
20
40
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

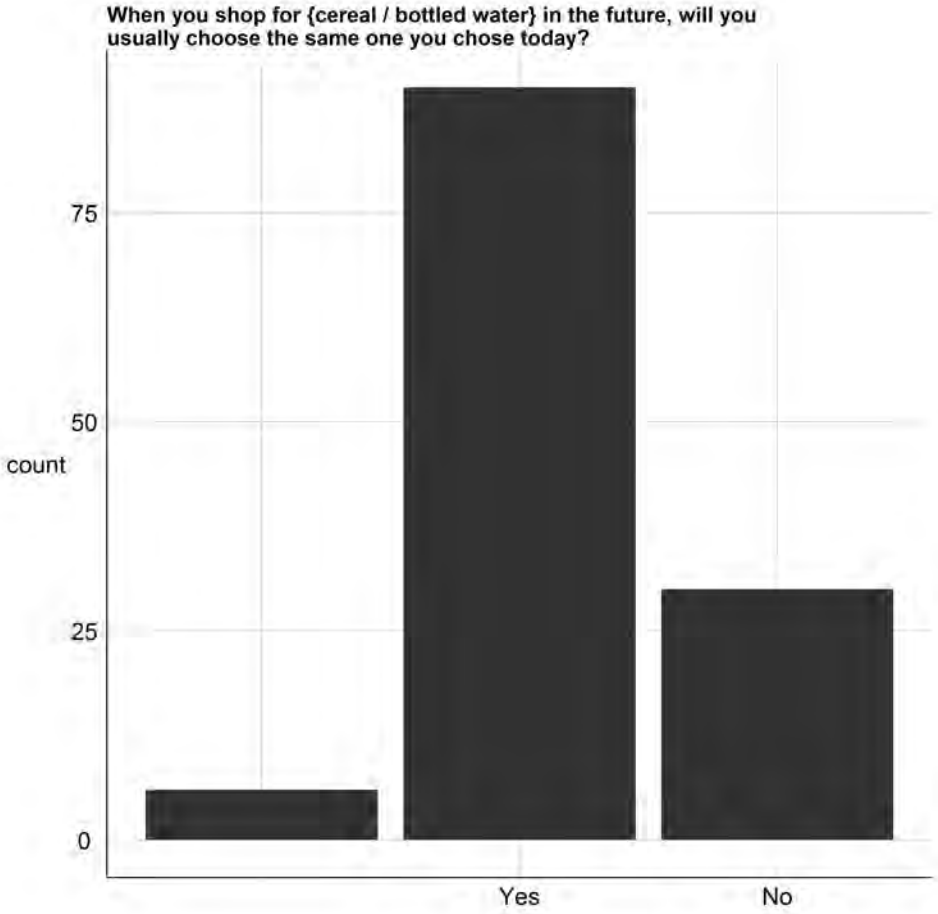

I would feel comfortable using the app in a store, around other people
count
75
50
25
0
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

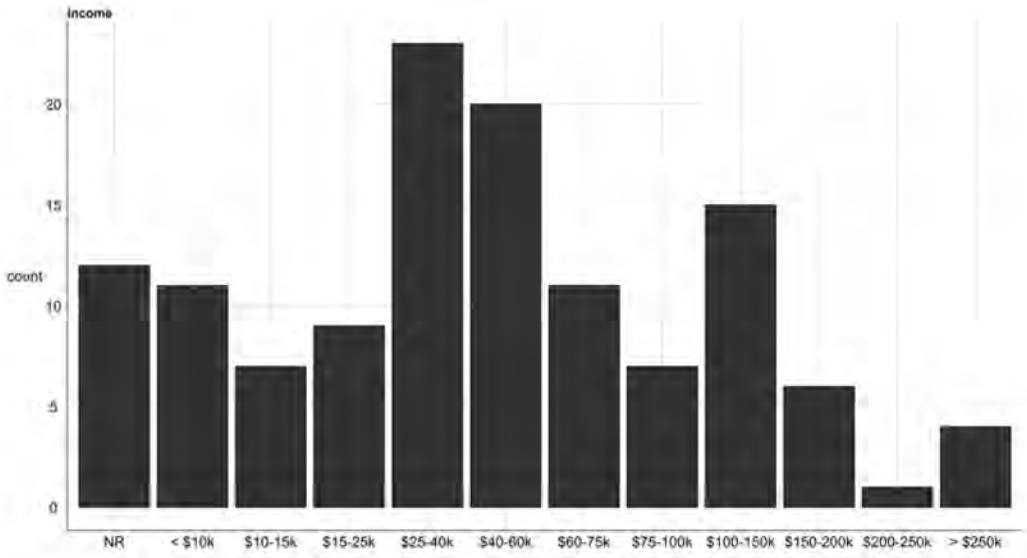

The app is very innovative and novel
count
80
60
40
20
0
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

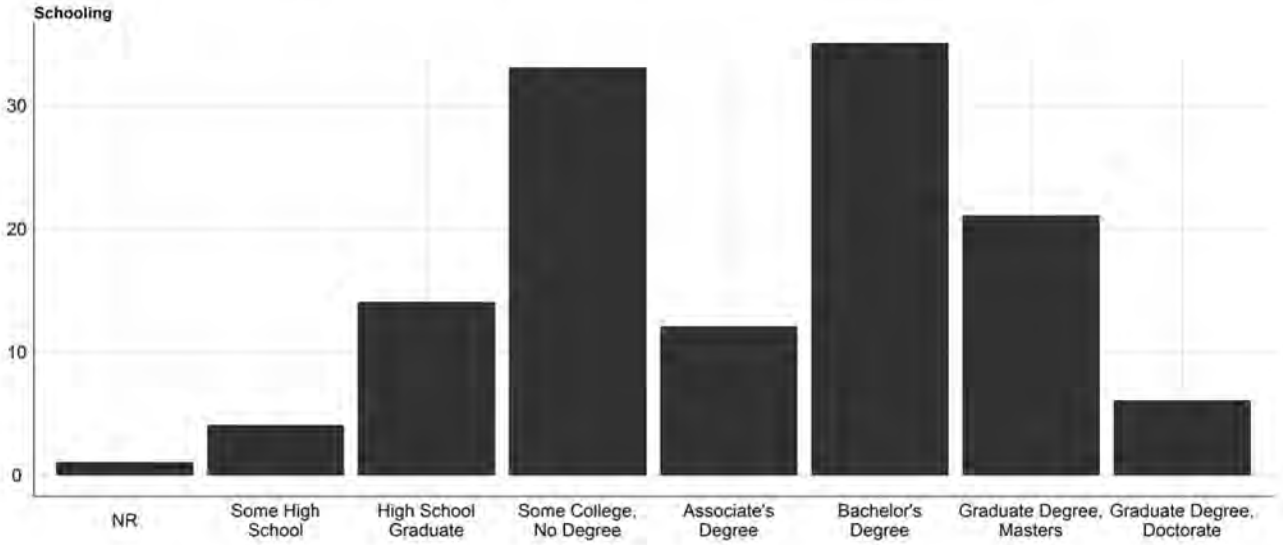

Using the app while choosing a product was easy for me
count
60
40
20
0
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree

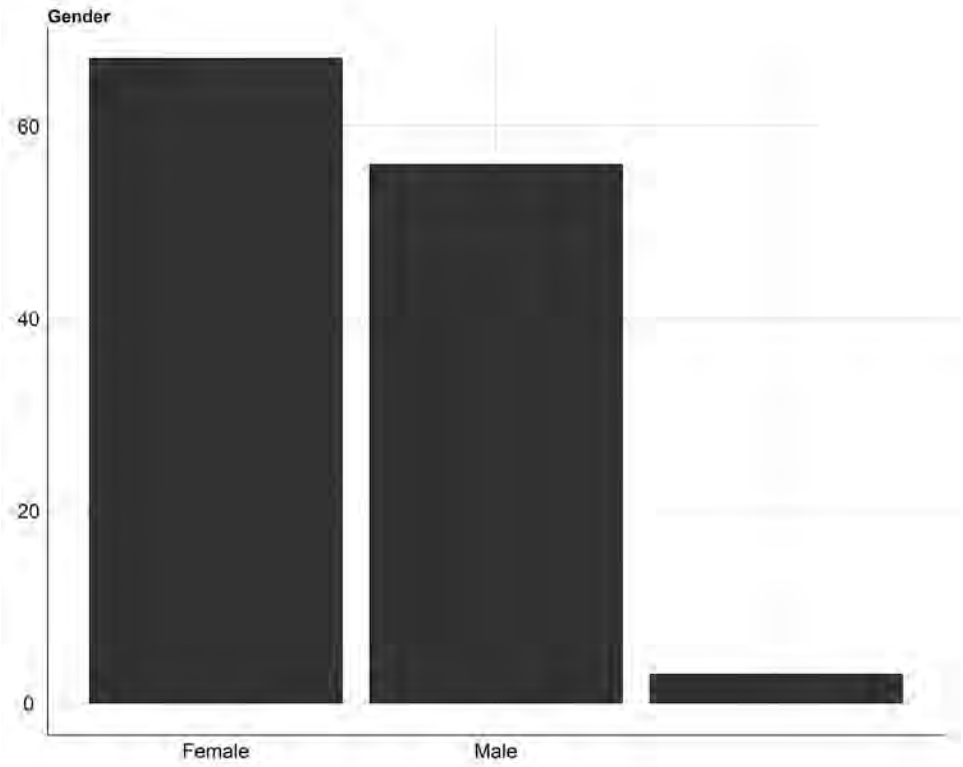

On an average trip to the grocery store, how many times do you look at products' nutrition facts or ingredients?
count
30
20
10
0
Never
Once or Twice
3-5 Times
5-10 Times
More than 10 Times

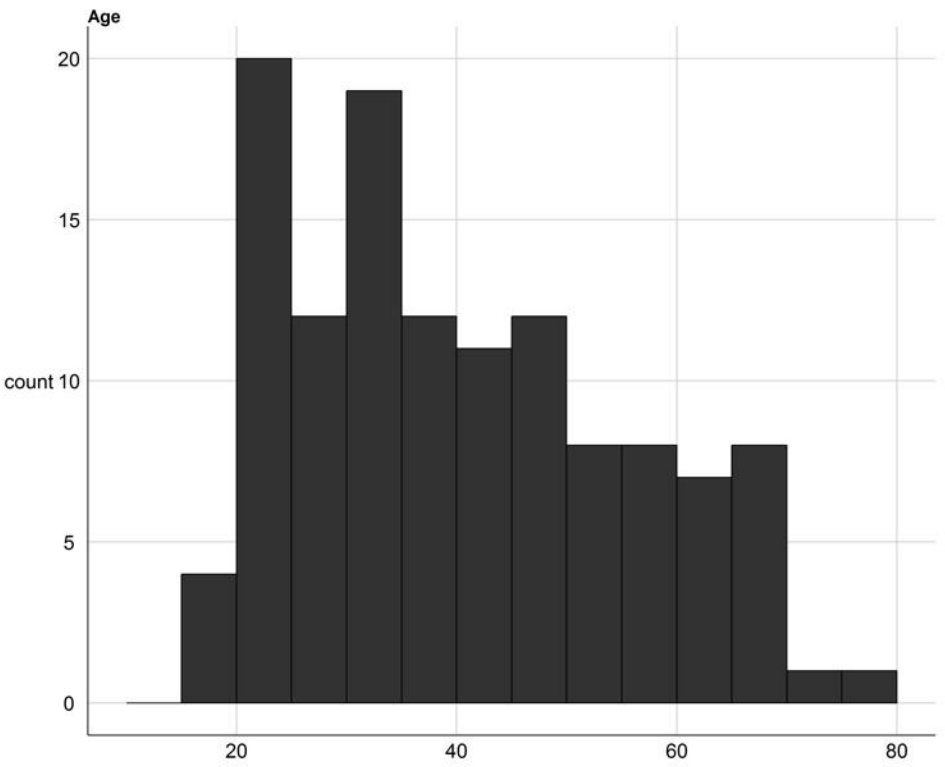

I feel comfortable using the latest technology
count
75
50
25
0
NR
Strongly Diasgree
Somewhat Disagree
Neither Agree nor Disagree
Somewhat Agree
Strongly Agree


When you shop for {cereal / bottled water} in the future, will you usually choose the same one you chose today?
count
75
50
25
0
Yes
No


Income
count
20
15
10
5
0
NR
< $10k
$10-15k
$15-25k
$25-40k
$40-60k
$60-75k
$75-100k
$100-150k
$150-200k
$200-250k
> $250k


Schooling
30
20
10
0
NR
Some High School
High School Graduate
Some College, No Degree
Associate's Degree
Bachelor's Degree
Graduate Degree, Masters
Graduate Degree, Doctorate


Gender
60
40
20
0
Female
Male


Age
20
15
count 10
5
0
20
40
60
80