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Short-term memory effects of eco-labeling: Evidence from the perceived environmental friendliness of sequential consumer behavior

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ABSTRACT

Can memory of eco-labeling bias how consumption is perceived and influence subsequent consumer decisions? We report three experiments showing that the perceived environmental friendliness of simulated shopping sequences is disproportionately influenced by what happens at the end of the sequence. For example, sequences that ended with a high carbon footprint item were perceived as less environmentally friendly than other sequences with the same content but with items in different order—a recency effect (Experiments 1–3). Judgments depended more on how often environmentally significant items were purchased than on the quantity of those items (Experiment 2). Furthermore, after completing a shopping sequence that was perceived as relatively harmful to the environment, participants were more prone to select a comparably expensive eco-labeled item over a cheaper but less environmentally friendly item in subsequent purchase decisions—a spillover effect (Experiment 3). The results stress the role of memory in environmentally significant consumer behavior.

1. Introduction

Imagine that you go to a supermarket or log on to a web shop. As you select various articles for purchase, you decide to buy an eco-friendly item to keep the carbon footprint of your shopping basket low. In relation to the perception of the combined environmental friendliness of your basket, does it matter *when* you make this eco-friendly purchase? Product labeling such as "organic", "fair trade", and the "green leaf" can help guide consumer behavior toward sustainable alternatives (Asioli et al., 2020; Holenweger et al., 2023; Schena et al., 2023; Suchier et al., 2023; Thøgersen, 2021; Torma & Thøgersen, 2023). However, labeling also has psychological effects that can distort perception and judgments. For instance, when a food item is labeled "organic", it is often perceived as having less calorific content (Prada, Garrido, & Rodrigues, 2017; Sörqvist et al., 2015), a better taste (Lee et al., 2013; Sörqvist et al., 2013), and a higher quality in general (Donato & D'Aniello, 2022). Labeling can also lead judgments of environmental impact astray. When "organic" food items are combined with food items with a high carbon footprint, people perceive a reduction in the carbon footprint of the whole meal (Gorissen & Weijters, 2016; see also Holmgren et al., 2018; Kusch & Fiebelkorn, 2019; Sokolova et al., 2023; Sörqvist et al., 2020). Similar findings have been obtained outside the food sector. For example, while people accurately perceive two petrol cars as having a higher environmental impact than one, they tend to think two hybrid cars have the same environmental impact as one hybrid car (Kim & Schuldt, 2018).

Past studies have looked at labeling effects on judgments made of products at item presentation. However, groceries such as food and clothes are often bought sequentially. When consumers visit shopping aisles in grocery stores and when they select products in online web shops, products are selected across temporal distances. Because of this, memory should play a role in how consumers perceive the environmental impact of the items in a shopping sequence, but this role has never been studied before. The overarching purpose of the current investigation is to fill this gap by studying how product eco-labeling interacts with sequential order-effects on judgment of consumer choices.

Item-order interventions can steer consumer behavior in certain directions. For example, putting sustainable dishes at the top of menus can increase restaurant guests' tendency to pick them over other less sustainable alternatives (Langen et al., 2022; but see Zhou et al., 2023).

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Such interventions might also come with other related psychological consequences. A general hypothesis is that the perceived environmental footprint of shopping sequences should depend on order effects from underpinning memory processes.

In the context of short-term memory of item sequences (e.g., recall of a recently seen word list), a typical finding is that memory is superior for the first (primacy) and the last (recency) items in the sequence in comparison with the middle items. These primacy and recency effects are found in both free recall (i.e., when participants are free to recall the items in any order; Tan, Ward, & Grenfell-Essam, 2010; Ward, 2002) and in serial recall (i.e., when items must be recalled in their order of presentation; Cowan, Saults, Elliott, & Moreno, 2002). Moreover, they are found when the to-be-recalled items comprise visual-verbal items (e.g., digits; Sörqvist, 2010) and pictures (e.g., Cohen, 1972; Manning & Schreier, 1988). Primacy effects are typically stronger than recency effects (Penny, 1989), but there are exceptions, such as when output interference from recall of the primacy part of the list is limited (Cowan et al., 2002). Moreover, recency effects are typically stronger when to-be-remembered items are presented in the auditory modality in comparison with when presented in the visual modality (Penny, 1989). Primacy and recency effects are not only found in the context of short-term memory – superior recall of the first and final parts of episodes are also found in the context of long-term memory (Li, 2009).

If retrospective judgments of environmental footprint of previously experienced shopping sequences depend on similar memory processes as recall of word lists, then these judgments should arguably be particularly influenced by what happens in the beginning and the end of the sequence. However, retrospective judgments seem to behave differently than item memory. For example, when people make judgments of perceived affect, these evaluations are usually a function of the final event (end) and the most significant (peak) event (Alaybek et al., 2022; Fredrickson, 2000; Fredrickson & Kahneman, 1993). Women's retrospective affective evaluation of pain during childbirth is disproportionately influenced by the pain peak and the experienced pain at the end of the episode, whereas the pain experienced in the beginning of the episode has a smaller effect (Chajut et al., 2014). This peak-end rule governs affective judgments of episodes experienced some time ago (Montgomery & Unnava, 2009) as well as judgments of episodes recently experienced (Schreiber & Kahneman, 2000). The beginning of an episode does not, in turn, produce a similar disproportional effect on affective judgments (Fredrickson, 2000; Kahneman et al., 1993). Hence, recency/ending effects are present in the literature on retrospective judgments as well as the literature on list recall, whereas primacy effects are not usually found in retrospective judgments. On this view, a recency effect should be found in the context of retrospective eco-judgments, such that judgments are disproportionately influenced by items at the end of the sequence, but a similar primacy effect should not be found.

While affective judgments are primarily influenced by the peak affect and the affective experience of the ending, the duration of the affective experiences often has a negligible effect on the affective evaluation of the episode as a whole. For instance, the duration of labor during childbirth has a negligible effect on the affective evaluations of the labor (Chajut et al., 2014). Duration neglect is a common finding (Alaybek et al., 2022) that has been observed for longer episodes (hours; Chajut et al., 2014; Rode et al., 2007) and shorter episodes (a few minutes; Schreiber & Kahneman, 2000; but see Fredrickson & Kahneman, 1993). Transposed to the context of perceived environmental friendliness of shopping sequences, one hypothesis that can be formed from what is known about duration neglect is that the number of items that is picked up during a shopping sequence could have a negligible effect on the perceived environmental friendliness of the shopping sequence. While a larger number of items should be associated with a larger carbon footprint than a smaller number—at least when the actual carbon footprint of the individual items is constant—it is possible that this aspect is neglected when a cognitive representation of the combined environmental friendliness of the shopping bag is constructed. On this view, duration neglect in retrospective evaluation of temporal item sequences resembles the quantity insensitivity effect found in environmental impact estimates of item combinations (Kim & Schuldt, 2018; Kusch & Fiebelkorn, 2019). When more items of a specific carbon footprint value are added to a set of other items with the same carbon footprint value, the environmental impact estimate of that entire set remains the same. A possible explanation of quantity insensitivity in eco-judgments is offered by the averaging account, which suggests that judgments of the environmental impact of a combination of high impact and low impact items approach the average rather than the sum of the item's environmental impact because people exhibit an averaging bias (Andersson et al., 2024; Holmgren et al., 2018; Sörqvist et al., 2020).

A recent study by Sörqvist et al. (2024) challenges some of these ideas. In this study, participants viewed rapidly presented sequences of items with the task to immediately estimate the items' carbon footprint (in kilogram carbon dioxide [CO_2] emission) after item presentation. Item's carbon footprint was varied at presentation by presenting items in either a red (high carbon footprint), yellow (intermediate carbon footprint) or green (low carbon footprint) color. The study found a recency effect, such that retrospective judgments of carbon footprint were disproportionately influenced by the color of the last item in the sequence. Also, there was no evidence of a corresponding primacy effect. Thus, regarding order effects, the findings were in line with what would be expected based on the literature on affect judgments. However, there was no evidence of quantity insensitivity. Longer sequences, comprising more items, were consistently assigned a higher carbon footprint estimate across all experiments.

Whether these findings generalize to the more applied context of shopping sequences is unclear. A passive task of viewing rapidly presented item sequences shares little resemblance with the active task of selecting goods during a shopping sequence. Evaluation of shopping sequences comprises continuous decision-making. Furthermore, items within shopping sequences are typically not viewed at a fixed ratio, but instead as a flexible item presentation that depends on participants own decision-making pace, which may modulate temporal order effects at item presentation. To test how memory processes influence the perceived environmental footprint of shopping behavior, it is therefore necessary to test whether order effects are also found in a more applied setting with higher ecological validity that simulates actual shopping behavior. The current study aimed to fill this gap.

The current paper also extends previous work using a different dependent measure, which serves both theoretical and applied purposes. Instead of requesting estimates of the items' kg CO_2, the participants of the current study were asked to estimate the items' environmental friendliness (cf. Sokolova et al., 2023). This difference in judgment scale contributes to the higher ecological validity in the experimental setting of the current study as it arguably bears a greater resemblance to how people normally perceive the environmental footprint of their shopping behavior. The judgment scale used here also serves a more theoretical purpose: While estimates of environmental friendliness is arguably closer to how people spontaneously evaluate their shopping behavior, these estimates are more qualitative/subjective while CO_2 estimates are more quantitative/objective (cf. Sörqvist & Holmgren, 2022). Qualitative and quantitative judgment scales can induce different mindsets and can modulate the extent to which people become susceptible to biases (Biernat et al., 1991). Most importantly for the purposes of the current study, a qualitative judgment such as the judgment of the environmental friendliness of an item sequence might be more open to quantity insensitivity in comparison with a more quantitative judgment of the items' kg CO_2. The reason for this is that "friendly" and "unfriendly" items tend to cancel each other out when combined into the same sequence, leading to an averaging bias (much like "good" and "bad" experiences produce a duration neglect/quantity insensitivity in affect judgments; Asutay et al., 2021), whereas "items producing much kg CO_2" and "items producing little kg CO_2" add together in a running total rather than canceling each other out. Because of this, we expected to find a quantity insensitivity in retrospective judgments of the environmental friendliness of shopping sequences.

A further extension from previous work is that the current study addresses a novel question concerning how the perceived environmental friendliness of consumer behavior influences subsequent consumer behavior. Factors that influence the perceived environmental friendliness of consumer behavior could potentially have consequences for subsequent consumer behavior—through behavioral spillover (Geiger et al., 2021; Maki et al., 2019; Nilsson et al., 2017; Thøgersen & Ölander, 2003; Truelove et al., 2014). Behavioral spillover can take many forms. For instance, a negative behavioral spillover takes place when a pro-environmental behavior leads to subsequent environmentally harmful behavior. A positive spillover, in turn, takes place when a pro-environmental behavior leads to a subsequent pro-environmental behavior. If, for example, a person perceives their past shopping behavior as relatively environmentally harmful, because they know they have purchased an item with a high carbon footprint, they might subsequently be more willing to select an environmentally friendly over a less environmentally friendly item in subsequent purchase decisions, even if the more environmentally friendly item is more expensive than the other item. A reason for this could be moral cleansing (Gholamzadehmir et al., 2019), whereby consumers feel inclined to compensate for the negative environmental impact of their past behavior by making subsequent pro-environmental decisions (Kaklamanou et al., 2015). Given the temporal distance between initial behaviors and their potential spillover on subsequent behavior, we argue that memory processes play an important role in the explanation of behavioral spillover.

1.1. Overview of experiments

The experiments reported in the current paper were designed to test whether primacy, recency, peak effects, and quantity insensitivity/duration neglect can be found in the context of perceived environmental friendliness of shopping sequences; and whether factors that influence the perceived environmental friendliness of shopping sequences have spillover effects on subsequent purchase decisions. Experiment 1 set out to test whether the selection of items labeled eco-friendly can produce a recency effect. Evidence for a recency effect would be obtained if shopping sequences ending with the selection of an eco-labeled item are perceived as more environmentally friendly than shopping sequences with the selection of the eco-labeled item in the middle (all else in the sequences being equal). Primacy effects (obtained if shopping sequences beginning with the selection of an eco-labeled item are perceived as more environmentally friendly than shopping sequences with the selection of the eco-labeled item in the middle, all else in the sequences being equal) were not expected, based on what is known from the literature on retrospective affect judgments. A second purpose of Experiment 1 was to test whether perceived environmental friendliness of shopping sequences is independent of the number of items selected—in analogy with duration neglect in retrospective affect estimates (Fredrickson, 2000) and quantity insensitivity in environmental impact estimates (Kim & Schuldt, 2018).

To preview, Experiment 2 expanded on this by introducing a negative (environmentally harmful) label (Grankvist et al., 2004) and aimed to test whether also negative labels can produce primacy and recency effects and compare the magnitude of those to effects produced by positive (eco-friendly) labels. Experiment 2 also tested the effects of peaks on the perceived environmental friendliness of shopping sequences. Here, peaks were operationalized as selecting many eco-friendly (or environmentally harmful) items at once. Finally, Experiment 3 was designed to test whether the perceived environmental friendliness of past shopping behavior can influence subsequent consumer decisions.

2. Experiment 1

2.1. Methods

2.1.1. Participants

A total of 32 participants (17 women and 15 men, mean age of 32.31 years, *SD*=10.92) took part in Experiment 1. The sample size was determined based on an a priori power analysis (using G*Power; Faul et al., 2007) of the effect size of the recency effect found in Experiment 1 of the paper by Sörqvist et al. (2024). The effect size (Cohen's $d_z = 0.64$) revealed that a sample size of 28 participants should be enough do detect the effect (one-tailed). The experiments reported in this paper received research ethical clearance from the Swedish Ethical Review Authority (Dnr 2023-01109-01). All participants gave their informed consent to take part in the study and received a small honorarium for their participation.

2.1.2. Materials

Response collection and stimulus presentations were controlled by a laptop computer. The stimulus material comprised pictures with pairs of food items. A total of 118 food items were used to create 59 pictures with two food items in each. One item was positioned to the left-hand side of the picture and the other item to the right-hand side. With these pictures, a total of 4 sequence types were created: (1) control sequences comprising non-labeled items only; (2) sequences comprising one picture with eco-labeled items in the first sequence position followed by pictures with non-labeled items (eco-label primacy); (3) sequences comprising one picture with eco-labeled items in the middle sequence position, preceded and followed by pictures with non-labeled items (eco-label middle); and (4) sequences comprising one picture with eco-labeled items in the last sequence position preceded by pictures with non-labeled items (eco-label recency). Moreover, each sequence type was created in three different lengths. The sequences were either 3 pictures/decisions, 5 pictures/decisions or 7 pictures/decisions long. Thus, a total of 12 sequences were created (4 types, each of 3 different lengths). The pictures were randomly selected from the set of 59 pictures when the sequences were created, with the restriction that all sequences with an eco-labeled item of the same length comprised the exact same wares but in different order. Hence, all sequences (with eco-labeled items) were matched in content, to isolate the order effect under investigation.

2.1.3. Design and procedure

The experiment comprised a 4(sequence type) × 3(number of ware decisions: 3 decisions, 5 decisions, or 7 decisions) factorial within-participants design. The dependent variable was estimate of the environmental friendliness of shopping sequences.

All participants sat in front of a desktop computer during the data collection. One of the data collectors (author 3 and 4) sat at a distance and were available in case the participant had any questions concerning the task instructions. Participants began by reading about the general purpose of the study, filled in a consent form, and answered demographic questions. Thereafter followed instructions to the task. They were told that they would conduct fictitious shopping sequences and chose among wares (some of which would be eco-labeled) by pressing the left or the right key on the computer keyboard to indicate which of the two wares in each picture they would like to buy. They were also told they will make 39 shopping sequences in total, and that they will be asked to estimate the environmental friendliness of each shopping sequence after each of them.

The experiment comprised a total of 39 trials. Each trial began with the words "READY – shopping sequence N" presented in black font for 500 ms at the center of the computer screen, at the position where the pictures of the sequence were going to be presented, followed by the first picture in the sequence. The "N" was replaced by a number, increasing arithmetically from 1 to 39, to let the participants orient themselves within the trial sequence. When the ready sign disappeared, one of the pictures with wares was presented. As soon as participants made their decision by pressing either the left or the right key, the next picture in the sequence was presented. After the final picture in the sequence, the participants were immediately presented with the statement "this shopping sequence was environmentally friendly" (cf. Sokolova et al., 2023). They responded by assigning a number between 1 and 9, where 1 represented "I do not agree at all with the statement" and 9 represented "I agree completely with the statement". The next trial begun immediately after participants made their environmental friendliness estimate.

The first 3 trials were considered warm-up trials. These were used to make participants acquainted with the task and the responses from these trials were not considered in the analysis. For the next 36 trials, each of the 12 sequences were presented 3 times each in random order. The whole experiment took about 15 min to complete.

Means across the three estimates of each sequence type were calculated, to obtain one measure of each of the 12 sequence types for each participant. These means were thereafter used as the observations in the analyses. Of the 1 152 trials in total, the participants failed to make an estimate on 1 trial. This missing value was replaced by the average value of the same participant's estimates of the other sequences of the same sort.

2.2. Results and discussion

As can be seen in Fig. 1, the retrospective evaluations of the shopping sequences' environmental friendliness were more favorable for sequences ending with the selection of an eco-labeled item in comparison with all other type of sequences. Hence, a recency effect was obtained. Sequences with selections of eco-labeled items first or in the middle were evaluated as more environmentally friendly than control sequences without eco-labeled items, but there was no difference between the two. There was, accordingly, no evidence of a primacy effect. This pattern of results—a recency effect but no primacy effect in retrospective estimates of item sequences—conceptually replicates previous studies (Sörqvist et al., 2024) and extends the results to a more ecologically valid setting. The conclusions were supported by a 4(sequence type) × 3(length of shopping sequence) repeated measures analysis of variance with environmental friendliness estimates as the dependent variable. The analysis revealed a significant main effect of sequence type, $F(3, 93) = 78.29$, $p < 0.001$, $\eta_p^2 = 0.72$, a significant main effect of length of shopping sequence, $F(2, 62) = 6.22$, $p = 0.003$, $\eta_p^2 = 0.17$, and a significant interaction between the factors, $F(6, 186) = 5.96$, $p < 0.001$, $\eta_p^2 = 0.16$. The grand mean estimates of eco-label recency shopping sequences were significantly higher than the corresponding means for eco-label primacy sequences ($M_{diff} = 1.55$, SD=0.95), $t(31) = 9.27$, $p < 0.001$, 95 % CI [1.21, 1.89], Cohen's d = 1.64, and eco-label middle sequences ($M_{diff} = 1.44$, SD=0.72), $t(31) = 11.36$, $p < 0.001$, 95 % CI [1.18, 1.70], Cohen's d = 2.01. In contrast, there was no significant difference between eco-label primacy and eco-label middle sequences ($M_{diff} = 0.11$, SD=.011), $t(31) = 1.27$, $p = 0.214$, 95 % CI [-0.30, 0.07], Cohen's d = 0.22.

The significant main effect of the length of the shopping sequence indicates general evidence against quantity insensitivity. The overall mean for shopping sequences with 7 ware selections were lower (M=4.77) in comparison with shopping sequences 5 selections in length (M=4.93) and those 3 selections in length (M=5.15). Thus, longer shopping sequences comprising more wares were generally evaluated as less environmentally friendly than shorter sequences with less wares, which is consistent with the fact that all wares have a carbon footprint, and more consumption hence adds to the overall carbon footprint of a shopping sequence. This result is not consistent with the general tendency of a duration neglect in retrospective affect judgments and quantity insensitivity in environmental impact estimates.

However, from the significant interaction between sequence type and shopping length (Fig. 1), it looks like the selection of an eco-friendly item at the end of the shopping sequence removes this tendency. The environmental friendliness estimates of shopping sequences with a selection of an eco-labeled item in the end, 3 and 7 items in length respectively, were nearly identical ($M_{diff} = 0.05$, SD=0.97), $t(31) = 0.30$, $p = 0.764$, 95 % CI [-0.40, 0.30], Cohen's d = 0.05. Similarly, the estimates of the control sequences are very similar across different lengths. In contrast, the corresponding estimates of shopping sequences with an eco-labeled selection in the middle were significantly lower for shopping sequences 7 selections long in comparison with shopping sequences 3 selections long ($M_{diff} = 0.65$, SD=0.85), $t(31) = 4.27$, $p < 0.001$, 95 % CI [0.34, 0.95], Cohen's d = 0.76. The same pattern was found for sequences with a selection of an eco-labeled item at the beginning ($M_{diff} = 0.74$, SD=0.89), $t(31) = 4.68$, $p < 0.001$, 95 % CI [0.42, 1.06], Cohen's d = 0.83. An eco-labeled item presented early in

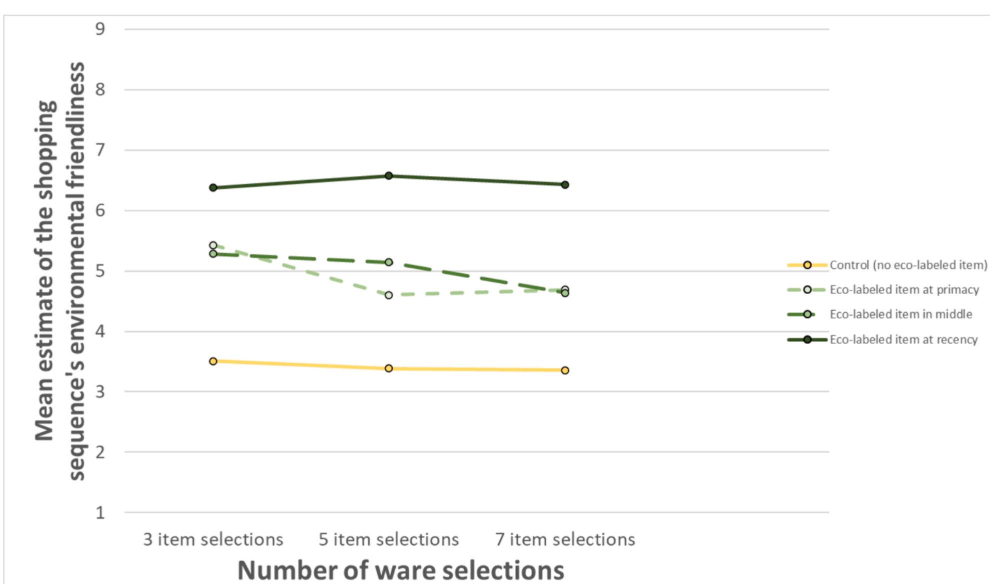

Fig. 1. The figure shows the means of retrospective estimates of sequence's environmental friendliness in Experiment 1. The sequences could comprise either 3, 5 or 7 ware selections, and include only selections of non-labeled items (control sequences) or a selection of an eco-labeled item in the beginning (primacy), middle or end (recency) of the sequence.

the sequence thus produced a larger upward shift in the environmental friendliness estimates in shorter sequences. This finding also points towards a role of short-term memory in these estimates. In the context of shorter sequences, the selection of an eco-labeled item at the beginning might be more active in memory at the time of estimation, giving the primacy item a larger effect on the behavioral outcome. This tendency for a primacy effect is surprising given that primacy effects are typically not found in retrospective judgments of temporal item sequences (e.g., Kahneman et al., 1993). Furthermore, the primacy effect was so weak and only appeared for the shortest sequence that it would need to be replicated before assigned further theoretical value.

3. Experiment 2

After a first observation of a recency effect in perceived environmental friendliness of shopping sequences it seemed desirable to establish the reliability of this effect by a conceptual replication in a separate sample. Experiment 2 was designed to serve this purpose. A second purpose of Experiment 2 was to test whether the recency effect could be extended to encompass negative labels. While green labels can be used to signal the environmental friendliness of items, red items can be used to signal a corresponding environmental harmfulness—a color signal system that can, for example, influence consumers' willingness to pay for products (Grankvist et al., 2004).

Green and red labels can also have asymmetric effects on consumer behavior. For instance, negative (red) environmental labels have a stronger effect on willingness to pay than positive (green) labels (Petersen et al., 2021)—a negativity bias. Traffic light labeling (i.e., using green, yellow, and red labels to signal degrees of carbon footprint or environmental friendliness; cf. Drescher et al., 2014) can also increase consumer's tendency to select low-CO_2 items over high-CO_2 items (Holenweger et al., 2023; Suchier et al., 2023). In Experiment 2, we explore whether red labels can produce recency effects similar to eco-friendly (green) labels and whether this recency is larger in size than the recency effect produced by eco-labels, in view of the negativity bias found in past research.

Experiment 2 also set out to test the effects of peak purchases, here defined as buying many items at once. This approach made it possible to further explore the role of quantity insensitivity in perceived environmental friendliness of item sequences. Since retrospective estimates of affective episodes are influenced primarily by the peak affective event and its end (Alaybek et al., 2022), a peak purchase might have a corresponding disproportional influence on the perceived environmental friendliness of shopping episodes. One possibility is that sequences with green peaks will be viewed as particularly environmentally friendly (and sequences with red peaks as particularly harmful), over and above sequences comprising green items at the end. Another possibility is that peaks do not drive environmental friendliness ratings, but instead it is the number of green events that matter most. This latter possibility would receive empirical support if, for example, sequences with green peaks (without eco-labeled items at its endpoints) are no different from sequences comprising single-item green products at the end (without the peak), whereas sequences with green peaks and single-item green products at the end are perceived as more environmentally friendly than sequences comprising either a green peak (without eco-labeled items at its endpoints) or an eco-labeled items at its endpoint (without the green peak). That is, empirical support for the assumption that the number of eco-friendly events rather than the quantity of eco-friendly items in the sequence determines sequence's perceived environmental friendliness would be found if sequences with two eco-friendly events are evaluated as more environmentally friendly than sequences with one eco-friendly event.

3.1. Methods

3.1.1. Participants

A total of 50 participants (60 % women, mean age of 31.90 years, *SD*=12.43) took part in Experiment 2. None of them took part in Experiment 1. An a priori power analysis (Faul et al., 2007) of the recency effect found in Experiment 1 suggested that a sample size of as few as 8 participants would be needed to detect the effect, but since Experiment 2 were more complex than Experiment 1, we decided to aim for a sample size that was larger than in Experiment 1. All participants gave their informed consent to take part in the study and all received a small honorarium for their participation. All participants reported normal or corrected-to-normal vision, but three participants reported difficulty seeing the difference between green and red colors. Control analyses with these participants removed confirmed that their responses did not alter the conclusions and they were therefore included in the analyses.

3.1.2. Materials

The materials were identical to that in Experiment 1 with the following exceptions. The stimulus material comprised pictures of groceries (e.g., fruit, meat, dairy products, shirts, jeans, shoes, etc.). A total of 84 products were used. Three labels were used to signal the items' environmental impact: one green label that said "eco impact A", one yellow label that said "eco impact D" and one red label that said "eco impact G" (inspired by the Foundation earth labeling system; https://www.foundation-earth.org/). These labels were superimposed on the products at stimulus presentation. Twenty-four items were arbitrarily selected for an "eco impact A" (green) label. The same items were also given an "eco impact G" (red) label. Whether a green or a red label was shown at item presentation depended on the experimental condition. This was done to isolate the effect of the label, independent of the characteristics of the product. The remaining 60 products were given an "eco impact D" (yellow) label.

With these items, a total of 13 sequence types were created: (1) control sequences comprising pairs of yellow "eco impact D" items only; (2) sequences comprising one picture with a pair of items with green "eco impact A" labels in the first sequence position followed by pictures with pairs of yellow "eco impact D" items (green primacy); (3) sequences comprising one picture with a pair of items with green "eco impact A" labels in the middle sequence position, preceded and followed by pictures with pairs of yellow "eco impact D" items (green middle); (4) sequences comprising one picture with a pair of items with green "eco impact A" labels in the last sequence position preceded by pictures with pairs of yellow "eco impact D" items (green recency); (5) sequences comprising one picture with a pair of items with red "eco impact G" labels in the first sequence position followed by pictures with pairs of yellow "eco impact D" items (red primacy); (6) sequences comprising one picture with a pair of items with red "eco impact G" labels in the middle sequence position, preceded and followed by pictures with pairs of yellow "eco impact D" items (red middle); (7) sequences comprising one picture with a pair of items with red "eco impact G" labels in the last sequence position preceded by pictures with pairs of yellow "eco impact D" items (red recency); (8) sequences comprising one picture with 5 pairs of items with green "eco impact A" labels (e.g., 5 melons and 5 bananas with green labels) in the middle sequence position, preceded and followed by pictures with pairs of yellow "eco impact D" items (green peak); (9) sequences comprising one picture with 5 pairs of red "eco impact G" labels (e.g., 5 melons and 5 bananas with red labels) in the middle sequence position, preceded and followed by pictures with pairs of yellow "eco impact D" items (red peak); (10) sequences comprising one picture with 5 pairs of items with green "eco impact A" labels (e.g., 5 packages of pasta and 5 packages of rice with green labels) in the middle sequence position, one picture with 1 pair of items with green "eco impact A" labels (e.g., tuna and pork with green labels) in the first sequence position, and the rest comprising pictures with 1 pair of yellow "eco impact D" items (green peak primacy); (11) sequences comprising one picture with 5 pairs of items with red "eco impact G" labels in the middle sequence position, one picture with 1 pair of items with red "eco impact G" labels in the first sequence position, and the rest comprising pictures with 1 pair of yellow "eco impact D" items (red peak primacy); (12) sequences comprising one picture with 5 pairs of items with green "eco impact A" labels in the middle sequence position, one picture with 1 pair of items with green "eco impact A" labels in the last sequence position, and the rest comprising pictures with 1 pair of yellow "eco impact D" items (green peak recency); and (13) sequences comprising one picture with 5 pairs of items with red "eco impact G" labels in the middle sequence position, one picture with 1 pair of items with red "eco impact G" labels in the last sequence position, and the rest comprising pictures with 1 pair of yellow "eco impact D" items (red peak recency). Moreover, each sequence type was created in three different lengths. The sequences were either 3 pictures/decisions, 5 pictures/decisions or 7 pictures/decisions long. Thus, a total of 39 sequences were created (13 sequence types, each of 3 different lengths).

Pictures with items with yellow labels were randomly selected from the set of 30 pictures when the sequences were created, with a few restrictions. The green primacy, middle and recency sequences of the same length were matched, in that they contained the exact same pictures but with picture-presentation in different orders. Green primacy, middle and recency sequences of the same length included a picture with one pair of items with green labels that was unique for that sequence length. Different lengths included different pictures of items with green labels. The same matching technique was used for the red primacy, middle and recency sequences. Similarly, the green peak was matched with the red peak sequences, the green peak primacy with the red peak primacy and the green peak recency with the red peak recency sequences.

3.1.3. Design and procedure

The experiment comprised a 13(sequence type) × 3(number of ware decisions: 3 decisions, 5 decisions, or 7 decisions) factorial within-participants design. The dependent variable was estimate of the environmental friendliness of shopping sequences.

The procedure was the same as in Experiment 1 with the following exceptions. In the task instructions, the participants were presented with a set of 8 eco-labels that varied in color and environmental impact, from dark green ("eco impact A+") to red ("eco impact G"). They were told they would conduct fictitious shopping sequences and chose among wares that are all labeled according to the presented scale. They were also told that the label represented the wares' environmental impact as calculated from a life cycle analysis, taking everything into consideration from production to recycling including transportation. Sometimes they would be asked to choose among two items, and sometimes they would be asked to make several purchases at once. They were also told they will make 81 shopping sequences in total.

The experiment comprised a total of 81 trials. The first 3 trials were considered warm-up trials. These were used to make participants acquainted with the task and the responses from these trials were not considered in the analysis. The next 78 trials were divided into two blocks, 39 trials in each. In each block, the 13 sequence types were presented 1 time each and in the 3 different lengths. The order of the sequences was random but identical to all participants. The two blocks were separated by a self-paced pause in which participants could rest before proceeding to the next block. The order between the two blocks were counterbalanced between participants. The whole experiment took about 30 min to complete.

Means across the two estimates of each sequence type and length were calculated, to obtain one measure of each of the 13 sequence types and lengths for each participant. This was made in order to increase measurement reliability. These means were thereafter used as the observations in the analyses. Except for one participant, whose data for one block was lost due to technical errors. The single estimate for each type of sequence was used in the analysis for this participant.

3.2. Results and discussion

As can be seen in Fig. 2, there was a clear effect of sequence type. The label manipulation had expected effects, whereby estimates of sequences with eco-labeled items were consistently higher in environmental friendliness than control sequences comprising only yellow-labeled items; and estimates of sequences with red-labeled items were consistently lower than control sequences. A 13(sequence type) × 3(list length) analysis of variance with environmental impact estimates as the dependent variable revealed a significant effect of sequence type, $F(12, 588) = 49.83$, $p < 0.001$, $\eta_p^2 = 0.50$, and a significant interaction between the factors, $F(24, 1176) = 6.48$, $p < 0.001$, $\eta_p^2 = 0.12$. There was, however, no main effect of sequence length, $F(2, 98) = 2.32$, $p = 0.103$, $\eta_p^2 = 0.05$, providing some further support for a potential duration neglect in environmental friendliness estimates. Overall, sequences with green peaks were evaluated as the most environmentally friendly and sequences with red peaks the least environmentally friendly, but only when these sequences also comprised an endpoint with an environmentally significant item. For example, sequences with green peaks (without eco-labeled items at either endpoint) were no different from green recency sequences ($M_{diff} = 0.02$, SE=0.11), $t(49) = 0.19$, $p = 0.852$, 95 % CI [-0.19, 0.23], Cohen's d = 0.03, even though sequences with peaks comprised more items in total. Sequences with green peaks and an eco-labeled item at recency, in turn, were significantly different from corresponding sequences without the green peak in the middle ($M_{diff} = 0.41$, SE=0.10), $t(49) = 3.98$, $p < 0.001$, 95 % CI [0.20, 0.62], Cohen's d = 0.56, suggesting that multiple events with eco-labeled items drives an environmentally friendly estimate rather than the quantity of the eco-friendly items in the sequence. The results thus provide evidence of another example of quantity insensitivity in the perceived environmental friendliness of shopping sequences.

These overarching analyses were followed by more detailed analyses. A first thing to note is that the ending-effect found in Experiment 1 was replicated in Experiment 2 and extended to encompass labels of environmental harm in addition to the eco-friendly label. As can be seen in Fig. 3, an item with an environmentally significant item presented at the end of the item sequence had a disproportional effect on the perceived environmental friendliness of the whole sequence. These conclusions were supported by a 2(label type: green vs. red) × 3(list position: first, middle, last) repeated measures analysis of variance, with estimates of environmental friendliness as the dependent variable. The analysis revealed a significant effect of label type, $F(1, 49) = 52.53$, $p < 0.001$, $\eta_p^2 = 0.52$. There was no significant effect of position overall, $F(2, 98) = 2.32$, $p = 0.103$, $\eta_p^2 = 0.05$, but a significant interaction between the two factors, $F(2, 98) = 12.42$, $p < 0.001$, $\eta_p^2 = 0.20$. Closer analyses revealed a significant difference between sequences with a green item at the end in comparison with sequences with a green item at the beginning ($M_{diff} = 0.35$, SE=0.09), $t(49) = 4.05$, $p < 0.001$, 95 % CI [0.17, 0.52], Cohen's d = 0.57. Estimates of sequences with a green item in the middle also differed from sequences with a green item at the beginning ($M_{diff} = 0.23$, SE=0.08), $t(49) = 2.74$, $p = 0.009$, 95 % CI [0.06, 0.40], Cohen's d = 0.39, but there was no significant difference between estimates of sequences with "green" items at the end and in the middle, respectively ($M_{diff} = 0.12$, SE=0.07), $t(49) = 1.57$, $p = 0.112$, 95 % CI [-0.03, 0.27], Cohen's d = 0.22. Conversely, there was a significant difference between sequences with a red (environmentally harmful) labeled item at the end in comparison with sequences with a red item at the beginning ($M_{diff} = 0.19$, SE=0.08), $t(49) = 2.50$, $p = 0.016$, 95 % CI [0.04, 0.35], Cohen's d = 0.35, and in comparison with sequences with a red item in the middle ($M_{diff} = 0.22$, SE=0.08), $t(49) = 2.83$, $p = 0.007$, 95 % CI [0.06, 0.38], Cohen's d = 0.40. No difference was found between sequences with red items in the beginning and red items in the middle ($M_{diff} = 0.03$, SE=0.09), $t(49) = 0.34$, $p = 0.738$, 95 % CI [-0.21, 0.15], Cohen's d = 0.05. There was, however, no evidence of a negativity bias. The recency effect produced by the red labels were not larger in magnitude than the corresponding recency effect produced by the

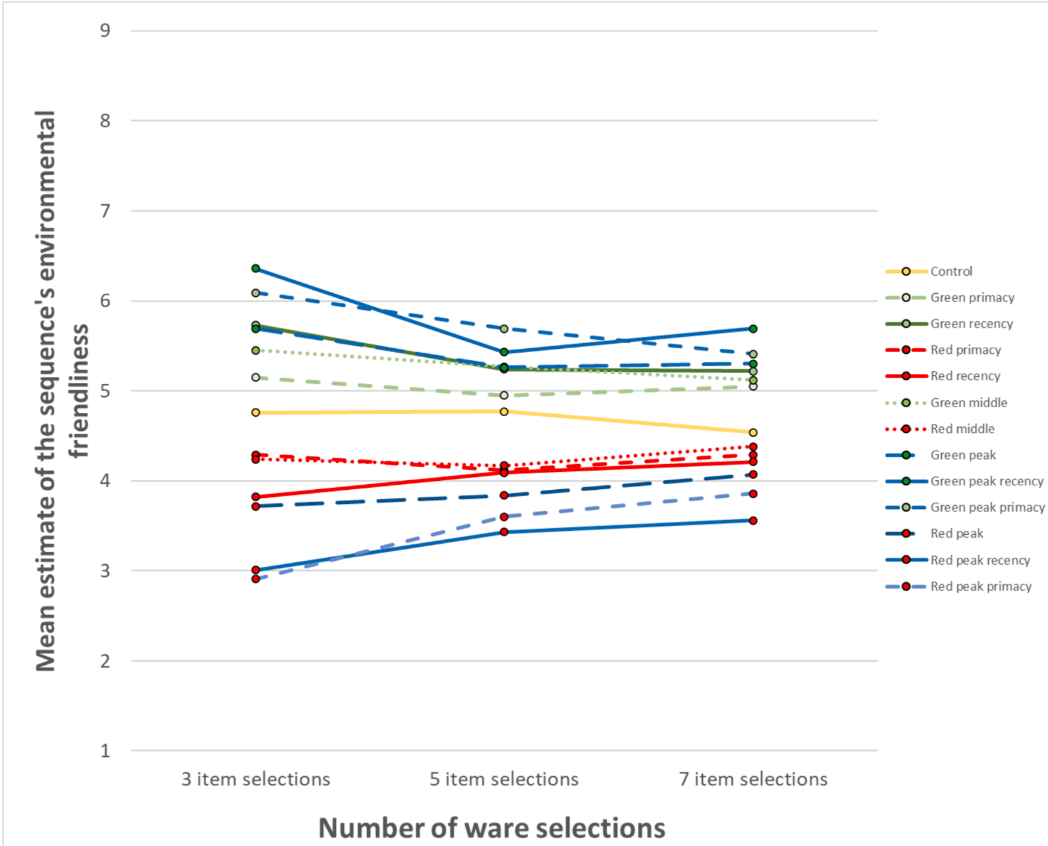

Fig. 2. The figure shows the means of retrospective estimates of sequence's environmental friendliness in Experiment 2. The sequences could comprise either 3, 5 or 7 ware selections, and include only selections of environmentally neutral/yellow items (control sequences); a selection of an environmentally friendly/green item in the beginning (primacy), middle or end (recency) of the sequence; or a selection of an environmentally harmful/red item in the beginning (primacy), middle or end (recency) of the sequence. Sequences could also include 'peaks' (the selection of many items at once) of environmentally significant items (labeled green or red). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

green labels.

A second thing to note it that these order effects appear to go away when labeled items at recency and primacy are combined with a peak in the middle. Both sequences with green peaks and an eco-labeled item at recency ($M_{diff} = 0.41$, $SE = 0.10$), $t(49) = 3.98$, $p < 0.001$, 95 % CI [0.20, 0.62], Cohen's d = 0.56, and sequences with green peaks and an eco-labeled item at primacy ($M_{diff} = 0.31$, $SE = 0.09$), $t(49) = 3.44$, $p < 0.001$, 95 % CI [0.13, 0.50], Cohen's d = 0.49, were viewed as more environmentally friendly than corresponding sequences with green peaks but without eco-labeled items at the end points. There was, in turn, no significant difference between sequences with green peaks and eco-labeled end-points at primacy and at recency, respectively ($M_{diff} = 0.10$, $SE = 0.10$), $t(49) = 1.00$, $p = 0.322$, 95 % CI [-0.09, 0.29], Cohen's d = 0.14. Similarly, both sequences with red peaks and a red item at recency ($M_{diff} = 0.54$, $SE = 0.09$), $t(49) = 6.07$, $p < 0.001$, 95 % CI [0.36, 0.72], Cohen's d = 0.86, and sequences with red peaks and a red item at primacy ($M_{diff} = 0.42$, SE=0.10), $t(49) = 4.29$, $p < 0.001$, 95 % CI [0.22, 0.62], Cohen's d = 0.61, were viewed as less environmentally friendly than corresponding sequences with red peaks but without red items at the end points. There was, conversely, no significant difference between sequences with red peaks and red-labeled end-points at primacy and at recency, respectively ($M_{diff} = 0.12$, SE=0.10), $t(49) = 1.27$, $p = 0.211$, 95 % CI [-0.07, 0.32], Cohen's d = 0.18.

We conclude that Experiment 2 replicated the main pattern of the order effects in the perceived environmental footprint of item sequences revealed in Experiment 1. The recency effect appears to be very robust and replicable. Also, it seems to generalize across different dependent measures and tasks (cf. Sörqvist et al., 2024). In turn, across several experiments, no evidence of a primacy effect has been found (with the exception of a small tendency of a primacy effect for short sequences found in Experiment 1 of the current paper). The primacy effect found in Experiment 1 for short sequences may hence be attributed to a Type I error, even though it is seemingly consistent with the idea that retrospective judgments are based on item memory, which should be particularly strong for primacy items in short sequences.

In addition, Experiment 2 found that the effect from positive (green) and negative (red) labels were similar in magnitude. Thus, there was no evidence of a negativity bias (Petersen et al., 2021). Finally, Experiment 2 provided further evidence of a type of quantity insensitivity whereby the perceived environmental friendliness of item sequences depended more on the frequency of environmentally significant shopping instances than on the quantity of the items bought at those instances.

4. Experiment 3

In Experiment 3, we turned to the question of whether the perceived environmental friendliness of past consumer behavior can have spillover effects on subsequent consumer behavior (Geiger et al., 2021). Experiment 3 specifically tested the hypothesis that consumers are more inclined to choose an expensive eco-friendly item over a cheaper, less environmentally friendly item in subsequent purchase decisions, after having completed a shopping sequence perceived as relatively environmentally harmful. Experiment 3 also tested whether the order effects in past shopping sequences modulate the magnitude of this spillover effect.

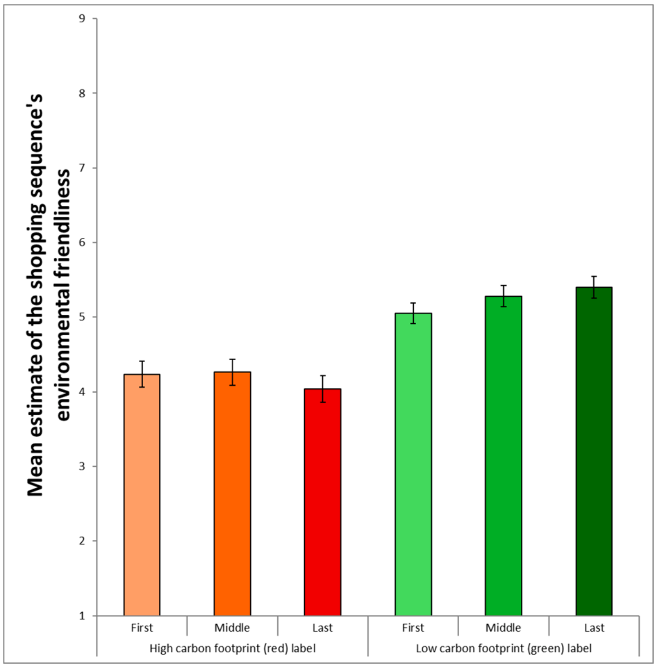

Fig. 3. The figure shows the grand means of environmental friendliness estimates of sequences with a selection of an environmentally significant item (labeled red or green) in the first, middle or last sequence position (all other selections being a selection of an environmentally neutral item, labeled yellow). Error bars represent standard error of means. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4.1. Methods

4.1.1. Participants

A total of 60 participants (60 % women, mean age of 26.12 years, *SD*=7.21) took part in Experiment 3. None of them took part in Experiments 1 or 2. We aimed for a sample size similar to Experiment 2. All participants gave their informed consent to take part in the study and all received a small honorarium for their participation. All participants reported normal or corrected-to-normal vision, and none of them reported difficulty seeing the difference between green and red colors.

4.1.2. Materials, design and procedure

The materials were identical to that in Experiment 2 with the following exceptions. After each sequence, immediately after estimating the environmental friendliness of the most recent shopping sequence, the participants were presented with a pair of objects and asked to indicate which of them they would be most willing to buy—henceforth called “spillover measurement task”. The two objects were identical except that one of them had a green “Eco label A”-label and a higher price and the other had a yellow “Eco label D”-label and a lower price. The price of the green object was always 1.25 times the price of the yellow object. The participants indicated which item they would prefer to buy by pressing the left arrow for the item to the left and the right arrow for the item to the right. The green item was presented to the left side of the screen for half of the stimuli and to the right of the screen for the other half of the stimuli. For simplicity, the experiment was shortened to include only primacy and recency sequences, with green and red labels respectively. The order of the stimuli in the spillover measurement task was counterbalanced between participants, so that all stimuli appeared after each type of shopping sequence an equal number of times. There was a total of 6 spillover trials in each experimental condition.

4.2. Results and discussion

As can be seen in Fig. 4 (Panel A), the order effect found in Experiments 1 and 2 was also replicated in Experiment 3. Environmentally significant items had a larger influence on the perceived environmental friendliness of the shopping sequence when bought at the end, as opposed to the beginning, of the shopping sequence. A 2(Type: environmentally friendly vs. environmentally harmful item) × 2(Position: first vs. last item in the sequence) × 3(Sequence length: 3 vs. 5 vs. 7 good selections) repeated measures analysis of variance with environmental friendliness estimates as dependent variable revealed a significant effect of type, $F(1, 59) = 64.26$, $p < 0.001$, $\eta^2_p = 0.52$. The effect of position was not significant, $F \approx 1.00$, but there was a significant interaction between position and type, $F(1, 59) = 22.88$, $p < 0.001$, $\eta^2_p = 0.28$. Estimates of environmental friendliness were significantly higher for shopping sequences ending with a green item in comparison with sequences beginning with a green item ($M_{diff} = 0.35$, SE=0.10), $t(59) = 3.42$, $p <$ 0.001, 95 % CI [0.15, 0.55], Cohen’s d = 0.44. Conversely, estimates were significantly lower for shopping sequences ending with a red item in comparison with sequences beginning with a red item ($M_{diff} = 0.24$, SE=0.07), $t(59) = 3.19$, $p = 0.002$, 95 % CI [0.09, 0.39], Cohen’s d = 0.41. The main effect of sequence length was also significant, $F(2, 118) = 3.84$, $p = 0.024$, $\eta^2_p = 0.06$, but this did not reflect a quantity sensitivity, as the mean was 5.04 (SE=0.16) for 3 item lists, 4.85 (SE=0.15) for 5 item lists and 4.98 (SE=0.16) for 7 item lists. Thus, even though there was a significant difference between means, judgments did not depend linearly on the quantity of the items in the sequences. Importantly, the three-way interaction was not significant, $F(2, 118) = 0.71$, $p = 0.493$, $\eta^2_p = 0.01$, suggesting that the crucial interaction between type and position was similar across sequence lengths.

Fig. 4 (Panel B) shows the tendency to select a relatively environmentally friendly but more expensive item over a less environmentally friendly but cheaper item at a purchase decision in the spillover measurement task, conducted immediately after completing the four types of shopping sequences, respectively. A 2(Environmentally significant type of item in preceding shopping sequence: friendly vs. harmful) × 2(Position of the environmentally significant item in preceding shopping sequence: first vs. last item) repeated measures analysis of variance, with mean for green items selected as dependent variable, revealed a significant effect of type, $F(1, 59) = 5.25$, $p = 0.026$, $\eta^2_p = 0.08$. The effect of position, and the interaction between type and position were not significant, both Fs ≈ 1.00. Thus, Experiment 3 revealed a spillover effect whereby participants were more inclined to select an environmentally friendly item in subsequent purchase decisions after making a relatively environmentally harmful shopping sequence. There was, however, no evidence suggesting that this spillover effect was modulated by the order of the environmentally significant items in the preceding shopping sequence. The differences between means point in the direction of a modulation by order, but the magnitude of the order effect on perceived environmental friendliness observed here was presumably too weak to yield a statistically reliable spillover effect.

5. General discussion

The experiments reported here revealed three main findings. First, items of relatively strong valence—either good or bad for the environment—have a disproportional effect on sequence evaluations when presented at the end of the sequence. For example, a shopping sequence that ends with the selection of an eco-labeled item, and otherwise comprises only selections of environmentally neutral items, tends to be evaluated as more environmentally friendly overall, in comparison with similar sequences having the selection of the eco-labeled item in the beginning instead (a recency effect). Labels signaling that a product is bad for the environment—a red label—had the same effect but in the opposite direction. Second, the effect of labeling on perceived environmental friendliness of shopping sequences appears to be driven

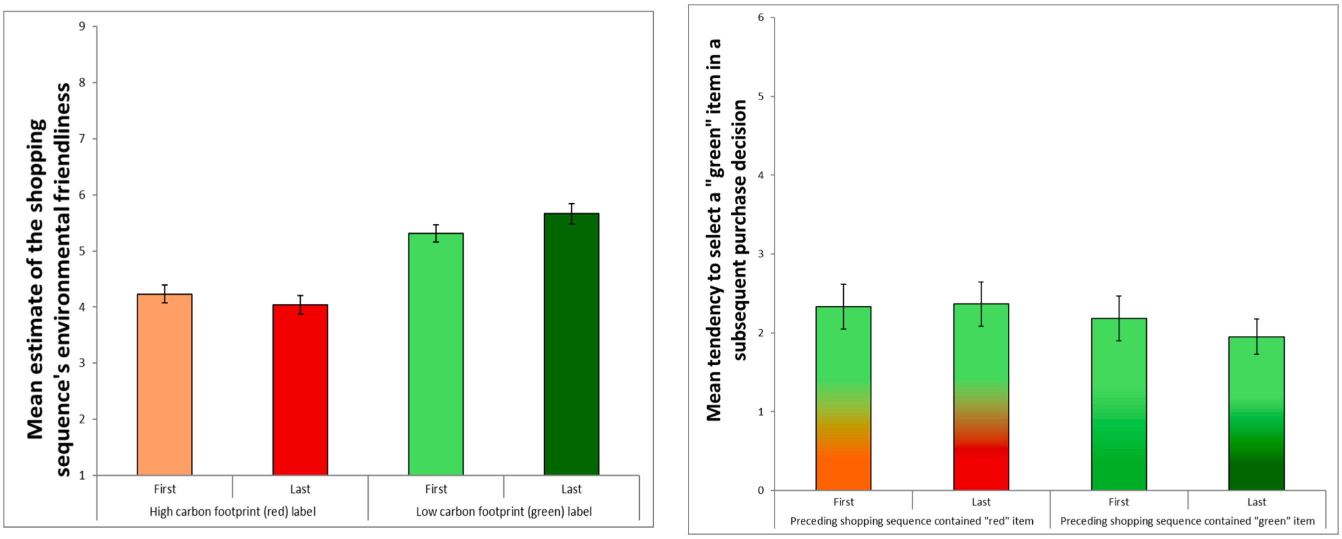

Fig. 4. The figure shows the grand means of environmental friendliness estimates of sequences with a selection of an environmentally significant item (labeled red or green) in the first or last sequence position (Panel A) and the tendency to select relatively environmentally friendly but more expensive item over a less friendly but cheaper item at a purchase decision after completing the preceding shopping sequence (Panel B). Error bars represent standard error of means. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

primarily by the number of events that include green/red labels, rather than the quantity of labeled items bought during the sequence (a type of quantity insensitivity). And third, the perceived environmental friendliness of past shopping behavior can have spillover effects on subsequent consumer decisions. Specifically, consumers are more willing to select a relatively expensive but more environmentally friendly item over a cheaper but less environmentally friendly item after completing a shopping sequence comprising an environmentally harmful (red) item as compared to an environmentally friendly (green) item (a negative spillover effect).

5.1. Theoretical interpretations

5.1.1. Explanations of the order effects

One of the main findings of the current series of experiments was that the environmental significance of recently bought goods has a disproportional effect on perceived environmental friendliness of shopping sequences. This result extends the key finding of a recency effect revealed in Sörqvist et al. (2024) to a more ecologically valid setting, involving continuous consumption-related decision-making and a more ecologically valid dependent measure. That recent but not early items have a compelling effect on holistic sequence evaluation coheres with the findings from judgements of perceived episode affect whereby what happens at the end of an episode usually determines affective judgements (Asutay et al., 2021; Chajut et al., 2014; Fredrickson & Kahneman, 1993) while what happens at the start has little, if any, influence (e.g., Kemp et al., 2008; Fredrickson & Kahneman, 1993; Redelmeier & Kahneman, 1996; Robinson et al., 2013).

Why are shopping sequences disproportionally evaluated by their endings? One interpretation of this finding relates to the temporal distinctiveness of the event. According to the temporal distinctiveness account of memory, items that are distinct are more easily remembered (Bireta et al., 2018; Glenberg & Swanson, 1986; Murdock, 1960; Neath, 1993), and should hence have a greater weight in their effects on subsequent judgment and decision-making processes. Items/events that occupy unique or discrepant temporal positions are better remembered than other items/events, such as items at the end of a shopping sequence, and because of this have a relatively large influence on sequence estimates. In turn, items/events in the middle of a sequence occupy less distinct positions, are less well remembered, and thus have less influence on subsequent judgments. As final items in the sequence are more temporally distinct than mid-list-items, they are better remembered at the time of judgment and consequently produces a recency effect in retrospective judgments. Thus, the recency effect can be explained by the temporal distinctiveness account.

The absence of a primacy effect is, in turn, not what would be expected from a temporal distinctiveness point of view. Why was there no evidence of a primacy effect, despite environmentally significant items presented at the beginning of a shopping sequence occupying a temporally distinct position? This is unclear from a strict interpretation of a temporal distinctiveness account wherein the availability of items in memory are solely determined by its distinctiveness at item presentation. However, the consumer choices in the middle of the shopping sequence may cause retroactive interference acting upon memory of the consumer choices taking place earlier in the sequence. Under the assumption that this retroactive interference is asymmetrically stronger than a corresponding proactive interference on the memory of consumer choices taking place later in the sequence (Izawa, 1980), the presence of a recency effect and the absence of a primacy effect are both expected. The magnitude of proactive and retroactive interference effects is often comparable, but there are also important differences in terms of the accessibility of items in memory (Unsworth et al., 2013). As retrospective judgment depends on how active to-be-remembered items are in memory at the time of judgment (Aldrovandi et al., 2015), an interesting avenue for future research would be to investigate the accessibility of items in memory at the time of judgment to test whether this can be the reason for the absence of a primacy effect.

Distinctiveness can also be driven by other stimulus features than temporal position (Murdock, 1960). Items that stand out or violate the stimulus context are also distinctively processed (Hunt, 2006). On this view, peaks—here defined as the presentation and purchase of many products at once—should be distinctively processed because these events deviate from the other product selections by number. Still, there was no clear evidence suggesting that peaks with green/red labeled items produce a larger effect on retrospective sequence evaluations than, for example, a single green/red labeled items at the end of the sequence. Furthermore, the recency effect was removed when an environmentally significant (green or red) item at the endpoints of the sequence was combined with a peak in the middle. This appears to suggest that more instances of environmentally significant purchase events have the capacity to overrule order effects, possibly because more frequent events become more active in memory at the time of the estimates. Future research should attempt to measure the memory of to-be-estimated items more directly to reach a better understanding of the underpinning role that memory plays in retrospective eco-judgments.

It should be noted though that the peaks in Experiment 2 were always presented in the middle of the sequence, and it is possible that peak events can interact with serial position to influence sequence evaluations. For instance, a peak ware selection at the end of the sequence might produce a stronger recency effect than single items. This possibility can be tested in future research.

5.1.2. Quantity insensitivity

Quantity insensitivity has been found in environmental impact estimates of objects previously. For example, one study revealed that the environmental impact estimates of two hybrid cars is no different from environmental impact estimates of one hybrid car (Kim & Schuldt, 2018). A similar pattern has been found for estimate of burgers (Kusch & Fiebelkorn, 2019). This quantity insensitivity appears to be limited to cases where relatively environmentally friendly items—such as hybrid cars—are added to another set of similarly friendly items. When relatively environmentally unfriendly items—such as regular cars—are added to other unfriendly items, environmental impact estimates tend to go up (Kim & Schuldt, 2018). In contrast, when environmentally friendly items are added to a set of unfriendly items, environmental impact estimates tend to go down (Holmgren et al., 2018), more so when more friendly items are added (Andersson et al., 2024)—called a negative footprint illusion (Gorissen & Weijters, 2016).

When environmentally friendly items are added to a set of environmentally harmful items, estimates of the average environmental impact of the items decrease. In turn, when an environmentally friendly item is combined with another environmentally friendly item, estimates of the set's average environmental impact remain the same. Hence, the averaging account of environmental impact estimates (Holmgren et al., 2018) can accommodate the quantity insensitivity in estimates when environmentally friendly items are added to identically environmentally friendly items (Kim & Schuldt, 2018) as well as the negative footprint illusion observed when environmentally friendly items are added to environmentally harmful items (Andersson et al., 2024). In both cases, the averaging account accurately predicts that estimates should reflect the average environmental impact of the items rather than their sum. The account cannot, however, accommodate the finding that environmental impact estimates of two identical, environmentally harmful items, is higher than estimates of one of the items alone (Kim & Schuldt, 2018). One possibility is that the presentation of environmentally harmful items triggers a different, quantitative mindset, leading participants to add rather than average the items' carbon footprint (cf. Gorissen et al., 2024; Holmgren et al., 2021).

The current study addressed another instance of quantity insensitivity. Instead of exploring estimates of items in the immediate view, the current study explored retrospective estimates of sequentially presented items not in view at the time of judgment. The results reported here were inconsistent. In Experiment 1, there was an effect of sequence length, such that longer sequences (comprising more items) were assigned a lower environmental friendliness estimate (Fig. 1). Crucially, in Experiment 1, the items were either unlabeled or labeled eco-friendly. With unlabeled items, participants' own preconceptions about the items' actual environmental impact can play a larger role than in Experiment 2. In Experiment 2, all items were labeled, either neutral (yellow), green (friendly) or red (harmful). Here, the environmental impact of the items was explicitly signaled to the participants, leaving less room for preconceptions. In this case, the estimates converged towards the sequence's average environmental friendliness and are consistent with the idea of a quantity insensitivity (Fig. 2). In Experiment 3, a difference in environmental friendliness estimates was found across sequence lengths, but in contrast to Experiment 1, the longest sequences were assigned on average a lower environmental friendliness than the sequences of intermediate length. Taken together, the results are inconsistent but might indicate that quantity insensitivity in environmental friendliness estimates of temporal item sequences emerge when the environmental friendliness of the to-be-estimated items is made explicit by a labeling system.

In the recent paper by Sörqvist et al. (2024), sequence length had strong, linear effects across all experiments, with longer lists consistently being assigned a higher carbon footprint, indicating strong evidence of a quantity sensitivity as opposed to quantity insensitivity. A reason for this difference in the pattern of results between the current study and the former study could be the different dependent variables across the two studies, as discussed in the Introduction. The more qualitative/subjective judgment scale used here may evoke a mindset whereby participants tend to evaluate the to-be-estimated items qualitatively, whereby "environmentally friendly" and "environmentally harmful" items cancel each other out, making the estimate approach an average instead of a sum of carbon footprint.

Another difference between the current study and the study reported by Sörqvist et al. (2024) is the stimulus material. Sörqvist et al. only used houses (with varying colors to represent different carbon footprints) as stimulus material, and thus a rather homogenous stimulus set. Perhaps this also has a bearing on whether a qualitative or quantitative mindset is adopted when participants make estimates. Perhaps stimulus variability/heterogeneity gives rise to qualitative judgements because there is more to keep track of (categories/inhibition of preconceptions [e.g., even though a product is labelled yellow, people might have preconception that it's green or red]) – thus some mental short-cuts might be exercised. Future research could explore this potential role of stimulus material further.

The current study also revealed another manifestation of quantity insensitivity. Experiment 2 found that estimates of sequences with two instances of environmentally significant events were evaluated differently than sequences with only one such instance. In turn, sequences with a single environmentally significant peak event were evaluated no differently from sequences with a single environmentally significant non-peak event. A similar tendency was found in Sörqvist et al. (2024) but the current paper extends this in several ways. First, the present study shows that the pattern of results generalizes to a more ecologically valid experimental setting with implications for consumer behavior. Second, it shows that the results are also similar for negative (red) peak-events. In all, the results of the current study suggest that environmental footprint estimates of shopping sequences depend on the frequency of environmentally significant events rather than the quantity of the goods bought at those events.

5.1.3. Behavioral spillover

Experiment 3 revealed a spillover effect such that past shopping sequences comprising environmentally harmful items increased the willingness to pay for a relatively expensive but environmentally friendly item. A possible explanation of this effect is that people purchase expensive green items as a way to be morally cleansed from past environmentally harmful consumer decisions; another that people become less willing to purchase expensive green items after already have conducted an environmentally friendly shopping sequence because they feel morally licensed to do so (Gholamzadehmir et al., 2019). Future research should tease these two possibilities apart.

From the results reported in the current paper, we can conclude that the perceived environmental friendliness of past shopping behaviors can produce spillover effects, with consequences for subsequent consumer decisions. This finding provides novel evidence of cognition in behavioral spillover, specifically a role for short-term memory traces of past consumer behavior. Factors that influence this memory trace, such as the recency effect found here, should arguably modulate the magnitude of the spillover effects, even though the recency effect found in the current study was too weak to produce this effect. Furthermore, these cognitive factors could also interact with other cognitive factors, such as cognitive accessibility (Sintov et al., 2019) and cognitive mindset

(Spaccatini et al., 2022) in producing spillover effects.

5.2. Applied implications

The results reported here are the first demonstration a recency effects in perceived environmental friendliness of shopping sequences and the second demonstration of recency effects in the environmental footprint evaluations of item sequences generally (Sörqvist et al., 2024). The recency effect appears to be highly robust but small in magnitude. From the robustness of the recency effect found here, and the ending effect in research of retrospective affect estimates of episodes (Alaybek et al., 2022), we anticipate that judgments of any sequence of events—not only shopping sequences—with variable environmental impact will be disproportionately influenced by the final event. For example, if someone is asked to evaluate how friendly they have behaved toward the environment during the last month, a memory record of an environmentally harmful behavior at the end of the episode will likely have a high weight on their response. Similar judgmental biases might also be found in other contexts, such as when people evaluate series of temperatures and to what extent participants attribute these to climate change and undertake climate mitigation activities. Future research should address the generalizability of the recency effect to longer time periods and other contexts than those addressed here.

Knowledge about how order effects influence consumer's perception of their shopping behavior could potentially be used in sustainability strategies and policy designs. For example, shop architects in their design of the (physical and on-line) shopping environments benefit from knowing that shopping environments, that increase the frequency of relatively environmentally harmful late purchases, will make consumers leave the shop with a slightly lower feeling of being an eco-friendly consumer, than another consumer buying the exact same things but in a different order. It is also valuable to know that the number of instances of environmentally significant purchases rather than the quantity at the specific instances drive perceived environmental footprint of the shopping sequence.

This perception, in turn, can influence subsequent purchase decisions through behavioral spillover. While the presence of green/red labels had an effect strong enough to influence both perceived environmental friendliness of shopping sequences and subsequent purchase decisions in the current investigation, the manipulation of item order was only strong enough to produce the recency effect on estimates of environmental friendliness but not strong enough to transmit into a modulation of the spillover effect. In view of the weak effect, the applied relevance of order effects for behavioral spillover might therefore be questioned. However, many factors influence the magnitude of recency effects (Bornstein et al., 1995; Howard and Kahana, 1999; Ward, 2002; Ward et al., 2010), and stronger recency effects should theoretically lead to consequences for spillover effects as well, provided they have a strong enough influence on the perceived environmental footprint of shopping sequences. It may well be the case that "single shot" (real) shopping episodes might yield larger recency effects than experimental, multiple sequence evaluations that might be generating proactive and retroactive interference between lists. Future research should aim to explore factors that increase the magnitude of the recency effect and relate these stronger order effects to behavioral spillover.

5.3. Limitations

The series of experiments reported here was designed to have high ecological validity and representative of real-world shopping situations. Yet, the need of experimental control also limited the ecological validity. In all experiments reported here, participants were always requested to choose between two items (or two sets of items) with the same label—except during the post-shopping decisions used to measure the spillover effect in Experiment 3. This was done to experimentally control the sequential order effects of the labels. By allowing participants to choose between, for instance, an eco-friendly item (with a green label) and an eco-harmful item (with a red label), that experimental control would be lost. However, sequences with items of the same environmental impact at each step of the shopping sequence creates a situation that is different from how decisions are typically made in real-life situations. Thus, while improving the ecological validity of the task and experimental setting from past research, the generalizability of the results to real-life situations requires further exploration. When making these types of selections in grocery stores, the choice can, for example, be between a more expensive eco-labeled item (e.g., bananas) and a cheaper non-labeled version of the same type of item (e.g., other bananas). Such an approach would lose experimental control of the order effects but opens the possibility of addressing several interesting research questions in future research.

Another limitation of the current study was the categories of the stimulus materials. Choosing food and clothes as stimulus material has several advantages with regard to having variables under experimental control, such as stimulus material being familiar to participants and having a fairly limited price range. However, this circumstance also makes it unknown if the results generalize to other stimulus materials. For example, the price of a product may have a stronger effect on item selection than perceived environmental friendliness of past consumer behavior, and a spillover from past consumer behavior on future behavior may only take place when product prices are low. Conversely, spillover effects from past shopping behavior involving expensive items on future consumer decisions may be stronger. Future research should investigate these interactions between price, perceived environmental friendliness and spillover magnitude.

5.4. Conclusions

In conclusion, the recency effect in environmental footprint estimates of sequences is a generally weak but very robust phenomenon that emerges in applied settings with comparably high ecological validity. Consumers appear to be relatively insensitive to the quantity of environmentally significant items they purchase when evaluating the shopping sequence's environmental footprint and instead assign greater weight to the frequency with which such items are bought; leaving a memory record that can influence subsequent consumer choices, by modulating the tendency to select cheaper but environmentally harmful items over more expensive but environmentally friendly items at later occasions.

CRediT authorship contribution statement

Patrik Sörqvist: Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Conceptualization. **Johanna Heidenreich:** Resources, Methodology, Investigation, Data curation. **Berland Hoxha:** Methodology, Investigation, Data curation. **Hanna Johansson:** Methodology, Investigation, Data curation. **John E. Marsh:** Conceptualization, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data are available in the Open Science Framework database and can be accessed from http://doi.org/10.17605/OSF.IO/MK2ET.

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