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Recycling shopping behaviour in Australian circular economy: An examination through central and peripheral routes

Dung Trung (Ben) Nguyen *, Clare D'Souza

Department of Management and Marketing, La Trobe University, Australia

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ABSTRACT

Under the operation of circular economy to tackle the waste crisis in Australia, there is an imperative call for boosting consumers' recycling shopping behaviour. Part of the process lies in recyclable packaging and how consumers make purchase decisions based on these types of packaging's information. Despite the urgency, how consumers process and respond to recyclable packaging cues – the very communication of packaging recyclability, including packaging materials, colour, and recycling signs remains equivocal in both literature and practice. The paper proposed an integrated framework by combining the Elaboration Likelihood Model and Theory of Planned Behaviour, in which the motivations and outcomes of both central and peripheral routes of processing these cues on recyclable packaging were explored, examining how each processing route would result in differentiated influences on purchasing intention. This is considered within the context of fast-moving consumer goods. Using Structural Equation Modelling and AMOS 29 software, the research confirmed the sole effect of the central route on attitudinal change through semiotic knowledge as a new construct and mediator, addressing the limitations of the Elaboration Likelihood Model and the issue of the circular economy in consumers' dimensions. Recommendations were proposed to manufacturers in retail environments and policymakers towards enhancing consumers' knowledge of recycling signs for circular economy. Through the introduction of semiotic knowledge, the research makes crucial theoretical contributions to addressing packaging waste by extending the two models and provides scholars and practitioners with an understanding of the implications involved and how they can assist in achieving a circular economy.

1. Introduction

Australia faces a significant waste crisis, with nearly 80 million tonnes of waste produced between 2020 and 2021, of which only roughly 50 % was recycled (Australian Bureau of Statistics, 2020; The Department of Climate Change, Energy, the Environment and Water, 2022). While other high-income nations perform slightly better in recycling, they still generate around 1.5 kg of waste per individual per day, far more than developing countries (Edmond, 2019; The Editors, 2020), yet their recycling rates remain just above 50 % (Statista, 2023). In Australia, households and individual consumers contribute significantly to this waste issue, producing up to 14 million tonnes, with only 13 % of it being recyclable (ABS, 2020). In addition to biodegradable organic waste, the most common materials generated by this sector include plastics, paper, and cardboard - key packaging items found in retail stores. This highlights a problem in the recycling-related activities of these materials, warranting further investigation with important implications for both Australia and other countries.

The concept of circular economy (CE[1]) has been in use for mitigating the issue of waste generation and recycling (Ellen MacArthur Foundation 2013a; Ellen MacArthur Foundation 2013b), in which the optimisation of product and material cycles is prioritised, simultaneously stressing the importance of consumer roles in choosing the right product and its packaging in the first instance (Shevchenko et al., 2023; Du Rietz and Kremel, 2024). This suggests that the very touchpoint in consumer recycling is recycling shopping behaviour - one's inclination or consideration to purchase products whose packaging can be easily recycled after use (Biswas et al., 2000), which satisfies the initiatives proposed above by CE and simultaneously addresses the issue of inadequate recyclables collected from households. Recent studies on both CE and recycling attributed the lack of relevant information to inadequate sustainable behaviour (Du Rietz and Kremel, 2024; Neves and Marques,

* Corresponding author.
E-mail addresses: t.nguyen7@latrobe.edu.au (D.T.(B. Nguyen), c.dsouza@latrobe.edu.au (C. D'Souza).

[1] CE will be used as the acronym for Circular Economy henceforth.

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2022; Shevchenko et al., 2023; Grafstrom and Aasma, 2021; Magnier and Schoormans, 2015, 2017; Seo and Scammon, 2017; Steenis et al., 2017).

Recycling information for relevant shopping decisions is typically conveyed through packaging recyclability indicators such as recycling symbols, materials, or colours (Grunert, 2011; Herbes et al., 2018; Du Rietz and Kremel, 2024), but the impact of each type on consumer behaviour remains underwhelmingly studied. Research shows inconsistent consumer responses after viewing recyclable packaging information (Magnier and Schoormans, 2015, 2017; Seo and Scammon, 2017; Steenis et al., 2017), without identifying clear explanatory factors. Specifically, consumers often struggled to identify which elements of packaging contribute to sustainability, such as whether it is recyclable or reusable, even after reviewing relevant information (Steenis et al., 2017). Additionally, when only exposed to visual cues like packaging design or colour, they sometimes interpreted sustainability claims as greenwashing (Magnier and Schoormans, 2015, 2017; Seo and Scammon, 2017). Retailers have mainly focused on packaging materials to signal recyclability, yet few studies assess whether this approach effectively alters consumer recycling behaviour and therefore should be preferred to recycling signs (Nguyen et al., 2020; Sekki et al., 2023); especially when these signs tend to be completely ignored by consumers and thus, their impacts are yet to be determined (Du Rietz and Kremel, 2024). The paper therefore asks an overarching research question:

> *"What are the differentiated effects of each source of packaging recyclability's information on consumers' recycling shopping decision?"*

Practically, understanding the distinct effects of different recyclability indicators on consumer behaviour is crucial for refining manufacturers' strategies in stores, given that recycling signs are the official recyclability markers (Australian Packaging Covenant, n.d.). Addressing these issues would enhance the literature on recycling behaviour and CE, as the role of communication types remains underexplored (Neves and Marques, 2022; Shevchenko et al., 2023). This could also inspire innovative recycling strategies in other countries, where these signs have received limited attention in both research and practice.

On a theoretical perspective, the paper set out to investigate the dual processing limitation of the Elaboration Likelihood Model (ELM[2]), on which further research is recommended to distinguish between the two routes' effects (Kitchen et al., 2014). Research established that recycling signs indicate central route of processing, whereas packaging materials/colours are processed as peripheral routes. The outcomes of each processing route will be investigated as an indicator of successful processing of respective route (Liu et al., 2022), in which the knowledge of recycling signs, or semiotic knowledge, indicates consumers' successful processing of those signs, and emotions for packaging materials or colours. Furthermore, to investigate the differentiated effects of these two routes, it is desirable to explore how differently the attitudinal change resulted from each route influences behavioural intention towards recycling shopping. An integration of the Theory of Planned Behaviour (TPB[3]) is therefore essential to capture these differentiated impacts, simultaneously extending the framework with semiotic as the new construct. The key theoretical contributions are therefore: (i) extending both the ELM and TPB by introducing semiotic knowledge as the new construct, (ii) addressing the ELM's issue of dual processing, and (iii) exploring how the ELM's central route can be further emphasised for more sustained behavioural change.

[2] ELM will be used as the acronym for the Elaboration Likelihood Model henceforth.

[3] TPB will be used as the acronym for the Theory of Planned Behaviour henceforth.

2. Theoretical underpinnings and development of hypotheses

2.1. The ELM

Since its introduction in 1979 by Petty and Cacioppo, the ELM has become one of the most prominent and influential frameworks in understanding message evaluation and persuasion. It has inspired a plethora of research studies, particularly in marketing and advertising (Kitchen et al., 2014; Schumann et al., 2012). The model is widely supported academically due to its clear processes, versatile outcomes, and extensive references (Jackson, 2005; Kitchen et al., 2014).

ELM's core concept revolves around two persuasion routes: the central and peripheral routes (Petty and Cacioppo, 1979, 1981; Petty et al., 1983). Petty and Cacioppo (1981) explained that these routes represent two distinct ways in which individuals process messages and become persuaded, based on their likelihood to elaborate, which is influenced by motivation and ability (Petty and Cacioppo, 1981; Petty et al., 1983). High motivation and ability lead to a high likelihood of elaboration, while the absence of these factors results in low likelihood. Abilities include factors like distraction, message clarity, or familiarity with the issue, while motivation stems from the need for cognition and personal relevance (Petty et al., 1983) and is later referred to as "response involvement" - the outcomes resulting from the elaboration process (Kitchen et al., 2014; Petty and Cacioppo, 1986). In recyclable packaging, central processing occurs through recycling signs or symbols, usually found on the back of packaging, while packaging materials and colours act as peripheral cues (Grunert, 2011; Herbes et al., 2018).

The ELM has been widely applied to study consumer responses to sustainability messages (Manca et al., 2020; Liu et al., 2022), highlighting its relevance to this research. Herbes et al. (2018) and Grunert (2011) identified specific processing routes in relation to recyclable packaging, further supporting the framework's suitability for investigating the variables in this context.

According to the ELM, successful elaboration leads to attitudinal change toward the behaviour promoted by the message. The persistence of the attitude shift and the strength of the intention depend on the processing route used (Cialdini et al., 1973; Chang et al., 2020; Manca et al., 2020). Previous research has explored how the two processing routes influence attitudinal change and behavioural intention (Liu et al., 2022). These concepts and hypotheses will be discussed further in the literature.

2.2. Semiotic knowledge as the outcome of central processing

Previous research has shown that environmental knowledge (EK) is a key factor in the success of central processing of sustainable messages (Liu et al., 2022). EK's general definition is an individual's awareness of the consequences of irresponsible consumption and is considered an important predictor of sustainable behaviour (Chang et al., 2014; Joshi and Rahman, 2015). Two types of EK are discussed in literature. One is general EK - consumers' awareness of critical environmental issues and the effects of environmentally harmful consumption (Kumar et al., 2017; Sun et al., 2022). This type of knowledge generates one's level of environmental concern; a construct widely studied in the literature. However, because general EK is not context-specific, many researchers have suggested its impact is often overestimated (Joshi and Rahman, 2015).

The second type of EK involves one's understanding of how to take specific actions on environmental matters, such as correctly recycling in this case (D'Souza, 2005). This form of knowledge is communicated through cues on recyclable packaging, like recycling symbols, which indicate the EK obtained through in-depth (central) processing of such cues (Grunert, 2011; Herbes et al., 2018). Therefore, it is both conceptually and practically appropriate to link the effectiveness of centrally processing recyclable packaging to one's knowledgeability of recycling symbols - a concept referred to as *semiotic knowledge* in this study.

Semiotic knowledge, according to prior research, encompasses consumers' overall ability to recognise and understand the signs used on recyclable packaging (D'Souza, 2005; Grunert, 2011; Herbes et al., 2018). Additionally, Chang et al. (2020) argued that perceived information completeness - how sufficient consumers believe the information is, serves as an indicator of successful central processing, supporting the definition of semiotic knowledge in this context. This leads us to propose a hypothesis regarding the outcome of central processing:

H1. Semiotic knowledge positively influences consumers' attitudes towards recycling shopping behaviour

2.3. Emotions as the outcome of peripheral route of processing

Persuasion via the peripheral route is influenced by secondary cues like packaging designs or colour, especially in recycling contexts (Grunert, 2011; Ketelsen et al., 2020; Petty and Cacioppo, 1981; Petty et al., 1983). This type of processing may lead to only short-term shifts in attitude but behavioural changes. Long-term changes in both attitude and behaviour, on the other hand, are generally achieved through central route processing. Repeated exposure to peripheral cues can gradually strengthen temporary attitude changes, which may eventually lead to central processing as the elaboration likelihood increases. Scholars have recognised that the ELM allows for simultaneous processing through both central and peripheral routes (Kitchen et al., 2014; Petty and Cacioppo, 1981, 1986; Petty et al., 1983), suggesting that consumers may engage with both pathways at once, influencing their attitudes. Kitchen et al. (2014) emphasised the need for further research into how central route persuasion can be enhanced, particularly in promoting sustainable consumption.

Research indicates that emotions can signal peripheral route processing (Liu et al., 2022). In recycling, the colour green on packaging has been shown to serve as a peripheral cue that fosters positive emotions and perceived social value (Felix et al., 2020). Emotional responses triggered by environmental factors are associated with a positive affective state (Batra and Ray, 1986; MacKenzie and Lutz, 1989), which can lead individuals to focus more on abstract, peripheral cues rather than detailed, central information (Liu et al., 2022). The hypothesis is therefore developed as follow to reflect the outcome of the peripheral route of processing of recycling cues:

H2. Positive emotions for recycling positively influence consumers' attitudes towards recycling shopping behaviour

2.4. Motivations for the processing routes

2.4.1. Recycling considerations for central processing

Since the central processing cues (recycling signs) are designed to convey the specific recyclability of packaging, and the attitudinal shift is aimed at influencing one's intention to recycle shopping to ultimately support recycling activities, the motivation or degree of personal relevance that affects the likelihood of elaboration via this route can be described as recycling considerations (Petty et al., 1983). Recycling considerations stimulate the cognitive factors consumers must consider when adopting recycling initiatives, including recycling shopping behaviour.

Defined as the consideration of recycling before making a purchase (Carrington et al., 2014), this pre-decision thought process would likely encourage consumers to be part of a cognitive elaboration process through central elements as the official indicators of packaging recyclability, leading to a positive shift in attitudes towards purchasing intentions in retail settings. Moreover, additional hypotheses can be developed to investigate the direct vs. indirect effects of recycling considerations on consumers' attitudes toward recycling shopping behaviour, with semiotic knowledge acting as a mediator. It is anticipated that the indirect path (recycling considerations–SK–Attitudes) will have more substantial effects, as consumers will have acquired a certain level of information about packaging recyclability before experiencing any attitudinal changes.

H3a. Recycling consideration positively influences consumers' semiotic knowledge

H3b. Recycling consideration positively influences consumers' attitudes towards recycling shopping

2.4.2. Environmental concern (EC) as a motivation for peripheral route of processing

One's consciousness of environmental issues and individual irresponsible consumption behaviour results in their concerns about the environment. EC is defined as the measured degree of one's apprehension of environmental issues (Kilbourne and Pickett, 2008). Being characterised as an individual's general concerns about the environment without any contextual specificity, EC does not necessarily drive consumers' focus on information provided by recycling cues for a cognitive outcome (Magnier and Schoormans, 2015; Magnier and Crié, 2015; Steenis et al., 2017; Herbes et al., 2018). In other words, EC triggers no motivation towards any specific behaviour, encouraging consumers to concentrate on peripheral cues (packaging materials/colours) instead (Liu et al., 2022). Research has suggested that those with high degrees of EC are associated with positive emotional responses to green advertising and sustainable marketing attempts, including recyclable packaging (Joshi and Rahman, 2015; Magnier and Schoormans, 2015; Magnier and Crié, 2015; Steenis et al., 2017; Herbes et al., 2018; Ibanez and Roussel, 2021). In the same manner as semiotic knowledge, hypotheses can be formed to draw a comparison between the direct and indirect effects of EC on attitudinal change via emotions:

H4a. EC positively enhances consumers' emotions towards recycling

H4b. EC positively enhances consumers' attitudes towards recycling shopping 2.5 The TPB

The TPB was originated from the Theory of Reasoned Action (TRA) (Ajzen and Fishbein, 1980). By introducing the additional construct of Perceived Behavioural Control (PBC), TPB addressed the constraints of TRA over "*behaviours over which people have incomplete volitional control*" (Ajzen, 1991). The TPB is among the most extensively quantitatively tested, and subsequently widely used in both social and business marketing contexts (Eagle et al., 2013) to predict sustainable behavioural intention. TPB examines one's behavioural intentions using the three constructs – attitude towards the behaviour, subjective norms, and PBC. Attitudes refer to the extent to which a person has favourable or unfavourable appraisal of an action, whereas subjective norms, usually being translated into social norms and personal norms/ morality (i.e., the social norms that have been personally internalised), refer to one's perceived pressure from the society on performing or not performing the behaviour. The last construct, which is also the additional antecedent to TPB, is PBC – one's perceptions of the resources or conditions required towards executing the behaviour in question. While the constructs of attitudes and subjective norms are measured using consistent scales, within the domain of sustainable behaviour, those of PBC may vary according to the contexts, ranging from convenience, opportunities, costs and available infrastructure for recycling intention (Ramayah et al., 2012; Chan and Bishop, 2013; Botetzagias et al., 2015), or availability and affordability of purchasing green products (Paul et al., 2016; Scalco et al., 2017; Hsu et al., 2017; Prakash and Pathak, 2017; Singh and Pandey, 2018). Some studies seek to measure PBC using more generic scales of one's perceived levels of difficulties or ease of taking action (White et al., 2009; Brockhaus et al., 2016; Mak et al., 2018; Clark et al., 2019). In this sense, PBC has also been measured as the perceived ability to carry out the behaviour of interest.

The framework is one of the most prominent in investigating behavioural intentions (Paul et al., 2016; Scalco et al., 2017; Hsu et al.,

2017; Prakash and Pathak, 2017; Singh and Pandey, 2018). To explore the differentiated effects of the two processing routes on purchasing intention, the use of TPB is plausible and desirable. Three hypotheses are therefore formed to reflect the original constructs of the model to predict the dependent variable in this study - recycling shopping intention.

H5a. Consumers' attitudes towards recycling shopping positively influence their intention

H5b. Consumers' subjective norms towards recycling shopping positively influence their intentions.

H5c. Consumers' perceived behavioural control towards recycling shopping positively influences their intentions.

2.5. Integration of the ELM and TPB

Although these two theoretical frameworks have been used separately in previous research works to investigate behaviour, some researchers suggested that they should both be expanded and investigated (Bitner and Obermiller, 1985; Meng and Choi, 2019; Liu et al., 2022). In this study, it is worth noting that the researchers primarily aimed at investigating the outcomes of two processing routes as the indicators of the ELM's constructs, i.e., semiotic knowledge and emotions, and their differentiated effects on intention. It was argued that, to investigate the two routes' differentiated effects on attitudinal change and behavioural intention, an adoption of a full theory of behavioural intention is advised, to engender sufficient conditions for successful behavioural change (Liu et al., 2022). Thus, the two hypotheses on PBC and subjective norms were developed for the purpose of successful behavioural intention to be investigated, and no further relationships with these variables were discussed.

The authors combined the two frameworks into one integrated model that expands the TPB by incorporating additional constructs originated by the ELM and adapted to the context of recyclable packaging (i.e., semiotic knowledge, emotions, recycling consideration and environmental concerns as motivations), to validate consumers' processing of recycling information. The integrated model is illustrated below in Fig. 1. The paper presents theoretical contributions including the novel antecedents of attitudes (i.e., semiotic knowledge and recycling consideration) to extend the TPB, which has always been desirable to further understand sustainable behaviour (Correia et al., 2022). Semiotic knowledge will also be tested on its ability to secure central processing as the dominating route, addressing the limitations of the ELM's dual processing.

3. Methodology

3.1. Data collection

The sample consists of adults aged 18 and older, as the concepts of recycling and purchasing intentions are challenging for minors to understand (Chan, 2001). The research adhered to Hair et al.'s (1998)

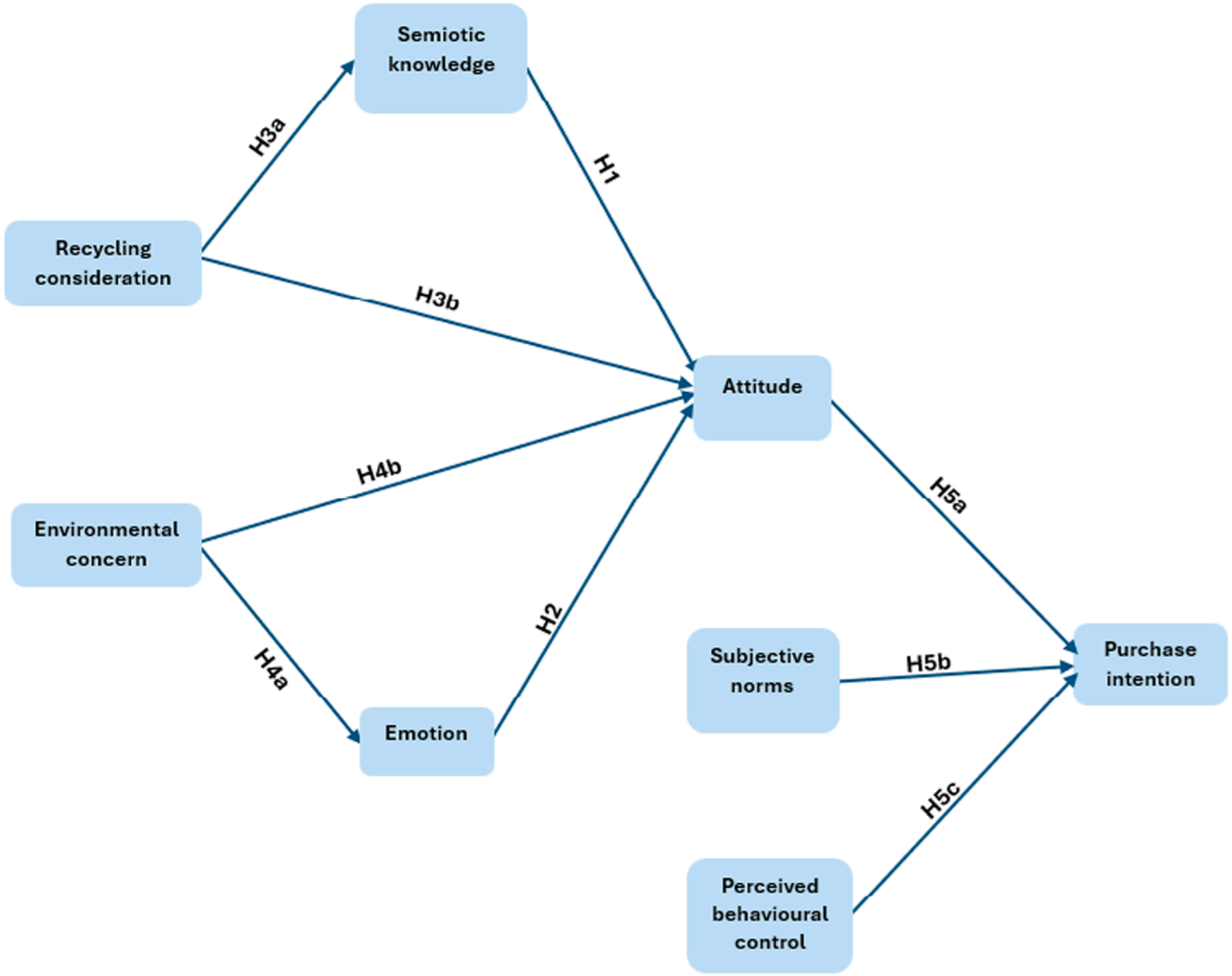

Fig. 1. – The integrated model.

suggestion of having roughly 20 respondents per variable, with 426 individuals initially recruited across Australia. However, 6 respondents were excluded from the final dataset due to excessive neutral answers (rated 3 on a 1–5 scale), leaving a final sample of 420, which is sufficient for structural equation modeling (Boomsma, 1987). Of these, 43.8 % were male and 56.2 % were female. The study also aimed at gathering a sample that was evenly distributed across various demographic characteristics to avoid potential biases related to these factors in sustainable consumption (Kim and Seock, 2019). Respondents were recruited and incentivised through Qualtrics, a well-known online survey company with access to population data, which also managed the survey and response rates. Thanks to Qualtrics' expertise, the response rate was as high as 80 %. Stratified random sampling was used, ensuring an unbiased and representative sample, giving each demographic group an equal chance of being selected. An information consent was displayed on the first page of the online survey, where respondents could choose to opt out, should they not agree to the conditions of the study.

The first screening question asked about the respondents' recycling habits, with those answering "Never" or "Rarely" deemed ineligible, ensuring participants engage in recycling and are familiar with the concept. All questions were asked about products with "*recyclable packaging*", which is not the same as those with recycled content. Some products with recycled packaging cannot be recycled any further; therefore, are not within the scope of this paper.

3.2. Measure

The questions to measure the TPB's constructs were taken and adapted from existing literature (Ajzen and Fishbein, 1980; Fishbein and Ajzen, 1975; Ajzen, 2006; Yadav and Pathak, 2016; Paul et al., 2016; Mak et al., 2018). The scales for measuring semiotic knowledge were adapted from two high-quality papers which measured consumers' knowledge of brands and visual rhetoric (Yoo, 2014; Bulmer and Buchanan-Oliver, 2006). The questions on the ELM were drawn and adapted from Cyr et al. (2018) and Liu et al. (2022). The authors also referred to the Marketing Scales Handbook (Bruner, 2009) for the other questions and to further validate those above scales.

4. Analysis process and result discussion

4.1. Measurement model

Due to the nature of the constructs being independent of the measures, and the investigated model being a reflective one, CB-SEM was employed (Dash and Paul, 2021; Coltman et al., 2008). The authors adopted the two-step approach to building a model recommended by Timm (2002) and Byrne (2004). The measurement model was examined before the structural model, so that the lack of fit could be assigned the measurement only. The relevant fitness indices were referred to warrant the fitness of the models. To increase the model fit, an assessment of the item's factor loadings and modification indices was conducted. Only question items with factor loadings of at least 0.5 were retained. As a result, 8 items were removed to ensure the measurement model is statistically and theoretically justified.

All measuring items had a factor loading of above 0.5, indicating that convergent validity had been achieved (Churchill, 1979). The model also obtained the required levels of fitness indices for all categories of model fit, with CFI (Comparative fit index)= 0.923, RMSEA (Root mean square error of approximation)= 0.057, and Chi-square/ df= 2.355.

Average Variance Extracted (AVE), Cronbach's α scores, and Composite Reliability (CR) were calculated to assess the scales' reliability and internal consistency. An AVE $\geq$ 0.5, α $\geq$ 0.7, and CR $\geq$ 0.6 is needed for each variable. With all AVE values being above 0.6, CR $\geq$ 0.9, and Cronbach's α scores ranging between 0.88 – 0.96, the scale's reliability and internal consistency were obtained (Hair et al., 1998). A discriminant validity index summary was then calculated to justify the constructs in the model are discriminant of each other. Essentially, the square root value of the AVE of each construct presented in the model needs to be greater than the correlation between respective ones, to achieve discriminant consistency (Fornell and Larcker, 1981). Table 1 below shows the AVE, CR, and Cronbach's α scores of the investigated constructs.

4.2. Common method variance (CMV)

Common method bias (CMB) is a frequent concern in behavioural research due to its focus on cognitive processing (Podsakoff et al., 2003). To address this issue, some approaches have been implemented, starting with careful design of measurement scales before data collection, along with using Harman's one-factor test for detection (MacKenzie and Podsakoff, 2012; Baumgartner et al., 2021). This study proactively identified potential sources of response bias and applied recommended preventative measures accordingly (MacKenzie and Podsakoff, 2012; Baumgartner et al., 2021). These steps included eliminating unclear or double-barrelled questions and maintaining respondent anonymity. Subsequently, Harman's single-factor test was conducted using all measurement items to assess common method variance (CMV). The analysis revealed that the single factor accounted for 45.24 % of the total variance, which is below the 50 % threshold. Common latent factor analysis showed minimal differences in regression weights (<0.200), as noted by Archimi et al. (2018). Based on these results, CMB was deemed unlikely to have significantly influenced the findings.

4.3. Hypothesis testing

The main hypotheses were tested based on the estimation of the structural model, using the combined sample (n = 420). The structural model displayed satisfactory fitness indices across the categories, with GFI (Goodness-of-fit index)= 0.979, AGFI (Adjusted goodness-of-fit index)= 0.974, RMSEA= 0.023, and Chi-square/ df= 1.226.

All hypotheses were supported except for H2. The p-values displayed significant results across paths except for emotions and attitude. Mediation analyses were performed using a bias-corrected bootstrapping procedure of 2000 samples and two-tailed significance. All the original constructs of the TPB (attitudes, subjective norms, and PBC) were found to exert positive and significant impacts on purchasing intention ($\beta_{attitude}$= 0.435, $\beta_{subjective\ norms}$= 0.372, β_{PBC}= 0.365 respectively, $p <$ 0.001). Both recycling considerations and EC displayed significant influence on attitudes (β_{RC}= 0.492, β_{EC}= 0.294 respectively, $p < 0.001$; however, the peripheral route via emotions showed insignificant result. These findings are plausible and well address the issue of ELM's dual processing, which calls for further research on the circumstances where the central route will be more pronounced.

Semiotic knowledge displayed a positive and significant impact on attitudes, indicating an attitudinal change as a result of central processing (β= 0.129). Recycling considerations showed positive and significant impacts on both SK and attitudes, indicating both direct and indirect effects (β = 0.458, β= 0.492 respectively, $p < 0.001$). The total effect of recycling consideration on attitudes was stronger with the mediation of SK (β= 0.502 vs. β= 0.492, $p < 0.001$), which well reflects the authors' argument that attitudinal change would be more enhanced when consumers process central cues (SK). Table 2 shows the hypothesis testing and results.

5. Discussion

5.1. Theoretical contributions

The study extended the TPB and ELM models by proposing a framework integration in the context of recycling shopping, introducing the new construct of semiotic knowledge as an antecedent for attitudinal change. Under the positive influence of one's consideration to recycle,

Table 1
Discriminant validity.

Construct	1	2	3	4	5	6	7	8
1. Attitude	**0.86**							
2. Subjective norms	0.64	**0.86**						
3. PBC	0.62	0.58	**0.79**					
4. SK	0.51	0.59	0.54	**0.89**				
5. RC	0.68	0.39	0.52	0.36	**0.76**			
6. EM	0.50	0.62	0.39	0.48	0.35	**0.82**		
7. EC	0.67	0.69	0.56	0.49	0.47	0.63	**0.87**	
8. PI	0.75	0.78	0.69	0.61	0.56	0.63	0.80	**0.89**
AVE	**0.74**	**0.75**	**0.62**	**0.79**	**0.58**	**0.67**	**0.76**	**0.80**
CR	**0.96**	**0.95**	**0.92**	**0.96**	**0.91**	**0.91**	**0.96**	**0.95**
Cronbach's α	**0.96**	**0.93**	**0.91**	**0.96**	**0.88**	**0.90**	**0.95**	**0.95**

Note: PBC= perceived behavioural control, SK= semiotic knowledge, RC= recycling consideration, EM= emotions, EC= environmental concern, PI= purchasing intention.

Table 2
Hypothesis testing and results.

Combined sample							
Path				**Standardised**	**SE**	**CR**	**Result**
H1	SK	➔	Attitudes	0.129 ***	0.029	4.401	Supported
H2	Emotions	➔	Attitudes	0.050 ^{ns}	0.033	1.518	Not supported
H3a	RC	➔	SK	0.458 ***	0.056	8.143	Supported
H3b	RC	➔	Attitudes	0.492 ***	0.036	13.824	Supported
H4a	EC	➔	Emotions	0.579 ***	0.031	18.491	Supported
H4b	EC	➔	Attitudes	0.294***	0.032	9.164	Supported
H5a	Attitudes	➔	Purchasing intention	0.435 ***	0.066	6.612	Supported
H5b	Subjective norms	➔	Purchasing intention	0.372 ***	0.038	9.899	Supported
H5c	PBC	➔	Purchasing intention	0.365 ***	0.063	5.796	Supported

Note: ***$p < 0.01$, **$p < 0.05$.
^{ns} non-significant. PBC= perceived behavioural control, RC= recycling consideration, EC= environmental concern, SK= semiotic knowledge.

consumers were encouraged to adopt the central route of processing, i.e., recycling signs or symbols, to successfully achieve semiotic knowledge. The subsequent outcome is the favourable attitudes towards recycling shopping intention, significantly strengthening the act. What is more interesting is that stronger influence was observed through the indirect effects of recycling consideration towards attitudes through semiotic knowledge versus direct ones, emphasising the important role of these recycling signs. On the other hand, emotions, as an indicator of peripheral processing of packaging materials or colour, showed no influence on one's attitudes (Petty and Cacioppo, 1979, 1981; Petty et al., 1983) in this research context. Past research had indicated that consumers' positive emotions displayed inconsistent effects on sustainable behaviour since individuals prefer contributing to sustainability in the way they are more knowledgeable of (Steenis et al., 2017), explaining this plausible outcome of the ELM in the study.

With regards to the ELM, dual processing via the two routes was commonly confirmed in past research studies (ShabbirHusain et al., 2024), and peripheral route was even found to be more dominant in some cases (Nguyen and D'Souza, 2025; ShabbirHusain et al., 2024). This is why the issue had been rather discussed as a limitation (Kitchen et al., 2014), suggesting that further research would be required to distinguish the two routes and preferably, explore how the central route could be emphasised. At least in the context of recycling shopping in Australia, that this study provided sufficient evidence to conclude that consumers' processing of recycling signs as the central route will work as the dominated route, eliminating the possibility of dual effects from peripheral one (environmental concern-emotions). In this sense, the study has also successfully justified the true effectiveness of recycling signs on packaging, which was previously hindered by consumers' prevalent attention to packaging materials or colour (Herbes et al., 2018; Grunert, 2011). A more streamlined policy can be introduced in this domain as a result.

The study is also among the firsts to investigate the role of semiotic knowledge (SK), extending the list of antecedents of both the ELM and TPB. Although the study suggested that EC significantly and positively influenced both attitudes and emotions, affirming its role as an important antecedent of sustainable behaviour in literature (Herbes et al., 2018, Gleim et al., 2013, Pancer et al., 2017, Magnier and Schoormans, 2015, Joshi and Rahman, 2015), EC's overestimation was also discussed by some researchers (Magnier and Schoormans, 2015; Joshi and Rahman, 2015), especially when those with a high degree of EC are observed to show inconsistent sustainable behaviour (Magnier and Schoormans, 2015; Magnier and Crié, 2015; Steenis et al., 2017). Therefore, the significant impacts of SK and recycling considerations found in this study indicate an alternative antecedent to be focused on in the context of recycling, simultaneously responding to the call for further research not only on the TPB (Correia et al., 2022), but also on recyclable packaging signs/ symbols – the very means of communication for packaging recyclability (Australian Packaging Covenant, 2018, Department of Climate Change, Energy, the Environment and Water, 2022).

Finally, the paper contributed to the body of knowledge of CE, by adding the new construct of semiotic knowledge and addressing the issue concerning the type of knowledge to enhance recycling behaviour to prolong the cycle of materials and products (Grafstrom and Aasma, 2021). Enhanced information was suggested to increase recycling rates; however, the type of information was not articulated in theories and hence still hampers recycling behaviour from consumers, aligning with the issue of peripheral and central routes of processing on recyclable packaging cues (Herbes et al., 2018; Grunert, 2011). Therefore, the introduction of semiotic knowledge is not only a contribution to the theory of ELM and TPB, but also a step further for theorists within the research domain of CE. Providing individuals with sufficient knowledge of recyclability signs will therefore partly address this predetermined issue of CE from the consumers' dimension (Shevchenko et al., 2023), shifting the future research's focus on the other dimensions instead.

5.2. Managerial implications and policy recommendations

Valuable recommendations can be provided with regards to companies' marketing efforts to communicate packaging recyclability in retail stores. The findings diminish the impacts of packaging materials or colour, which are abundant in use and limited in effectiveness (Ketelsen et al., 2020; Herbes et al., 2018; Grunert, 2011; Rokka and Uusitalo, 2008). Manufacturers should focus on promoting recycling signs/ symbols and assisting consumers with achieving sufficient levels of semiotic knowledge to enhance their intentions of buying products with this type of packaging. This can be done by repositioning the recycling signs on packaging to subsequently enhance consumers' attention to in retail stores or provide semiotic knowledge in commercial marketing campaigns, as per the perception process (Babin and Harris, 2018). This will also help companies to fulfill their commitments to curtailing waste generation (The United Nations, 2021). This task is not far-fetched, given the availability of these signs on both corporates and government's websites (Department of Climate Change, Energy, the Environment and Water, 2022; the Coca-Cola Company Australia, 2022).

The sole significant influence of SK on attitudes (vs emotions) emphasised the need for promoting pre-purchase thought of recycling among consumers instead of a generic concern towards the environment. Indeed, those who are merely concerned about the environment may retrieve unintended messages after processing peripheral information from the packaging. In line with past research which indicated that consumers might mistake green messages as a price-increasing tactic, packaging materials/colours in the peripheral route may fail to convey a clear message towards packaging recyclability; therefore, not essentially benefit recycling shopping. Promoting recycling consideration before one's shopping journey is thus advised, to encourage in-store processing of recyclable packaging's central cues (Horne, 2009; Carrington et al., 2014; Nguyen and D'Souza, 2025) and subsequently enhance purchase intention of products with recyclable packaging. A reminder poster at the entrance of supermarkets, for example, will do the job.

Following the suggested recommendation towards commercial partners' enhanced efforts to provide consumers with adequate knowledge of signs through their in-store packaging modifications and advertising campaigns, policies can be introduced to ensure compliance. Mandating certain pieces of information in advertising or product packaging is not a new initiative when such details as ingredients, calory intakes, or health star rankings are compulsory in advertising materials (Australian Competition and Consumer Commission, 2021). In the same sense, since manufacturers have already signed agreements to achieve recycling/ waste reduction targets by 2030 (The United Nations, 2021, Department of Climate Change, Energy, the Environment and Water, 2022, the Coca-Cola Company Australia, 2022), enforcing relevant regulations is not at all unreasonable. This proposed scheme to mandate manufacturers' focus on recycling signs will also help prevent firms' greenwashing activities which usually exploit consumers' sole attention on packaging materials or colour. In addition, the Government can also introduce a streamlined, universal category of waste-reduction signs and their meanings to be adopted by companies, through their social marketing campaigns. The combined efforts from both local councils and businesses will generate heightened semiotic knowledge among people, boosting both purchasing and recycling behaviours.

6. Limitations and future research

The research has its limitations, which open opportunities for future studies. While this paper justifies the investigation of behavioural intentions, a follow-up study that examines actual behavioural change would gather more conclusive results. Future research could also explore how factors such as situational variables or demographic characteristics affect the impacts of both central and peripheral routes on recycling shopping behaviour. Further understanding of how the effects of these two routes can be enhanced would be valuable. Additionally, studying the duration of attitude changes resulting from each route (short-term vs. long-term) based on the ELM would help confirm the importance of central processing through recycling signs. Lastly, since recycling signs are typically represented as symbols on packaging, it would be beneficial to investigate how different types of signs (icons, indexes, and symbols) or the addition of written communication influence consumers' perception of semiotic knowledge. This would be an interesting direction for an experimental study, as indexes have been suggested to be more effective in conveying sustainable messages and intentions (Ewing et al., 2012), although there is limited research on their application in recycling contexts.

CRediT authorship contribution statement

Dung Trung (Ben) Nguyen: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Clare D'Souza:** Validation, Supervision, Project administration.

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.

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Appendix A. – Measuring items and factor loadings

Purchase intention AVE= 0.80 CR= 0.95 α= 0.95	Factor loading scores
1 What is the likelihood that you would buy products with recyclable packaging in retail stores?	0.868
2 Please rate the probability that you would buy products with recyclable packaging in retail stores?	0.913
3 In the future, I will try to purchase products with recyclable packaging in retail stores	0.857
4 In the future, I am going to purchase products with recyclable packaging in retail stores	0.914
5 In the future, I will plan to purchase products with recyclable packaging in retail stores	0.917
Recycling consideration AVE = 0.58 CR = 0.91 α = 0.88	
Please rate the likelihood of you considering recycling, before shopping in retail stores, on a scale 1–5	
1 Likely	0.792
2 Existent	0.720
3 Definitely	0.699
4 Certain	0.630
5 Possible	0.895
6 Probable	0.911

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(*continued*)

Purchase intention AVE= 0.80 CR= 0.95 α= 0.95	Factor loading scores
7 Very frequent	0.853
8 Probably	0.922
Attitude AVE = 0.74 CR = 0.96 α = 0.96	
How do you find purchasing products with recyclable packaging, on a scale 1–5	
1 Good	0.886
2 Important	0.896
3 Satisfactory	0.888
4 Superior	0.810
5 Excellent	0.882
6 Useful	0.902
7 Beneficial	0.736
8 Favourable	0.872
9 Positive	0.852
Emotions AVE = 0.67 CR = 0.91 α = 0.90	
How would you feel whenever you fail to consider recycling? (Reversed scales)	
1 Angry	0.787
2 Guilty	0.783
3 Sad	0.803
4 Regretful	0.858
5 Depressed	0.844
Semiotic knowledge AVE = 0.79 CR = 0.96 α = 0.96	
The following questions will be asked with regards to the recyclable signs in general that you may find on a variety of packaged products in retail stores	
1 Recyclable packaging signs are familiar to me	0.914
2 I know about most recyclable packaging signs	0.907
3 I am aware of recyclable packaging signs	0.895
4 I can comprehend recyclable packaging signs	0.930
5 I make decisions based on these recyclable packaging signs	0.819
6 I fully comprehend what recyclable packaging signs want me to do	0.856
7 I have no trouble understanding the messages delivered by recyclable packaging signs	0.888
Environmental concern AVE = 0.76 CR = 0.96 α = 0.95	
1 I am very concerned about the environment	0.887
2 I am concerned about the natural resource shortages in the future	0.873
3 I would be willing to reduce my consumption to protect the environment	0.892
4 I would give up some economic good for a cleaner environment	0.865
5 Major social changes are necessary to protect the natural environment	0.847
6 Anti-pollution laws should be enforced more strongly	0.856
7 We all need to change our behaviour to protect the natural environment	0.899
8 The balance of nature is delicate and can be easily upset	0.835
Subjective norms AVE = 0.75 CR = 0.95 α = 0.93	
1 Most people who are important to me would purchase products with recyclable packaging	0.878
2 Most people who are important to me would want me to purchase products with recyclable packaging	0.913
3 Most people who are important to me would think I should purchase products with recyclable packaging	0.912
4 My friends' positive opinions influence me to purchase products with recyclable packaging	0.852
5 My family's positive opinions influence me to purchase products with recyclable packaging	0.870
6 My neighbours' positive opinions influence me to products with recyclable packaging	0.747
Perceived Behavioural Control AVE = 0.62 CR = 0.92 α = 0.91	
1 Whether or not I purchase products with recyclable packaging is completely up to me	0.562
2 I have the necessary resources, time, and opportunities to purchase products with recyclable packaging	0.810
3 I am confident that I have the ability to purchase products with recyclable packaging	0.847
4 I feel that purchasing products with recyclable packaging is totally within my control	0.811
5 There are likely to be plenty of opportunities for me to purchase products with recyclable packaging	0.853
6 I see myself as capable of purchasing products with recyclable packaging	0.832
7 Products with recyclable packaging are generally available in the shops where I usually do my shopping	0.751

Source: Authors own work

Appendix B. – Demographics

	Frequency	*Percent*
Gender (Std. Dev. 0.497)		
Male	184	43.8
Female	236	56.2
Total	420	100.0
Age (Std. Dev. 1.601)		
18–24	16	3.8
25–34	70	16.7
35–44	63	15.0
45–54	65	15.5
55–64	73	17.4
65+	133	31.7
Total	420	100.0
Recycling frequency (Std. Dev. 0.682)		
Occasionally	46	11.0

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(*continued*)

	Frequency	*Percent*
Often	159	37.9
Always	215	51.2
Total	420	100.0
Employment status (Std. Dev. 2.810)		
Employed full-time	126	30
Employed part-time	70	16.7
Self-employed	20	4.8
Unemployed	38	9.0
Retired	123	29.3
Student	4	1.0
Homemaker	32	7.6
Other	7	1.7
Total	420	100
Annual income before tax (Std. Dev. 2.010)		
$0-$24,999	93	22.1
$25,000-$49,999	113	26.9
$50,000-$74,999	96	22.9
$75,000-$99,999	54	12.9
$100,000 or greater	64	15.2
Total	420	100
Highest level of education (Std. Dev. 1.113)		
Primary school	6	1.4
High school	110	26.2
TAFE/ Technical certificate or diploma	144	34.3
University degree	109	26.0
Post-graduate degree or higher	48	11.4
Other	3	0.7
Total	420	100

Source: Authors own work

Data availability

Data will be made available on request.

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