Walking and cycling infrastructure priorities: Qualitative testing of a Best-Worst Scaling experiment

Fahad Albahlal
Cardiff University
Paul Haggar
University of Bath
Dimitris Potoglou (potogloud@cardiff.ac.uk)
Cardiff University

Research Article

Keywords: Cognitive interviewing, pretesting, validity, best-worst scaling, walking, walking and cycling auditing tools

Posted Date: October 31st, 2022

DOI: https://doi.org/10.21203/rs.3.rs-2179978/v1

Abstract

The built environment plays an important role on individuals' propensity to walk and cycle and local authorities increasingly invest financial resources towards their development. Organisations managing the built environment have developed auditing tools as guidelines to inspect routes and identify improvements to support active travel. Using several auditing tools, this study developed 21 walking and 25 cycling investment-relevant factors that were embedded into two choice-based survey instruments focusing on walking and cycling, respectively. The study aims to internally validate a preference-based elicitation approach known as Best-Worst Scaling (BWS) aimed to capture pedestrian and cyclist preferences. Preferences directly translate into investment priorities aimed at increasing the rates of walking and cycling. As part of a survey instrument, these experiments will help obtain a ranking (preference) order of the most and least important factors that are likely to encourage people to walk and cycle on a common scale. We report findings on the internal validity of the BWS choice tasks as these were examined via a series of cognitive interviews with 20 participants (10 participants for each experiment). In both sets of interviews, four themes emerged regarding how the participants approached the BWS task and six themes related to the understanding of the factors.

The study findings provide insights on how participants perceive BWS experiments, which can improve our large-scale BWS survey and similar studies. Furthermore, the study aims to produce an internally consistent BWS instrument that any local authority can use to determine which walking and cycling infrastructure investments to prioritise.

1. Introduction

The importance of the physical environment in encouraging physical activity, and thus in improving public health, is widely recognised (Frank and Engelke, 2001; Handy et al., 2002; Jackson, 2003). Mayne et al. (2015) and Smith et al. (2017) systematically reviewed the literature on the effects of different types of interventions in the built environment on physical activity. They found that infrastructure improvements, mainly targeting active travel, have greater impacts on physical activity. Public policy increasingly focuses on improving the built environment in ways to encourage people to walk and cycle for different purposes (UK Department for Transport, 2020). Similarly, organisations responsible for designing, managing and planning for the built environment have developed auditing tools as guidelines to assess the quality of routes and identify improvements to support active travel. Such walking and cycling auditing tools have been developed for assessing micro-level pedestrian and cyclist environments in the UK (Beynon et al., 2014; Millington et al., 2009), North America (Cain et al., 2012; Day et al., 2006; Nabors et al., 2012, 2007), Australia (ARRB, 2011; Clifton et al., 2007; Pikora et al., 2002; Taylor et al., 2017), Canada (MTO, 2014) and China (Cerin et al., 2011; Sun et al., 2017). Operating within a stringent financial environment, another way to use these auditing tools is to help identify citizen's priorities for (physical) interventions so that these will have an impact upon cycling and walking uptake. However, auditing tools involve a multitude of factors (e.g. normally more than 20) and identifying priorities using traditional ranking or rating exercises may lead to different complications and bias (Finn and Louviere,

1992; Soutar et al., 2015). For example, asking survey respondents to rank a set of more than 20 factors involves a significant cognitive burden even if respondents are familiar with the area of investigation. Most importantly, ranked items will be ordered without any further information regarding the relative level of importance between them. Among other issues, rating scales (e.g. Likert) involve inconsistencies in annotations by the same or different authors, scale region bias, the scale's constricted granularity (Adamsen et al., 2013) and the cognitive burden on respondents (Campbell and Erdem, 2015). Last but not least, every factor in the audit tool may be rated as important on the rating scale (Marti, 2012) thus making it impossible to identify priorities among the different factors. In this study, we employ an alternative approach to address the above shortcomings by using a preference-elicitation technique known as Best-Worst Scaling (BWS) as it affords adequate information to develop a definite scale and even more to improve individual-level scales (Flynn et al., 2007). BWS was introduced by Louviere and Woodworth (1990) as an extension of Thurstone's (1927) multiple-choice method of paired comparison. Finn and Louviere (1992) applied BWS as a different method to rating and ranking scales to obtain effective measures of relative preferences. The BWS method is centred on the idea of making the participants facing choices among sets of three or more options[1] and asks them to choose the "best" and the "worst" options of each collection (Soutar et al., 2015). Three types of BWS were developed by Louviere et al. (2015). Case 1, the "Object" case, is suitable when the analyst is concerned with the relative values related to each item (object) of a list of items (Flynn and Marley, 2014). Items are shown as stand-alone, with no attribute or level structure (Larranaga et al., 2019). Case 2, the "Profile or Attribute" case, was presented by Szeinrach (1999) and McIntosh and Louviere (Flynn and Marley, 2014). Profiles in Case 2, subsets of the complete list of attributes or items, are shown one at a time, and respondents indicate their choices within a profile (without considering the value of the profile as a whole) (Larranaga et al., 2019). Profiles should describe particular specifications of products or services, where each profile presents a combination of factors and their related levels (Louviere et al., 2015). Case 3, the "Multi-profile" case, is almost equivalent to a traditional Discrete Choice Experiments (DCEs) where respondents are asked to indicate their choices among entire profiles (Flynn, 2010). The information elicited using BWS is richer and cognitively easier than other rating or ranking scales (Marti, 2012). BWS requires participants to choose only the extreme "Best" and "Worst" on partial sets of the complete list; thus, much making it easier for respondents to provide their preference in an unbiased setting (Campbell and Erdem, 2015). The BWS approach can overcome response biases by asking respondents to distinguish between the items as there is only one way to choose the most or least important item; therefore, respondents cannot always choose the mid-points, end points or one end of a scale (Cohen and Markowitz, 2002). An operational advantage of BWS over rating scale is its simplicity and undemanding since respondents choose just one item for best and one for worst, that is eventually improving data quality (Soutar et al., 2015). Another advantage is that because BWS uses a common scale this is independent of cultural context thus an instrument can be applied across different countries (see, for instance, Auger et al. (2007)). In this study, we employed BWS – Case 1 as we treated auditing tools factors as 'objects' corresponding to aspects of the quality of walking and cycling as the selected factors stand-alone, with no level structure (see, Section 2). In particular, the focus of this study was to report the process of developing a universal BWS scale instrument for eliciting people's preferences and

demonstrate the value of cognitive interviews aimed at ensuring the internal validity of a BWS - Case 1 experiment to elicit people's priorities for walking and cycling prior to a large-scale quantitative survey. [1] As explained in the following paragraph, 'options' can be attributes (Case 1), attribute levels (Case 2) or alternatives (Case 3).

2. Methods

2.1 Identifying walking and cycling factors

We firstly synthesised evidence from numerous studies published between 2010 and 2020 to establish what has been documented as factors that encourage as well as those that discourage people from walking or cycling. Those factors were then matched with the corresponding factors in the "Design guidance: Active travel" published by the Welsh Government (Beynon et al., 2014). The guidance provides recommendations on creating, modifying, and managing the built environment to support infrastructure for active travel. The design guidance includes walking and cycling route auditing tools, comprising several factors under five categories: safety, directness, attractiveness, comfort, and cohesion. Twenty-one (21) walking factors and twenty-five (25) cycling factors were identified and then compared across other auditing tools within the UK and other countries.

Finally, each factor was presented with a brief description inferred from auditing tools. The initial list of walking and cycling factors used in this study is shown in Tables 1 and 2, respectively.

Table 1
Walking factors

No	Factor	No	Factor
1	Feeling safe while walking along the footways	12	The total time given for pedestrians to cross
2	Availability of lighting along the footway	13	The overall condition of the footway, viability of footway for walking and pushing a pushchair
3	Clear lines of sight to all pathway users from all directions	14	The width of the footway and the ability for pedestrians to maintain a distance from traffic
4	Adequate separation between traffic and the footway	15	How steep or hilly is the pathway?
5	Traffic volume low, or you can keep distance from moderate traffic volumes	16	The materials used to create a pavement for pedestrians
6	Traffic speeds low, or you can keep distance from moderate traffic speeds	17	Having no obstructions that restrict clearance width of the footway
7	Provision of continuous footways for walking journeys	18	Availability of measures to slow down traffic and give priority for pedestrians
8	Presence of footways from the origin point to destination with limited/minimal number of crossing points	19	The level of noise and air pollution that pedestrians might be exposed to
9	Crossing points follow desire lines	20	Street furniture and amenities (e.g. Benches and/or ledges for sitting. Rubbish bins. Drinking fountains. Heat lamps. Public restrooms)
10	Possibility of crossing a route where no controlled crossings present	21	Availability of dropped kerbs and tactile paving on the footway
11	Total time spent on crossings and its effect on trip time		

Table 2
Cycling factors

No	Factor	No	Factor
1	Pathway construction providing smooth and level surface	14	Cycling pathway clear of physical hazards such as evasion room, guardrail
2	Density of defects including raised/sunken covers, gullies, potholes	15	Routes should follow the shortest option available
3	Cycling comfortably without risk of conflict with other users (effective path width)	16	Cyclists have few stops or have priority over other vehicles
4	How steep or hilly is the pathway?	17	The length of delay caused by junctions
5	Feeling safe while riding a bicycle along the pathway	18	The length of delay caused by not being able to bypass slow moving traffic
6	Separation of cyclists from traffic	19	The ability for easily and safely join and navigate along the pathway and between different routes in the network
7	Availability of measures to reduce the risk of collisions at junctions	20	The continuity of cycling pathway
8	Non-complex and self-explanatory cycling network design	21	Availability of clear and direct signs towards destinations
9	Risk of collision resulted from conflict with kerbside activity	22	Availability of overlooked routes throughout its length
10	Reducing the speeds of motor vehicles on the shared route	23	Access to secure cycle parking
11	Risk of collision because of increasing traffic volume	24	The level of air pollution that cyclists might be exposed to on the pathway
12	Risk of collisions due to conflict with Heavy Good Vehicles (HGVs)	25	The level of noise that cyclists might be exposed to on the pathway
13	Availability of lighting along the pathway		

2.2 Experimental design of BWS Case 1

Following Louviere et al. (2013) recommendation on using a balanced incomplete block design (BIBD) to construct the choice cards for the BWS experiment that each would include a smaller number of factors instead of the full list of 21 factors for walking and 25 factors for cycling, respectively. To design the combinations of different factors into choice cards, we used two CRAN packages in R software (R Core Team, 2020), support.BWS (Aizaki, 2021) and crossdes (Sailer, 2013) to generate BIBDs for both experiments. A BIBD design involves a specific number of properties (Mark and White, 2021): firstly, the design matrix contains *t* number of factors (objects) shown in *b* number of choice cards; secondly, each

choice card contains k number of factors; finally, each factor (t) appears r times; finally, each pair of items appears λ times. The design is balanced when $\lambda = r(k-1)/(t-1)$ and both λ and r are integers.

In the BWS – Case 1 design for the walking experiments, $t = 21$ walking factors, $b = 21$ choice cards, $k = 5$ factors per choice card, each factor was repeated five times ($r = 5$), and each pairwise comparison occurs 1 time ($\lambda = 1$). The same with the cycling experiment except that $t = 25$ factors, $b = 30$ choice cards, and each factor was repeated six times ($r = 6$). Figure 1 shows the BIBDs for both experiments, in which rows refer to the number of the choice card, the five columns represent the five options in each choice card, and the numbers in each column are the factors numbered as in Tables 1 and 2.

2.3 Sampling and participants

Due to the Covid-19 pandemic restrictions, participants were recruited through Respondents.io, an online platform specifically for research purposes. The sample target was ten participants (five for each experiment). However, this process over-sampled female pedestrians and male cyclists. Therefore, 10 more participants were invited, using the platform to specifically target cyclists (being less common than pedestrians). The sample composition is shown in Table 3. The interviews took place between February and March 2021 and were conducted online using video conferencing software. The duration of the interviews was between 32 and 40 minutes. Ethical approval and informed consent were obtained prior to the commencement of the interviews.

Table 3
Participant's characteristics

Walking				Cycling			
No	Gender	Age	Education	No	Gender	Age	Education
P1	Male	18–24	Some higher education, no degree	P11	Male	35–44	Postgraduate
P2	Female	35–44	Undergraduate	P12	Male	25–34	Postgraduate
P3	Female	35–44	Postgraduate	P13	Male	25–34	Postgraduate
P4	Female	45–54	Undergraduate	P14	Male	25–34	Undergraduate
P5	Male	25–34	Undergraduate	P15	Female	25–34	Undergraduate
P6	Male	25–34	Undergraduate	P16	Female	25–34	Undergraduate
P7	Female	25–34	Postgraduate	P17	Female	35–44	Postgraduate
P8	Male	25–34	Some higher education, no degree	P18	Female	35–44	Postgraduate
P9	Male	35–44	Undergraduate	P19	Male	25–34	Undergraduate
P10	Female	35–44	Some higher education, no degree	P20	Female	25–34	Some higher education, no degree

2.4 Cognitive interviews

Cognitive interviews can use different techniques including "thinking aloud" and "verbal probing", which can be used in conjunction (Collins, 2003). The "thinking aloud" technique involves asking the respondents to verbalise their thoughts during questionnaire answering (Willis, 1999) and reveals the types of information that participants retrieve from memory when deciding their answer to an item or a question (Knafl et al., 2007). In the verbal probing technique, the interviewer asks specific questions based on the responses (Beatty and Willis, 2007) and asks the respondents to verbalise their understanding of questionnaire items and rephrase or comment on the items' wording (Knafl et al., 2007). We employed both techniques to elicit verbal information to assess how sufficiently the questions satisfy their aims (Beatty and Willis, 2007), and better understanding the questionnaire response process (Drennan, 2003).

The BWS choice task materials were presented on MS PowerPoint slides using the 'share screen' function in a video conferencing software. The interviews were semi-structured, audio-recorded, and notes were

taken throughout. The interview began with a brief introduction to the interview process including thinking aloud and verbal probing techniques. The introduction was then followed by three background questions shown one at a time (see Table 4). These questions were used as a practice to the main section of the cognitive interviews (Willis, 1999).

Table 4
Background questions

Walking experiment		Cycling experiment	
No	**Question**	**No**	**Question**
Q1	Are you able to walk comfortably for more than five minutes at a time? • Yes • No	Q1	Do you ride a bicycle? • Yes - and I have regular access to a bicycle (including borrowed or public hire bikes) • Yes - but I don't have regular access to a bicycle • No
Q2	Do you walk independently (un-assisted)? • Yes • No, I need assistance from others (e.g. family, friends, carer) • No, I need assistance (e.g. wheelchair, mobility scooter, guide dog)	Q2	How often do you ride a bicycle? • Once a week • Between 2 and 3 times a week • More than 3 times a week • Once a fortnight • Less than once a fortnight
Q3	How often do you walk? • Once a week • Between 2 and 3 times a week • More than 3 times a week • Once a fortnight • Less than once a fortnight	Q3	How long have you been cycling? • Less than 6 months • 6–12 months • 1–3 years • 3–5 years • More than 5 years

The participants were then shown the instructions to complete the BWS choice task (see, Fig. 2). Once read it, they were asked questions (see, Part A of Table 5) to probe their understanding of the task described.

Following the instructions slide, the first-choice cards was presented (see, Fig. 3 for an example). Each choice card involved a prompt text (repeated in each choice card) and a combination of five factors out of the total 21 factors (Table 1) in the walking experiment and out of the total 25 (Table 2) in the cycling experiment, respectively.

Once the participants completed the choice task, or when they were engaged in dialogue, they were asked several questions (see, Part B in Table 5) to better understand their thoughts and comprehension of the task and the reasons for choices.

Table 5
Cognitive probe questions

Part	Questions
A	● How did you find that?
	● Was there any part you had to go back and re-read
	● Was it easy or difficult to follow?
B	● How easy or difficult was this question to answer? Why?
	● So, which one would you choose is the most important for you? And which is the least?
	● I would like to ask you, in your own words, how would you describe the most important factor you chose?
	● Could you please put into words the least important factor that you chose?
	● Why did you choose the factors you did in this question?
	● What comes to mind for [word/phrase]?
	● Could you tell me a bit more about that?
	● You said ‘xxx’, perhaps you could elaborate on that for me?
	● Would you like to add any other factors you think are important?

2.5 Analysis plan

The analysis of the cognitive interviews was built upon coding and interpretation of recorded notes taken during the cognitive interviews (Willis and Artino, 2013). These notes usually indicate substantial observations about the functioning of an item. Verbatim transcription and notes relevant to each factor were aggregated across the interviews. All interesting features of the data, either dominant trends that repeatedly emerge or detected in a single interview, were coded. Interesting features include statements such as "there is a little bit of vagueness", indicating ambiguity; overlapping between two factors, as in "it almost seems like the fourth one is contained within the fifth"; and potentially including technical terms: "I have never really heard that word before, so I am not sure what that means" and such. Codes were sorted into a table with participant-rows and theme-columns, collating all data pertinent to each theme.

Willis (1999) observed that some discoveries in cognitive interviewing might turn out to be very important, even if they are only discovered in a single interview, because they can significantly impact data quality in some cases, or because these issues are still likely to be quite common in the final survey. Following a thematic analysis as described by Braun and Clarke (2006), a recursive rather than a linear process of

coding issues of the factors, aggregating codes into themes, reviewing, defining and naming themes was conducted to produce the results in the next section. The themes that emerged were categorised under two main groups: how the participants approached the BWS task and understanding of the factors.

3. Results

In both sets of interviews, 10 themes emerged with four were relating onto how the participants approached the BWS task, and six concerning the understanding of the factors. All themes are presented in detail in the following sections and in selected cases along with illustrative quotes from participants.

3.1 How the participants approached the BWS task

Four themes were identified in terms of how the participants approached the BWS task:

- Missing a frame of reference,
- Travel context,
- Decision-making strategy, and
- Concrete thinking.

Theme one: Missing a frame of reference

The repeated question on each choice card in both experiments “Out of the five factors below, which are The Most and The Least Important factors that would encourage you to (walk more/ride a bicycle)” lacked a frame of reference. Some participants were indecisive about making their choices and linked them to the purpose of travel. They often indicated that by saying, ‘it depends’:

- “I suppose it depends on the purpose of encouraging me to ride a bicycle, if it was for commuting and transport rather than pleasure then I suppose length of delay would probably be the most important factor” (P11);
- “I suppose it depends on the type of walk, if it's walking to work, the street furniture and amenities is probably neither here nor there. If it's going on a long walk, well, perhaps that is slightly more relevant” (P4).

Missing a frame of reference could make the question more difficult to answer, make people more uncertain in their answers, and could potentially lead to misinterpretation.

Theme two: Travel context

This theme is linked with the wording issue of the repeated question found in theme one. The cognitive interviews showed that some participants responded in terms of their current travel context rather than hypothetically. For example, P17 constantly interpreted the factors in terms of her situation: “If I was aware that a cycle pathway wasn't lit at all, I would probably avoid it. And so certainly sections of the

[cycle path through the park], I wouldn't cycle along there in the dark because they're not lit." Another participant (P18) said "In [the city] where I live, I don't think there was anything complicated about how, where to move and know where to cycle but maybe in [a city] like London or bigger cities, it's much more complex than where I am."

Further, one participant in the cycling experiment had a very much rural point of view. P12 answers were based on the countryside and never looked at the factors in terms of their preferences in the abstract. P12 pointed out having a sort of an 'urban bias', in that a lot of factors are in terms of urban environments, where there are lots of cycle paths and complex road structures, whereas in the countryside, it is much more basic. The participant did acknowledge that: "It's sort of semi-rural where I live, but if I lived in [a big city] probably navigating the city safely would probably ranking a bit higher for me. The signs and direction as to me doesn't have any impact, but I guess it depends on the end user. If I perhaps live in a city centre, I perhaps would use it more often."

In the previous theme, some participants claimed that their answers depended on whether the travel was for work or leisure. In contrast to this theme, some participants responded in terms of their preferences for the existing infrastructure rather than what improvement they would prefer to encourage them to walk or cycle.

Theme three: Decision- making strategy

The cognitive interviews revealed different strategies followed by the participants in making their choices. For example, the *heuristics approach*, as a decision-making strategy, provides a framework in which individuals can make satisfactory decisions with less effort (Shah and Oppenheimer, 2008). This approach was evident in some cases such as P15 who focussed on the shortest sentences and keywords, and if the sentences were of the same length or she could not find any special keyword, she would return to start from the top. In one of the choice cards, P15 said: "Sorry, I'm aware that I'm sort of hopping from one to the other. I'm going to go back to the first question."

Compensatory decision-making was also obvious as a strategy used by some participants. This approach implies that the alternative chosen would be the most significant relative to the other choices in the sum of the weighted advantages of all the features considered and led to maximisation of advantages (Shiloh et al., 2001). P18, for example, was compensating one factor for another; "there's a few good ones here that the most important. I am kind of torn between third and fourth, but I think for me most often is the lighting as a female, especially in the evenings. I prefer to have very clear visibility not only from my bike, but from the streetlights. So, I can see far if there is anyone there."

Furthermore, the *methodical approach* was also apparent with participant P3, as she wanted to understand the thought about everything before deciding. On the first-choice card, P3 ranked the factors from the most to the least important. However, by telling her that the task is to choose one as the most important and one as the least important, she said: "I feel like even if that is the goal, I feel like this still be

my process. I would kind of rank them in my head and then determine which is the most and which is the least."

Theme four: Concrete thinking

Some participants seemed to be concrete thinkers while trying to figure out the meaning of some factors. On the first-choice card, P3 was uncertain as some of the factors were slightly abstract, such as the width of the footway and the ability for pedestrians to maintain a distance from traffic, crossing points follow desire lines and feeling safe while walking along the footways. But 'another choice card' included factors such as 'street furniture and amenities (e.g., benches and/or ledges for sitting, rubbish bins, drinking fountains, heat lamps, public restrooms)', 'the level of noise and air pollution that pedestrians might be exposed to' and 'availability of measures to slow down traffic and give priority for pedestrians'. So, P3 said: "This makes much more sense than the previous one. It's got specific suggestions, suggestions for improvements, I think this is easier for me to engage with."

Another participant (P5) appreciated examples: "If I took it away from that example, the bits of brackets, I would look at street furniture and amenities and go probably think of benches and other stuff … bins, and things like that. But it's nice to have it laid out in a way that confirms while thinking." Further, when there were no examples, P5 tried to think of one: "The way it's currently phrased … because there's no a specific object like an intangible kind of concept. I've got to mentally think about. So, in my head, I'm thinking about going down a public footway and then all of a sudden, there's a tree in the way that's across the footway. I had to visually imagine it because there's no exact word for tree in the footway or any other object. Just being hung up on that one trying to make it more linguistic."

3.2 Understanding of the factors

Six themes were identified concerning the understanding of the factors in both experiments (see, Tables 6 and 7): (1) Factors with ambiguous words or phrases; (2) Overlapping of two or more factors; (3) Factors phrased negatively; (4) Factors containing technical terms; (5) General wording issues; and (6) Presupposition about some factors.

Table 6
Themes highlighted by the participants about walking factors

No[a]	Description	Ambiguous words	Overlapped factors	Negatively phrased factors	Technical term	General wording issues
1	Feeling safe while walking along the footways	1[b]	1 (4, 14)[c]			
4	Adequate separation between traffic and the footway		2 (14)			
5	Traffic volume low, or you can keep distance from moderate traffic volumes					2
6	Traffic speeds low, or you can keep distance from moderate traffic speeds		2 (4)			1
9	Crossing points follow desire lines				4	
10	Possibility of crossing a route where no controlled crossings present		1 (18)	2		
12	The total time given for pedestrians to cross					1
15	How steep or hilly is the pathway?					1
16	The materials used to create a pavement for pedestrians					
17	Having no obstructions that restrict clearance width of the footway			3		
19	The level of noise and air pollution that pedestrians might be exposed to					1
20	Street furniture and amenities (e.g. Benches and/or ledges for sitting. Rubbish bins. Drinking fountains. Heat lamps. Public restrooms)			1		

No[a]	Description	Ambiguous words	Overlapped factors	Negatively phrased factors	Technical term	General wording issues

[a] Walking factors numbered as of Table 1

[b] # of participants indicating issues

[c] Factor number that overlapped with the current factor

Table 7
Themes highlighted by the participants about cycling factors

No[a]	Description	Ambiguous words	Overlapped factors	Negatively phrased factors	Technical term	General wording issues
1	Pathway construction providing smooth and level surface		2[b] (2)[c]			
2	Density of defects including raised/sunken covers, gullies, potholes		1 (5) / 1 (5, 12)			
3	Cycling comfortably without risk of conflict with other users (effective path width)					1
4	How steep or hilly is the pathway?					1
5	Feeling safe while riding a bicycle along the pathway		1 (10, 19)			
7	Availability of measures to reduce the risk of collisions at junctions	2				
8	Non complex and self-explanatory cycling network design	1				
9	Risk of collision resulted from conflict with kerbside activity	3		1		
11	Risk of collision because of increasing traffic volume					
12	Risk of collisions due to conflict with Heavy Good Vehicles (HGVs)			1		
14	Cycling pathway clear of physical hazards such as evasion room, guardrail	2				
17	The length of delay caused by junctions		1 (18)			
18	The length of delay caused by not being able to bypass slow moving traffic	1				

No[a]	Description	Ambiguous words	Overlapped factors	Negatively phrased factors	Technical term	General wording issues
19	The ability for easily and safely join and navigate along the pathway and between different routes in the network	1				
22	Availability of overlooked routes throughout its length				2	

[a] Cycling factors numbered as of Table 2

[b] # of participants indicating issues

[c] Factor number that overlapped with the current factor

Theme 1: Factors with ambiguous words or phrases

Several participants reported ambiguity issues about the instructions sheet prior to the BWS choice cards in Fig. 2, as follows:

1. Some participants did not notice the title 'Best-Worst scaling' and others were uncertain about its meaning:

- "I did not read the title, did I?" (P2);
- "I am not sure it describes what the tasks are" (P19).

1. The first bullet point was difficult to read and understand because "it [flowed] too quickly, without punctuation" (P9).
2. Some participants found the third bullet point:

- "approach is too long" (P9) for the point message and
- difficult to read "I don't get on with that" (P14).

1. The way numbers were presented in the last bullet point confused several participants, "either your sums are wrong, or there are duplications" (P4).
2. Some participants found the instruction difficult to follow:

- "I would want to read over again" (P15), and
- "harder to retain some of the information" (P19).

P3 found the task "a little bit complicated" and could not easily "visualise exactly what [was] going to happen", finding it "unclear" whether elements in the task "are things that do not already exist, or things

that would be introduced."

Furthermore, P3 found the phrase 'feeling safe' in 'Feeling safe while walking along the footways' ambiguous about whether feeling safe from 'other people' or 'cars'.

The other participants were indeed in one of these two interpretations or both:

- "you feel safe if it is a public footpath that is used regularly and there is plenty of people around" (P2);
- "fear of effectively crime or in a flip side like natural danger", such as "walking along a river" (P5);
- "I guess from traffic. I would not want to walk along the motorway or dual carriageway" (P8);
- "Traffic is definitely one part of it, but probably also from other people" and "bicycles" (P6).

Two participants (P18 and P20) were confused about the word 'measures' in 'Availability of measures to reduce the risk of collisions at junctions' and found it very broad, "What do you classify as the measures that reduce the risk?" (P18). The participant (P18) also found that 'Non-complex and self-explanatory cycling network design' was difficult to read, "that is quite complicated question." However, after rereading, she went to describe the item in detail: "I mean in [this city] I do not think there is anything complicated about how, where to move and where to cycle but maybe in like London or bigger cities, is much more complex."

Finally, English was not the participant's (P16) first language, so her first reaction to 'Risk of collision resulted from conflict with kerbside activity' was, "Oh, what is the kerbside?". Further, one participant (P11) found that 'The length of delay caused by not being able to bypass slow moving traffic' confusing about "whether that was on a bike or that would encourage [him] to be on a bike as opposed to be in the car." Another participant (P13) pointed out that 'The ability for easily and safely join and navigate along the pathway and between different route' was too long and "a lot of construction going on there."

Theme two: Two or more overlapping factors

One participant (P3) found: 'The width of the footway and the ability for pedestrians to maintain a distance from traffic' to overlap with 'Adequate separation between traffic and the footway' as both factors offer a distance from traffic: "I am not sure what in practice that means the difference between those two." Another participant (P6) found those two factors to overlap with 'Feeling safe while walking along the footways': "maybe just that one, feeling safe while walking along the footways, kind of ties in a bit to the separation of traffic and the footway width."

Likewise, two participants (P4 and P10) found 'Traffic speeds low, or you can keep distance from moderate traffic speeds' to overlap with 'Adequate separation between traffic and the footway': "because they are also offered me the chance for adequate separation" (P4). One participant (P3) indicated an overlap between 'Possibility of crossing a route where no controlled crossings present' and 'Availability of

measures to slow down traffic and give priority for pedestrians': "giving priority to pedestrians is also enabling them to cross safely."

One participant (P13) found: 'Pathway construction providing smooth and level surface' "is kind of covered with" the 'Density of defects including raised/sunken covers, gullies, potholes'. Further, P13 found that 'Feeling safe while riding a bicycle along the pathway' "is redundant" to the feeling safe offered by 'Reducing the speeds of motor vehicles on the shared route' and 'The ability for easily and safely join and navigate along the pathway and between different routes in the network' as all these factors "make you feel safe."

Finally, participant 19 indicated that 'Density of defects including raised/sunken covers, gullies, potholes' "kind of encompasses" 'Feeling safe while riding a bicycle along the pathway'. However, another participant (P15) had the opinion that 'Feeling safe while riding a bicycle along the pathway' "encompasses the risk of collisions and the defects on the road."

Theme three: Factors phrased negatively

P3 pointed out that 'Possibility of crossing a route where no controlled crossings present' factor "does not feel like it is a choice for the pedestrian to make." Additionally, P9 found the word 'crossing' a problem of "the same word [that has] different meanings in the same sentence." Some participants (P4, P5 and P10) looked bewildered because of the double-negatives in 'Having no obstructions that restrict clearance width of the footway' factor, "it is a little bit of a no and then a restrict" (P4).

P4 also found the term 'rubbish bins' in street furniture and amenities factor "a negative item [that] tends to suggest household waste." Further, some participants noticed the negative start 'risk of collision' in the wording of three factors (CF9, CF11, and CF12): "It is obviously inferred, but you want to reduce that, not increase that" (P13).

Negatively phrased factors could make the participants underestimate their value, neglect their importance, and most probably not choose them thus leading to dominance (Soekhai et al., 2021).

Theme four: Factors containing technical terms

Two phrases, one in each experiment, 'desire lines' in 'Crossing points follow desire lines' and 'overlooked routes' in 'Availability of overlooked routes throughout its length', were hard to understand by several participants and caused different interpretations:

- "I have never heard [desire lines] before. So, I cannot be sure what that is meant" (P1);
- "I do not really know what you are saying there [overlooked routes]. So, I cannot say how important it is" (P13).

Theme five: General wording issues

Several participants were uncertain about the meaning of the word ‘footway’, which was set out in many walking factors, “It is not a word I have actually sort of heard or used before” (P2).

In addition, the interviews revealed that the gradient factor ‘How steep or hilly is the pathway?’, phrased the same in both experiments, was chosen as the most important factor on both opposite sides. For example, P7 walks through “a lot of hills” on her way to work and “feels like getting a proper workout from that.” On the other hand, P15 had “ridden up some really long hills and it [was] killer for [her] legs and would have preferred not to.” Therefore, the reason behind choosing this factor as the most important, whether desirable or not, will not be apparent unless in an interview.

Finally, P14 was hesitant to respond to the pathway factor ‘Cycling comfortably without risk of conflict with other users (effective path width)’ and found “the use of brackets is probably not that useful [and the statement] is just a long one.”

Theme six: Presupposition about some factors

Some participants had presuppositions about some factors as either unrealistic or facts that could not be changed. Two participants in the walking experiment thought that the level of noise and air pollution is a fact that cannot be changed and should be accepted: “if I thought I was going to go for a walk around the city, then that's what I would be expecting there. I’d be expecting the noise. I'd be expecting the car pollution I would be expecting, you know, pedestrians, it'd be a busy environment. So, I suppose it depends on the area that you're walking in. It wouldn't put this off. It wouldn't be the most or the least important to us. It would just be a factor that's there” (P10). However, P16, in the cycling experiment, was confident that “the level of noise [is] important, but don't know how they would reduce it.”

One participant (P17) chose ‘The continuity of cycling pathway’ as the least important factor because she thought of it as unrealistic: “We don't have many continuous cycling paths, a lot of it is roads or walking paths. So, it's not realistic, I don't think for it to be a continuous cycling pathway. So, it wouldn't be an important factor for me.”

4. Discussion

The aim of this study was to devise a survey-based instrument to elicit preferences for investment in walking and cycling infrastructure by using BWS as a way to address the shortcomings of rating and ranking tasks. The initial step was to identify relevant walking and cycling factors via auditing tools. This was followed by the design of the BWS experiment and conducting a series of 20 cognitive interviews to ensure the BWS instrument’s internal validity. Accordingly, ten themes emerged in both experiments, detailed in the following subsections linked to the result section.

4.1 How the participants approached the BWS task

The four themes related to how the participants completed the BWS task were addressed as follows. Missing a frame of reference found in the repeated question on each choice card was addressed by rephrasing it into “Which of the following areas should be the highest priority and which of the areas should be of the lowest priority for your local council to pursue to encourage walking/cycling”. This wording refers to the action required by the local council to pursue to encourage walking and cycling in general. Furthermore, the rephrased question would encourage the respondents to think hypothetically and consider what infrastructure improvement they would prefer to walk or cycle, hence addressing the travel context issue in theme two. The concern over the urban bias is addressed as the transport categorisation schemes on which the study is based often used to evaluate urban environments rather than rural ones.

Decision-making strategy was identified as a clue onto how the participants made their decisions rather than an issue with the BWS task. Participants followed different approaches to deciding between options that involve multiple items (Gunten and Scherer, 2019). If one of the options was perceived as exceptional, the others become petty. Still, decision-making can become highly complicated if two or more options shared the importance (Einhor and Hogarth, 1981; Payne, 1982). Once none of the factors is dominant, then a person would be forced to give up some factors favouring others (Gunten and Scherer, 2019). The way people make their decisions, either following a compensatory or non-compensatory strategy, would rather be a personality and situation differently (Shiloh et al., 2001; Zakay, 1990). However, some participants who followed the heuristic approach were discouraged about the long sentences and tended to ignore them. Therefore, factors with long sentences were shortened while retaining the meaning; so that each factor is presented in one line. Likewise, all factors were phrased to appear with no significant difference in length.

Further, concrete as a thought process defined physical things in the real world and does not go further than the evident, verbatim impression of a word; thus, words are not framed beyond their direct, palpable meanings (Gustafson and Waehler, 1992). Concrete thinking can be enhanced through retrieving exemplars of items (Tsai and Thomas, 2010). Therefore, the wording of the walking and cycling factors was enhanced with some descriptive words, such as ‘Well-maintained and level footpaths for walking and pushchairs’, ‘Pathways free of defects such as gullies and potholes’, and ‘Low levels of air pollution along the footpaths’. Furthermore, some factors were further explained by adding a hover-over-text, such as ‘Short waiting times at controlled crossings’ with hover-over-text ‘Most crossings are single-phase pelican/ puffin or zebra crossings’.

4.2 Understanding of the factors

The psychology of survey response (Tourangeau et al., 2000) emphasises the importance of precise wording. The wording complexity of questions is frequently related to the vagueness and complicated semantic and grammatical structure (Menold, 2020) such as using ambiguous and inaccurate words and phrases (Lenzner et al., 2010), or by the sentence length and the memory capacity of the individual trying to understand it (Yan and Tourangeau, 2008). The ambiguity in the instructions for the choice cards task, for both walking and cycling experiments, was cleared by deleting the title so not to disturb the

participants and make them pose different assumptions about it (see, Fig. 4). Further, the four bullet points concerning the instructions before the BWS task were rewritten into more precise sentences, and an example of a choice card has been added, as shown in Fig. 4.

The phrase ‘feeling safe’ in both experiments was ambiguous about what it meant to be safe. Further, it encompassed and overlapped with the other safety factors. So, based on how the participants interpret, data for this factor can take either one of three findings: a) safety from other people, b) safety from vehicles or c) safety from both people and vehicles. As a result, the data will not reveal which of the three ways people chose to feel safe. Therefore, ‘feeling safe’ factor was rephrased into a more precise statement considering the safety of crime, since other factors address traffic safety from different aspects, and this wording would also remove the overlap with the other factors. The need to address the safety of crime, violence, and vandalism to encourage walking and cycling was evident in many studies. For example, Foster et al (2014) found a reduction of recreational and transport walks within the local neighbourhood associated with an increased fear of crime. In neighbourhoods without violence, women and the elderly were significantly more afraid and avoiding walking outdoors; however, the difference between men and women narrows as a neighbourhood’s violence rises (Roman and Chalfin, 2008). People tend to cycle less once the risk of being involved in an accident is increased (Rietveld and Daniel, 2004; Southworth, 2005). Mosquera et al (2012) found that women were more susceptible to personal assault, mugging and injuries while cycling than men.

The overlap between some of the factors was cleared by rephrasing each factor to address different issue. For example, ‘Feeling safe while walking along the footways’ rephrased into ‘Footpaths are clear of any signs of crime or vandalism’. The footpath width factor rephrased into ‘Adequate footpath width to accommodate both walking directions’ with a hover-over-text ‘for example, you do not need to ‘give and take’ with other walkers or walk on roads’ to highlight only the width issue.

Traffic speed factor reworded into ‘Low traffic speeds or you can walk away from high-speed areas’ to clear its overlap with ‘Adequate separation between the road and footpaths’. Surface material factor rephrased into ‘Pathways are smooth and with level surface’ with hover-over-text ‘Machine laid a smooth and non-slip surface’ to distinguish it from the surface maintenance factor which was reworded to ‘Pathways free of defects such as gullies and potholes’.

Schriesheim and Eisenbach (1995) found that positive wording accounted for a greater proportion of personality trait variance than negative wording, implying that positive phrasing are more reliable of true attitude than negative phrasing. The negative wording found in some factors was changed into positive statements consistent with the required meaning of the factors encouraging walking and cycling (Soekhai et al., 2021). As a result, the double negation and the negative start in some factors were all addressed. For example, ‘Having no obstructions that restrict clearance width of the footway’ was changed into ‘Footpaths free of obstructions such as poles and signs’. Further, ‘Risk of collision because of increasing traffic volume’ rephrased into ‘Low traffic volumes to reduce risk of collision’.

The technical language used in some factors was simplified and explained more with a hover-over-text. For example, ‘Crossing points follow desire lines’ rephrased into ‘Crossing points are along the footpath of destination’, with the hover-over-text ‘Crossings do not divert you away from your destination’. In addition, ‘Availability of overlooked routes throughout its length’ replaced by ‘Pathways are near city amenities throughout their length’, and the text ‘Cycling pathways are close to shops, cafes, services / enhance the feeling of social safety’ was added as a hover-over-text.

The confusion caused by general wording issues such as the word ‘footway’ was changed into ‘footpaths’ in all walking factors. Similarly, the way the gradient factor (How steep or hilly is the pathway?) was phrased, presenting more than one aspect together in a single question (Bradburn et al., 2004) might increase the cognitive burden on the respondents (Menold, 2020). More importantly, data for this factor chosen as the most important will not be clear whether it is desirable or not, which was evident in both experiments. Therefore, rewording it into ‘Flat (footpaths/pathways) with no steep gradients throughout’ would make it read as a statement, definitive and cohesive with the other factors. Further, it will be apparent that once people choose it as the most important, they prefer the footpaths/pathways to be flat.

Finally, the question can express a limited set of options, each of which has no known location as the correct answer and thus pushed the respondents to faulty presuppositions (Tourangeau et al., 2000). Some participants’ presuppositions about some factors were addressed by rewording those factors to positive and encouraging statements. For example, ‘The level of noise and air pollution that pedestrians might be exposed to’ was divided into two factors ‘Low levels of noise along the footpaths’ and ‘Low levels of air pollution along the footpaths’. Similarly, ‘The continuity of cycling pathway’ replaced by ‘Provision of continuous pathways for cycling’. The amended wording of the walking and cycling factors is shown in Tables 8 and 9, respectively.

Table 8
The amended wording of walking factors

	Factor	Hover-over text
1	Footpaths are clear of any signs of crime or vandalism	
2	Availability of lighting along the footpath	
3	Clear lines of sight to all footpath users from all directions	
4	Adequate separation between the road and footpaths	
5	Low traffic or you can avoid walking near high traffic	
6	Low traffic speeds or you can walk away from high-speed areas	
7	Provision of continuous footpaths for walking	Walking not interrupted by road traffic
8	Low levels of noise along the footpaths	
9	Crossing points are along the footpath of destination	Crossings do not divert you away from your destination
10	Only possible to cross the road from controlled crossings	
11	Short waiting times at controlled crossings	Most crossings are single-phase pelican/ puffin or zebra crossings
12	Pedestrians have enough time to cross the road	
13	Well-maintained and level footpaths for walking and pushchairs	
14	Adequate footpath width to accommodate both walking directions	For example, you do not need to ‘give and take’ with other walkers or walk on roads

	Factor	Hover-over text
15	Flat footpaths with no steep gradients throughout	
16	Footpaths constructed with top-quality materials	
17	Footpaths free of obstructions such as poles and signs	
18	Measures to stop traffic and give priority for pedestrians	Measures to stop traffic such as zebra crossing, pedestrian signals with pushbuttons, school crossing
19	Low levels of air pollution along the footpaths	
20	Footpaths with street furniture and amenities	Street furniture and amenities including sitting areas, drinking fountains, litter bins and public toilets
21	Footpaths with dropped kerbs and tactile paving	Dropped kerbs are where the footpath gently slopes to the same level as the road. Tactile paving is a system of textured strips on footpaths to assist visually impaired people

Table 9
The amended wording of cycling factors

	Factor	Hover-over text
1	Pathways are smooth and with level surface	Machine laid a smooth and non-slip surface
2	Pathways free of defects such as gullies and potholes	
3	Adequate path width to prevent conflict with other users	
4	Flat pathways, with no steep gradients throughout	
5	Pathways free of any signs of crime or vandalism	High-quality street scenery and pleasant interaction
6	Adequate separation between the road and pathways	
7	Measures to reduce risk of collision at junctions	Measures such as closing side roads or treating them to blend in with footpaths
8	Clear, understandable pathway markings and layout	
9	Pathways clear from conflict with kerbside activities	No interaction with vehicles parking or loading, bus stops
10	Low speeds of motor vehicles on shared routes	
11	Low traffic volumes to reduce risk of collision	
12	Measures to avoid conflict with Heavy Goods Vehicles	Measures such as banning of HGVs along cycling paths
13	Availability of lighting along the pathway	
14	Pathways clear from physical hazards such as guardrails	
15	Pathways follow the shortest option available	
16	Few crossing-stops or priority over other vehicles along the route	
17	Short waiting times at junctions along the route	
18	Being able to bypass slow moving traffic to reduce delay	You can always choose an appropriate speed and pass other vehicles

	Factor	Hover-over text
19	Safely join/leave and navigate along pathways	
20	Provision of continuous pathways for cycling	
21	Clear and direct signs towards all destinations	
22	Pathways are near city amenities throughout their length	Cycling pathways are close to shops, cafes, services / enhance the feeling of social safety
23	Access to secure cycle parking along the route	
24	Low levels of air pollution along the pathways	
25	Low levels of noise along the pathways	

5. Conclusion

In this paper, we demonstrate a process to arrive to a universal survey instrument that enables identification of funding priorities for walking and cycling infrastructure via citizens' preferences. We argue for the use of BWS experiments (instead of ranking or rating tasks) as they offer a cognitively easier and methodologically robust way to elicit these preferences. So far, the implementation of BWS experiments, however, has remained limited in the field of transportation research (Gong et al., 2021; Song et al., 2021).

This paper highlights the importance of the qualitative process (via cognitive interviews) prior to a large-scale survey. Cognitive interviews and thus pretesting of a BWS experiment can help enhance data accuracy through the early detection of cognitive challenges. Most importantly, refining materials through cognitive pretesting can improvement the internal validity of the instrument – i.e., bridge the gap between the researcher's intent and participants' interpretation of questions. Cognitive interviewing is an effective tool in ensuring the validity and usability of a questionnaire before distribution, especially in the case of BWS experiments. The findings in this paper present a case for ways to revise and use infrastructure-related factors related to elicit investment priorities for walking and cycling. We recommend that cognitive interviews and BWS experiment to be more widely adopted as part of the questionnaire development process, especially if the survey items are objective, such as auditing tools.

Declarations

Ethical Approval

The project had received ethical approval from Cardiff University's School of Geography and Planning - Ethical Committee

Competing interests

The authors declare that they have no conflict of interest.

Authors' contributions

Conceptualization: [Fahad Albahlal; Dimitris Potoglou], Data curation: [Fahad Albahlal], Methodology: [Fahad Albahlal; Paul Haggar; Dimitris Potoglou]; Formal analysis and investigation: [Fahad Albahlal]; Writing - original draft preparation: [Fahad Albahlal]; Writing - review and editing: [Dimitris Potoglou; Paul Haggar], Supervision: [Dimitris Potoglou]

Funding

This work was supported by the Saudi Arabian Cultural Bureau in London, Saudi Ministry of Education.

Availability of data and materials

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

References

1. Adamsen, J.M., Rundle-Thiele, S., Whitty, J.A., 2013. Best-Worst scaling: reflections on presentation, analysis, and lessons learnt from case 3 BWS experiments. Market & Social Research 21, 9–27.
2. Aizaki, H., 2021. Support.BWS: Tools for Case 1 Best-Worst Scaling [WWW Document]. https://CRAN.R-project.org/package=support.BWS.
3. ARRB, 2011. Walkability Audit Tool. Perth, Western Australia.
4. Auger, P., Devinney, T.M., Louviere, J.J., 2007. Using best-worst scaling methodology to investigate consumer ethical beliefs across countries. Journal of Business Ethics 70, 299–326. https://doi.org/10.1007/s10551-006-9112-7
5. Beatty, P., Willis, G., 2007. Research Synthesis: The Practice of Cognitive Interviewing. Public Opinion Quarterly 71, 287–311. https://doi.org/10.1093/poq/nfm006
6. Beynon, R., Golding-Williams, K., Jones, P., Mayo, A., Russell, T., Peck, C., Thomas, C., 2014. Design Guidance: Active Travel (Wales) Act 2013.
7. Bradburn, N.M., Sudman, S., Wansink, B., 2004. Asking Questions: The Definitive Guide to Questionnaire Design- For Market Research, Political Polls, and Social and Health Questionnaires. Jossey-Bass, San Francisco.
8. Braun, V., Clarke, V., 2006. Using thematic analysis in psychology. Qualitative Research in Psychology 3, 77–101. https://doi.org/10.1191/1478088706qp063oa

9. Campbell, D., Erdem, S., 2015. Position Bias in Best-worst Scaling Surveys: A Case Study on Trust in Institutions. American Journal of Agricultural Economics 97, 526–545. https://doi.org/10.1093/ajae/aau112
10. Cerin, E., Chan, K., Macfarlane, D.J., Lee, K., Lai, P., 2011. Objective assessment of walking environments in ultra-dense cities: Development and reliability of the Environment in Asia Scan Tool — Hong Kong version (EAST-HK). Health & Place 17, 937–945. https://doi.org/10.1016/j.healthplace.2011.04.005
11. Clifton, K.J., Livi, D., Rodriguez, D., 2007. The development and testing of an audit for the pedestrian environment. Landsc Urban Plan 80, 95–110. https://doi.org/10.1016/j.landurbplan.2006.06.008
12. Cohen, S., Markowitz, P., 2002. Renewing market segmentation: some new tools to correct old problems. Amsterdam.
13. Collins, D., 2003. Pretesting survey instruments: An overview of cognitive methods. Quality of Life Research 12, 229–238. https://doi.org/10.1023/A:1023254226592
14. Day, K., Boarnet, M.G., Alfonzo, M., Forsyth, A., 2006. The Irvine–Minnesota Inventory to Measure Built Environments. Am J Prev Med 30, 144–152. https://doi.org/10.1016/j.amepre.2005.09.018
15. Drennan, J., 2003. Cognitive interviewing: verbal data in the design and pretesting of questionnaires. Journal of Advanced Nursing 42, 57–63. https://doi.org/10.1046/j.1365-2648.2003.02579.x
16. Einhor, H.J., Hogarth, R.M., 1981. Behavioral Decision Theory: Processes of Judgment and Choice. Journal of accounting research 19, 1–31. https://doi.org/10.2307/2490959
17. Finn, A., Louviere, J.J., 1992. Determining the Appropriate Response to Evidence of Public Concern: The Case of Food Safety. Journal of Public Policy & Marketing 11, 12–25. https://doi.org/10.1177/074391569201100202
18. Flynn, T.N., 2010. Valuing citizen and patient preferences in health: recent developments in three types of best – worst scaling. Expert Review of Pharmacoeconomics & Outcomes Research 10, 259–267. https://doi.org/10.1586/erp.10.29
19. Flynn, T.N., Louviere, J.J., Peters, T.J., Coast, J., 2007. Best – worst scaling: What it can do for health care research and how to do it. J Health Econ 26, 171–189. https://doi.org/10.1016/j.jhealeco.2006.04.002
20. Flynn, T.N., Marley, A.A.J., 2014. Best- worst scaling: theory and methods, in: Hess, S., Daly, A. (Eds.), HANDBOOK OF CHOICE MODELLING. Edward Elgar Publishing Limited, Cheltenham, UK, pp. 178–201.
21. Foster, S., Knuiman, M., Hooper, P., Christian, H., Giles-Corti, B., 2014. Do changes in residents' fear of crime impact their walking Longitudinal results from RESIDE. Preventive Medicine 62, 161–166. https://doi.org/10.1016/j.ypmed.2014.02.011
22. Frank, L.D., Engelke, P.O., 2001. The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health. Journal of Planning Literature 16, 202–218. https://doi.org/10.1177/08854120122093339

23. Gong, S., Hin Sing Cheng, V., Ardeshiri, A., Rashidi, T.H., 2021. Incentives and concerns on vehicle-to-grid technology expressed by Australian employees and employers. Transportation Research Part D: Transport and Environment 98. https://doi.org/10.1016/j.trd.2021.102986
24. Gunten, C.D. Von, Scherer, L.D., 2019. Self – other differences in multiattribute decision making: Compensatory versus noncompensatory decision strategies. Journal of Behavioral Decision Making 109–123. https://doi.org/10.1002/bdm.2099
25. Gustafson, L., Waehler, C.A., 1992. Assessing Concrete and Abstract With the Draw-a-Person Technique. Journal of personality assessment 59, 439–447. https://doi.org/10.1207/s15327752jpa5903_2
26. Handy, S.L., Boarnet, M.G., Ewing, R., Killingsworth, R.E., 2002. How the Built Environment Affects Physical Activity: Views from Urban Planning. American Journal of Preventive Medicine 23, 64–73. https://doi.org/10.1016/S0749-3797(02)00475-0
27. Jackson, L.E., 2003. The relationship of urban design to human health and condition. Landscape and Urban Planning 64, 191–200. https://doi.org/10.1016/S0169-2046(02)00230-X
28. Knafl, K., Deatrick, J., Gallo, A., Holcombe, G., Bakitas, M., Dixon, J., Grey, M., 2007. Focus on Research Methods: The Analysis and Interpretation of Cognitive Interviews for Instrument Development. Research in Nursing & Health 30, 224–234. https://doi.org/10.1002/nur
29. Larranaga, A.M., Arellana, J., Rizzi, L.I., Strambi, O., Cybis, H.B.B., 2019. Using best – worst scaling to identify barriers to walkability: a study of Porto Alegre, Brazil. Transportation 46, 2347–2379. https://doi.org/10.1007/s11116-018-9944-x
30. Lenzner, T., Kaczmirek, L., Lenzner, A., 2010. Cognitive Burden of Survey Questions and Response Times: A Psycholinguistic Experiment. APPLIED COGNITIVE PSYCHOLOGY 24, 1003–1020. https://doi.org/10.1002/acp
31. Louviere, J., Lings, I., Islam, T., Gudergan, S., Flynn, T., 2013. An introduction to the application of (case 1) best – worst scaling in marketing research. International Journal of Research in Marketing 30, 292–303. https://doi.org/10.1016/j.ijresmar.2012.10.002
32. Louviere, J.J., Flynn, T.N., Marley, A.A.J., 2015. BEST-WORST SCALING: Theory, methods and applications. Cambridge University Press, Cambridge.
33. Louviere, J.J., Woodworth, G.G., 1990. Best-Worst Scaling: A Model for Largest Difference Judgment.
34. Mark, H., White, I., 2021. bwsTools: An R package for case 1 best-worst scaling. Journal of Choice Modelling 39. https://doi.org/10.1016/j.jocm.2021.100289
35. Marti, J., 2012. A best-worst scaling survey of adolescents ' level of concern for health and non-health consequences of smoking. Social Science & Medicine 75, 87–97. https://doi.org/10.1016/j.socscimed.2012.02.024
36. Mayne, S.L., Auchincloss, A.H., Michael, Y.L., 2015. Impact of policy and built environment changes on obesity-related outcomes: A systematic review of naturally occurring experiments. Obesity Reviews 16, 362–375. https://doi.org/10.1111/obr.12269

37. Menold, N., 2020. Double Barreled Questions: An Analysis of the Similarity of Elements and Effects on Measurement Quality. Journal of Official Statistics 36, 855–886. https://doi.org/10.2478/jos-2020-0041
38. Millington, C., Thompson, C.W., Rowe, D., Aspinall, P., Fitzsimons, C., Nelson, N., Mutrie, N., 2009. Development of the Scottish Walkability Assessment Tool (SWAT). Health Place 15, 474–481. https://doi.org/10.1016/j.healthplace.2008.09.007
39. Mosquera, J., Parra, D.C., Gomez, L.F., Sarmiento, O., Schmid, T., Jacoby, E., 2012. An inside look at active transportation in Bogotá: a qualitative study. Journal of Physical Activity and Health 9, 776–785. https://doi.org/10.1123/jpah.9.6.776
40. MTO, 2014. BIKEWAYS DESIGN MANUAL. Ministry of Transportation, Ontario, Canada.
41. Nabors, D., Gibbs, M., Sandt, L., Rocchi, S., Wilson, E., Lipinski, M., 2007. Pedestrian Road Safety Audit Guidelines and Prompt Lists. Washington, DC.
42. Nabors, D., Goughnour, E., Thomas, L., DeSantis, W., Sawyer, M., 2012. Bicycle Road Safety Audit Guidelines and Prompt Lists. Washington, DC.
43. Payne, J.W., 1982. Contingent Decision Behavior. American Psychological Association 92, 382–402. https://doi.org/10.1037/0033-2909.92.2.382
44. Pikora, T.J., Bull, F.C.L., Jamrozik, K., Knuiman, M., Giles-corti, B., Donovan, R.J., 2002. Developing a Reliable Audit Instrument to Measure the Physical Environment for Physical Activity. Am J Prev Med 23, 187–194. https://doi.org/10.1016/S0749-3797(02)00498-1
45. R Core Team, 2020. R: A language and environment for statistical computing [WWW Document]. Vienna: R Foundation for Statistical Computing. URL https://www.r-project.org/ (accessed 5.18.20).
46. Rietveld, P., Daniel, V., 2004. Determinants of bicycle use: do municipal policies matter? Transportation Research Part A 38, 531–550. https://doi.org/10.1016/j.tra.2004.05.003
47. Roman, C.G., Chalfin, A., 2008. Fear of Walking Outdoors: A Multilevel Ecologic Analysis of Crime and Disorder. American Journal of Preventive Medicine 34, 306–312. https://doi.org/10.1016/j.amepre.2008.01.017
48. Sailer, M.O., 2013. Crossdes: Construction of Crossover Designs [WWW Document]. https://CRAN.R-project.org/package=crossdes.
49. Schriesheim, C.A., Eisenbach, R.J., 1995. An Exploratory and Confirmatory Factor-Analytic Investigation of Item Wording Effects on the Obtained Factor Structures of Survey Questionnaire Measures. Journal of Management 21, 1177–1193. https://doi.org/10.1016/0149-2063(95)90028-4
50. Shah, A.K., Oppenheimer, D.M., 2008. Heuristics Made Easy: An Effort-Reduction Framework. Psychological Bulletin 134, 207–222. https://doi.org/10.1037/0033-2909.134.2.207
51. Shiloh, S., Koren, S., Zakay, D., 2001. Individual differences in compensatory decision-making style and need for closure as correlates of subjective decision complexity and difficulty. Pers Individ Dif 30, 699–710. https://doi.org/10.1016/S0191-8869(00)00073-8

52. Smith, M., Hosking, J., Woodward, A., Witten, K., MacMillan, A., Field, A., Baas, P., Mackie, H., 2017. Systematic literature review of built environment effects on physical activity and active transport - an update and new findings on health equity. International Journal of Behavioral Nutrition and Physical Activity 14. https://doi.org/10.1186/s12966-017-0613-9
53. Soekhai, V., Donkers, B., Levitan, B., de Bekker-Grob, E.W., 2021. Case 2 best-worst scaling: For good or for bad but not for both. Journal of Choice Modelling 41. https://doi.org/10.1016/j.jocm.2021.100325
54. Song, F., Hess, S., Dekker, T., 2021. A joint model for stated choice and best-worst scaling data using latent attribute importance: application to rail-air intermodality. Transportmetrica A: Transport Science 17, 411–438. https://doi.org/10.1080/23249935.2020.1779384
55. Soutar, G.N., Sweeney, J.C., McColl-Kennedy, J.R., 2015. Best-worst scaling: an alternative to ratings data, in: LOUVIERE, J.J., FLYNN, T.N., MARLEY, A.A.J. (Eds.), BEST-WORST SCALING: Theory, Methods and Applications. Cambridge University Press, Cambridge, pp. 177–187.
56. Southworth, M., 2005. Designing the walkable city. Journal of urban planning and development 131, 246–257. https://doi.org/10.1061/(ASCE)0733-9488(2005)131:4(246)
57. Sun, G., Webster, C., Chiaradia, A., 2017. Objective assessment of station approach routes: Development and reliability of an audit for walking environments around metro stations in China. Journal of Transport & Health 4, 191–207. https://doi.org/10.1016/j.jth.2017.01.010
58. Szeinrach, S.L., Barnes, J.H., MCGHAN, W.F., MURAWSKI, M.M., Corey, R., 1999. Using Conjoint Analysis to Evaluate Health State Preferences. Therapeutic innovation & regulatory science 33, 849–858. https://doi.org/10.1177/009286159903300326
59. Taylor, S., Giang, C., Chau, P., Aumann, P., 2017. Cycling Aspects of Austroads Guides, Third edit. ed. Austroads Ltd., Sydney.
60. Thurstone, B., 1927. A law of comparative judgment. Psychological Review 34, 273–286. https://doi.org/10.1037/h0070288
61. Tourangeau, R., Rips, L.J., Rasinski, K., 2000. The Psychology of Survey Response. Cambridge University Press, Cambridge, United Kingdom.
62. Tsai, C.I., Thomas, M., 2010. When Does Feeling of Fluency Matter? How Abstract and Concrete Thinking Influence Fluency Effects. Psychological Science 22, 384–354. https://doi.org/10.1177/0956797611398494
63. UK Department for Transport, 2020. Gear change: A bold vision for cycling and walking. London.
64. Willis, G.B., 1999. Cognitive Interviewing: A “How To” Guide.
65. Willis, G.B., Artino, A.R., 2013. What Do Our Respondents Think We’re Asking? Using Cognitive Interviewing to Improve Medical Education Surveys. Journal of graduate medical education 5, 353–356. https://doi.org/10.4300/JGME-D-13-00154.1
66. Yan, T., Tourangeau, R., 2008. Fast times and easy questions: the effects of age, experience and question complexity on web survey response times. Applied cognitive psychology 22, 51–68. https://doi.org/10.1002/acp

67. Zakay, D., 1990. The role of personal tendencies in the selection of decision-making strategies. Psychol Rec 40, 207–213.

Figures

BIBD for walking experiment

```
> set.seed(123)
> find.BIB(t=21, k=5, b=21)
      [,1] [,2] [,3] [,4] [,5]
 [1,]    1    6   12   16   19
 [2,]    5   15   16   20   21
 [3,]    3    5    6    7   18
 [4,]    4    7   10   11   16
 [5,]    1    2    3   10   20
 [6,]    3    4   13   19   21
 [7,]    4    6    8   17   20
 [8,]    2    7    8   15   19
 [9,]    2    6   11   14   21
[10,]    2   13   16   17   18
[11,]    5   10   14   17   19
[12,]    8   10   12   18   21
[13,]    3   11   12   15   17
[14,]    2    4    5    9   12
[15,]    1    5    8   11   13
[16,]    1    7    9   17   21
[17,]    6    9   10   13   15
[18,]    7   12   13   14   20
[19,]    9   11   18   19   20
[20,]    3    8    9   14   16
[21,]    1    4   14   15   18
> isGYD(bibd)

[1] The design is a balanced incomplete block
 design w.r.t. rows.
```

BIBD for cycling experiment

```
> set.seed(4763)
> find.BIB(t=25, k=5, b=30)
      [,1] [,2] [,3] [,4] [,5]
 [1,]    2   10   21   24   25
 [2,]    2    7    9   13   19
 [3,]    9   13   20   23   24
 [4,]    6   13   15   16   21
 [5,]    3    9   14   16   22
 [6,]    2   11   12   15   17
 [7,]   11   14   19   23   25
 [8,]    1   10   12   14   20
 [9,]    8   13   14   17   21
[10,]    1    2   16   18   23
[11,]    7    9   10   17   18
[12,]    1    3    5   17   24
[13,]    1    7   15   22   25
[14,]   16   17   19   20   25
[15,]    3    6    7   11   20
[16,]    4    7   12   14   16
[17,]    3    8   10   15   23
[18,]    1    6    8   10   19
[19,]    1    4    9   11   21
[20,]    4    6   17   22   23
[21,]    5   10   11   13   22
[22,]    2    3    5    6   12
[23,]    5    7   18   21   23
[24,]   12   19   21   22   24
[25,]    5    8    9   12   25
[26,]    3    4   13   18   25
[27,]    4    8   11   16   24
[28,]    6   14   15   18   24
[29,]    2    8   18   20   22
[30,]    4    5   15   19   20
> isGYD(bibd)

[1] The design is a balanced incomplete block
 design w.r.t. rows.
```

Figure 1

BIBDs for walking and cycling experiments

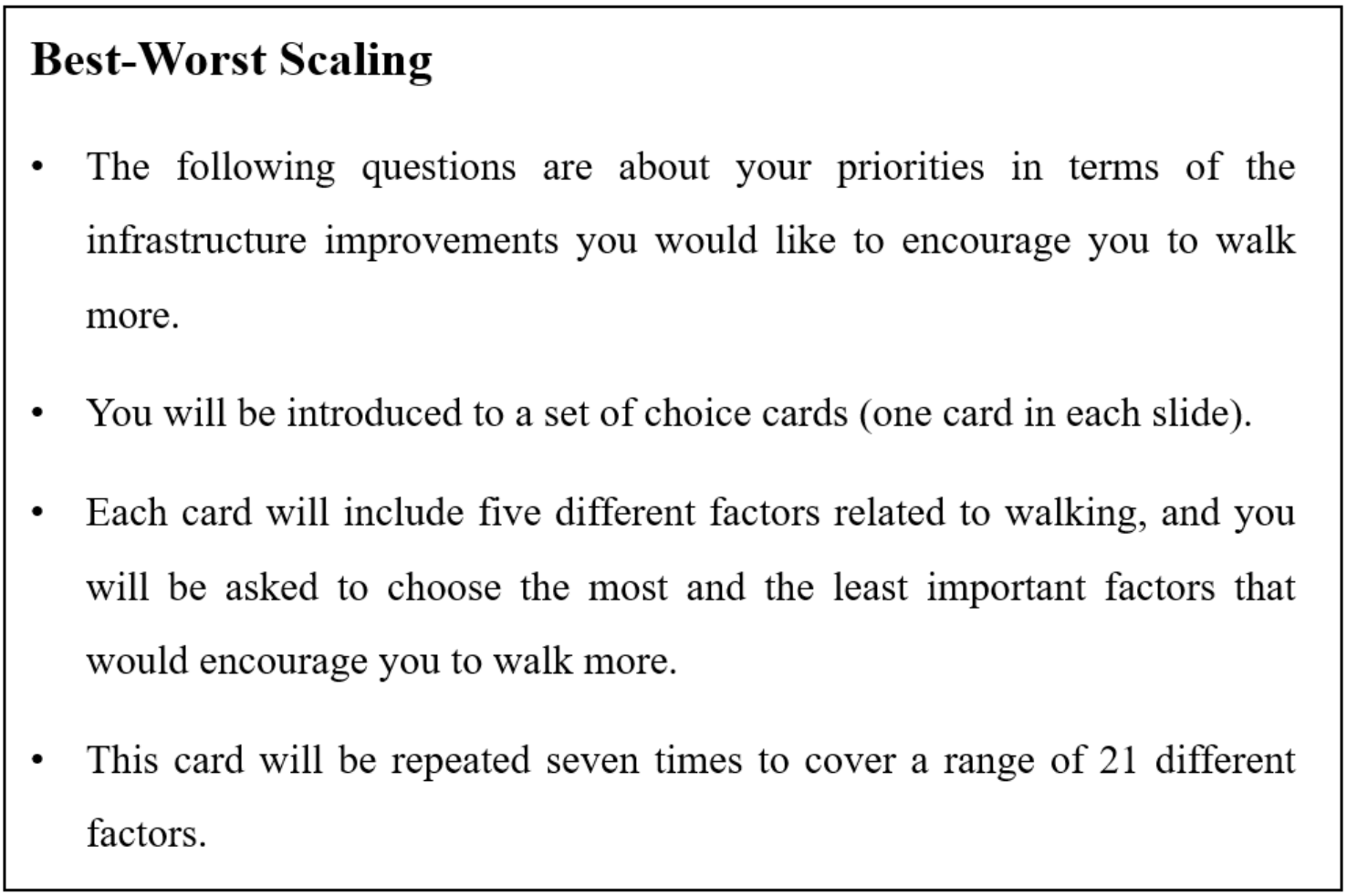

Figure 2

Instructions for BWS task

Out of the five factors below, which are **The Most** and **The Least Important** factors that would **encourage you to walk more**

Most Important	Factors	Least Important
	Possibility of crossing a route where no controlled crossings present	
	Availability of dropped kerbs and tactile paving on the footway	
	Having no obstructions that restrict clearance width of the footway	
	Feeling safe while walking along the footways	
	Presence of footways from the origin point to destination with limited/minimal number of crossing points	

Figure 3

Example of choice card

From this point on, we would like you to consider that your local council is planning to improve infrastructure for pedestrians to encourage walking.

We will ask you to look at seven (7) cards, each showing five (5) areas for improvement to encourage walking (see, choice card 1 below). These areas, for example, may cover physical infrastructure, safety, comfort, etc.

We would like you to weigh up the pros and cons for improving each of these areas.

Then we would like you to choose, which area should be the highest priority and which area should be the lowest priority in each choice card.

Areas underlined with dots have further description once you hover the mouse over them. There are no right or wrong answers to these choices; we are only interested in your own views.

Choice card 1 of 7

Which of the following areas should be **the highest priority** and which of the areas should be **the lowest priority** for your local council to pursue to **encourage walking?**

Highest priority		**Lowest priority**
○	Low traffic or you can avoid walking near high traffic	○
○	Footpaths constructed with top-quality materials	○
○	Flat footpaths with no steep gradients throughout	○
○	Footpaths with dropped kerbs and tactile paving	○
○	Footpaths with street furniture and amenities	○

Figure 4

The new instruction card