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Valuing the walk environment

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Abstract

The results of a combined Stated Preference (SP) and rating questionnaire to value aspects of the walking environment from the pedestrian's perspective are reported for 1,025 residents of Greater Metropolitan Sydney, Illawarra and Hunter regions surveyed between December 2020 and February 2021.

The walk environment was measured on a 5-star scale and the value to pedestrians was measured in walk time minutes which were then converted into dollars using a value of travel time. Attributes such as pavement smoothness, trees, litter/graffiti etc were valued via their importance in explaining the pedestrian's overall rating for actual and hypothetical walks. The results were benchmarked against thirteen studies.

It is surprising and somewhat disappointing that so little has been published on the demand effect of improving the walk environment. Current methodologies either apply only to existing walk volumes or blithely assume a percentage increase in walk trips. To fill the gap, a model is outlined and applied to a notional quality improvement. The forecast increase in walk demand is classified by source with summary elasticity measures provided.

1. Introduction

A combined Stated Preference (SP) and five-star rating survey was developed to value the walking environment from the perspective of the NSW pedestrian. 1,025 residents of Greater Metropolitan Sydney, Illawarra and Hunter regions were surveyed between December 2020 and February 2021 using an internet panel.

As well as valuing the overall rating of walk routes, the relative importance of attributes such as pavement smoothness, pavement width, amount of road traffic, pedestrian crowding and presence of trees, litter and graffiti, seating, signing and lighting was established enabling changes in provision to be valued.

A model is outlined to assess the demand effects of changes in walk quality.[1] The model is used to estimate the impact of an improvement that raises the rating of the walk route from 60% to 70% for a 10-minute walk. The model is indicative but could assist in the assessment of the 'externality' benefits of walking (health, noise, pollution, CO2, accidents etc) which have been the focus of 'active travel' and 'place making' project appraisals.

Section 2 provides an overview of the study and section 3 reviews the literature. Section 4 describes the profile of the survey. Section 5 describes the walks both actual and hypothetical

[1]A demand framework with indicative elasticities is provided in the consultancy report, Douglas (2022).

and models estimated on the rating and attribute data. Section 6 describes the SP survey that valued improvements in the walk environmental rating. Section 7 presents a model to forecast the demand impact of improving the walk environment. Section 8 revisits the main points made.

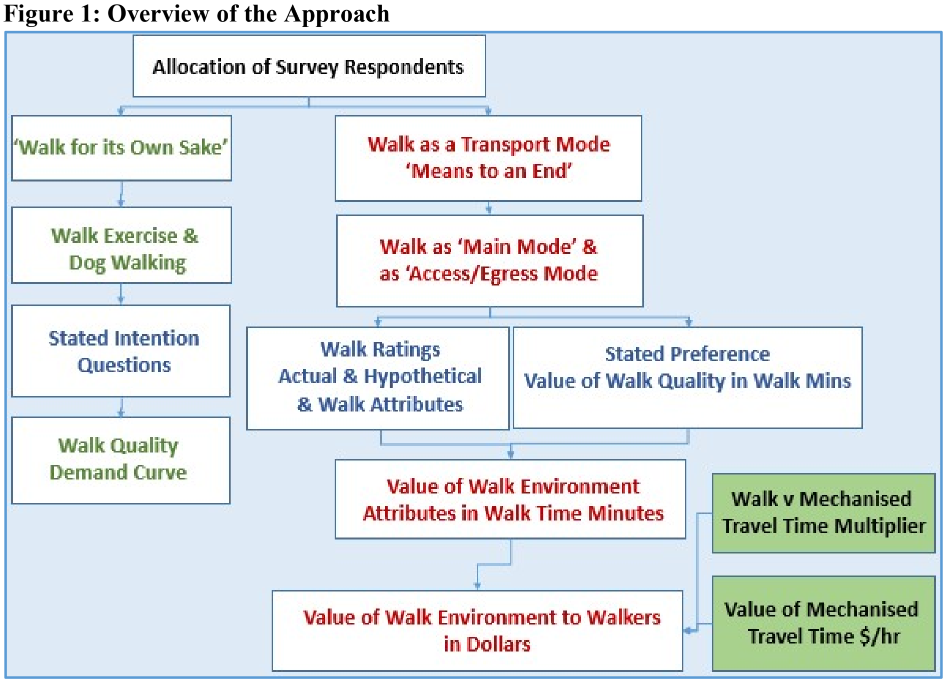
2. Overview

The original intention was to undertake the survey on-street by face-to-face interviews (F2F) but COVID19 ruled this out. Instead, an internet panel (IP) was used. Given the body of evidence pointing to IP respondents being overly cost sensitive, the survey steered clear of asking Willingness to Pay (WTP) type questions and instead valued the walking environment in terms of equivalent walk time minutes. This decision was also supported by the literature review which showed that attempts to value walk quality directly in dollar terms had only had patchy success. Concerns regarding the lower quality of IP responses were addressed by discarding 'speedsters', flat-liners and respondents who made gibberish comments.[2]

A five-star rating system scoring quality from ½ star (very poor) to 5 stars (very good) was used. Similar five-star systems are used for restaurants, hotels, films, books, car safety and on-line purchases.[3] It has also been used to rate bus, train and ferry services in NSW. Respondents were therefore considered likely to be familiar with the system.

Different approaches were used to distinguish walking as a 'means to an end' from walking 'for its own sake'. Figure 1 shows the two approaches.

Figure 1: Overview of the Approach



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[2] Speedsters were people who completed the questionnaire in under 3 minutes. Flat liners gave the same response to several questions. Gibberish comments made no sense such as 'tyuiop' (adjacent keys on the keyboard).

[3] Five-star has also been adopted as the name of a political movement by hirsute Beppe Grillo who failed to finish his accountancy degree became a comedian and got 25.5% of the votes in the Parlamento Italiano in 2013.

Walking as a 'means to an end' includes walking to or from work or shops (where walk is the 'main mode') and walking to or from a bus stop, train station, ferry wharf (where walk is an access or egress mode to public transport (PT)). For these walks, a set of Stated Preference (SP) questions were given. Respondents were asked to choose between two walk routes (A and B) which differed in quality (stars) and walk time. By analyzing response, walk environmental quality was able to be valued in equivalent walk minutes.

The SP-rating approach did not apply to walk trips made 'for their own sake' such as exercising or walking the dog. The pilot surveys found respondents were content with their walks and were reluctant to trade-off lower quality for a shorter walk. Therefore, in the main survey, exercisers and dog walkers were asked a different set of questions about how often they exercised or walked their dog and whether they would walk more often or for longer if the quality of their walk was improved to 5 stars. A quarter responded they would walk more often and one in ten said they would take longer walks if walk quality was improved to 5 stars (i.e. very good). By analyzing response, a demand curve that related walk trips (and walk hours) to the quality of the walk environment was developed (see section 7).

3. Literature review

Before setting out and designing the survey, a literature review was undertaken to see what previous researchers had attempted and how their methods had fared. Thirteen studies were reviewed of which ten provided willingness to pay (WTP) values of the walk environment. Seven studies had been undertaken in the UK, two in Sydney and one was a global review. Table 1 summarizes the studies, the improvement packages and the reported values. As can be seen the range in value is enormous. The lowest value was 0.2 cents per minute for street lighting in UK towns (#7) and the highest was 36 cents per minute for a wide high quality pavement compared to walking on the side of the road (#13). These two studies provide 'bookends' to the range with a value of 7 cents per minute in the centre.

Table 1: Value of Walk Environment Improvements

#	Study	Year	Location	Scope	Improvement	Valuation	Local Value	Aus c/min
1	Heuman	2005	London	Route	Worst to Best Package	WTA tax rebate	£135/year	7.2
2	Sheldon	2007	London	Street	Worst to Best Package	Tax, rent, fare	£44/year	2.3
4	Kelly	2011	Leeds	Area	Clean & Quiet streets	Tax Rebate	£33/month	2.1
5	ITS	2011	UK	Street	Pedestrianization	Local Tax	£64/year	3.3
7	Willis	2003	UK	Town	Street Lighting	WTP (household)	£12/year	0.2
9	Accent	2013	Sydney	Street	Pedestrianized/Trees/Quiet	Notional fee	6c/min	6.0
10	MVA	2012	London	Trip	Improvement Package	Bus/train fare	3p/min	6.0
11	SDG	2014	London	Trip	Improvement Package	Bus/train fare	6p/min	12.0
12	Tsai	2019	Sydney	Route	Improvement Package	#2 Sourced	na	2.7
13	Nunns &Dodge	2020	Global Review	Trip	High Quality v No Pavement Shared Space v Basic^	Walk time ratio Global review	NZ37c/m NZ25c/m	34.2 23.1

^ from 'shared space' worked example in Table 2.8; c/m = cents per minute

Tsai (2019) calculated a somewhat low value of 2.7 cents per minute (c/min) for a precinct improvement in Sydney based on the 2007 London survey (#2) by Sheldon. The value compares with 6 c/m for pedestrianizing George Street Sydney estimated by Accent in 2013 (#9) and 12 c/m estimated by SDG in a 2014 London survey (#11).

The method of payment influenced the values such as whether local tax (increase or a rebate) or bus fare. Researchers generally struggled to get respondents to think about 'cost' for what is a 'free' activity apart from shoe leather. Given the problems experienced it was decided to value walk quality in terms of walk time and then use an externally derived NSW value of travel time to convert minutes into dollars.

The reported values were also affected by whether a specific walk trip was valued (street or route) or an area or town and whether the value was paid per trip, day, month or year. It was decided that given most the values would be mostly used for specific projects that the questioning should be for a specific walk made either during the day or at night.

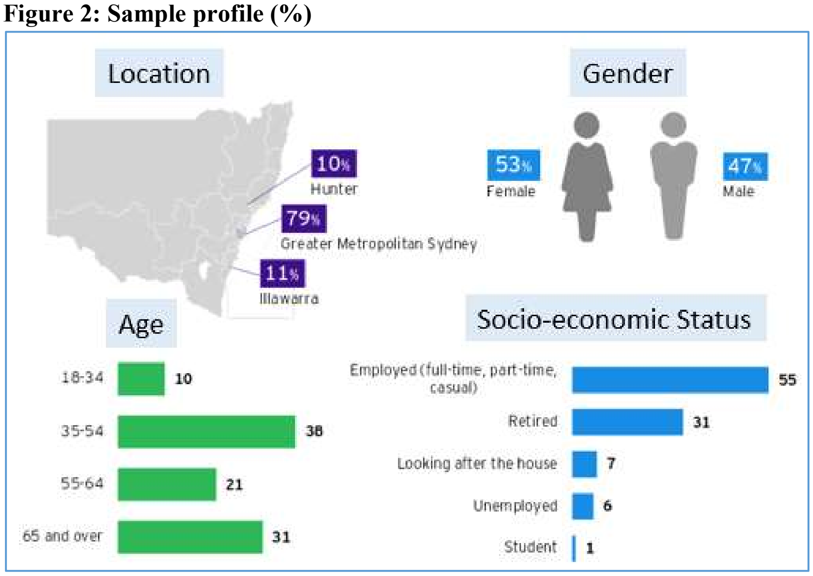
The studies differed in terms of how respondents were recruited and interviewed. It was decided that the sample should be representative of the walking public but acknowledging that under 18s would need to be excluded due to market research protocol. Questions would be about a recent walk so that trip purpose and context was 'fresh in mind'. Ideally, interviews should be 'Face-to-Face' (F2F) undertaken on street or at activity centres (e.g. shopping malls, bus stops) using a short questionnaire (4-8 minutes) on hand-held computer tablets.

4. Sample size and profile

The questionnaire was developed between June and December 2020. Unfortunately, COVID19 made F2F interviewing impossible. Instead, an Internet Panel (IP) questionnaire was developed. There was a silver lining which was that an IP enabled a longer questionnaire of 8 and 10 minutes. The survey went 'live' between December 2020 and February 2021 with a total of 1,186 responses achieved. Quality controls reduced the sample by 14% to 1,025.

Figure 2 presents the profile of the 'cleaned' sample of 1.025.

Figure 2: Sample profile (%)

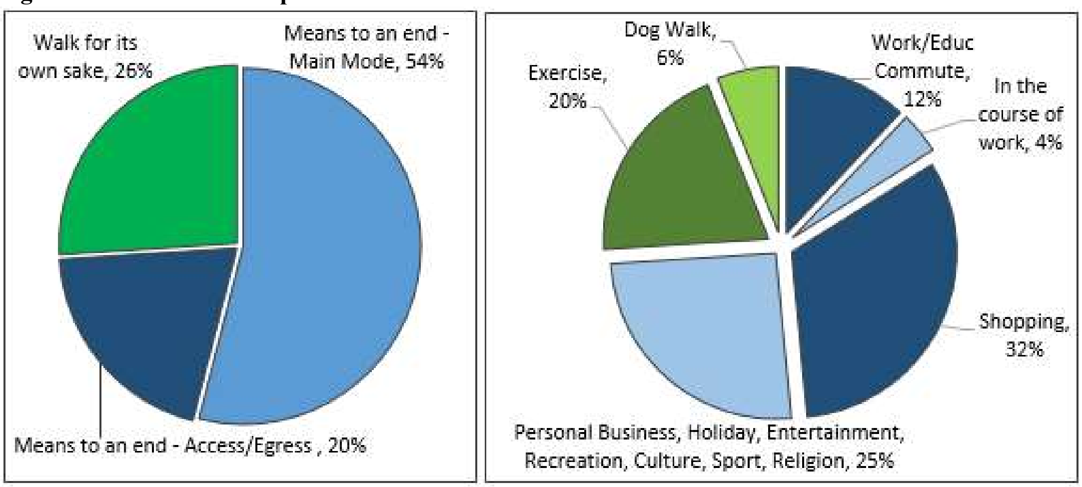


Location quotas were used to obtain a target of 80% resident in the Greater Metropolitan Sydney (GMS) region with 10% in the Illawarra and 10% in the Hunter regions. Just over half the sample was female with age skewed towards older respondents due to under 18s being excluded. Few students were surveyed (1%) with just over one half being employed, 31% retired, 7% 'looking after the house' and 6% unemployed.

Respondents were asked the purpose of the walks made within the previous week as part of determining a specific walk to frame the rating and SP questions. For the selected walk, three-quarters had walked to a destination either 'all the way' (54%) or accessed or egressed a bus stop, train station or ferry wharf (20%) with one quarter making a walk for 'its own sake' as can be seen in the left-hand chart of Figure 2.

The right-hand chart shows the journey purpose profile. Just under a third were walking to or from shops with one in eight walking to or from work or education. A small percent (4%) were making a walk trip during the course of their work. A fifth were exercising and 6% had walked their dog (which equals to 26% 'walking for its own sake' in the left-hand chart).

Figure 3: Selected walk trips



Respondents were asked how long their 'selected' walk had taken. The median was 15 minutes and the mean 27 minutes due to some longer walks that averaged 49 minutes made by exercisers and dog walkers.[4] Excluding them reduced the average to 20 minutes for walking 'all the way' and 17 minutes for access/egress walks to PT.

Walks were classified into suburban, city and park. Suburban walks dominated with 681 out of 1,025 (66%). A further 9% walked through suburbia and park areas, 5% through suburbia and city areas and 2% through all three areas. In total, 82% involved suburban walking. Likewise, as Figure 4 shows, 22% involved park and 13% city walking.

Just over half of park walks (56%) were made by dog walkers and exercisers whereas 95% of city walks were a 'means to an end' either 'all the way' (52%) or to/from PT (43%). Just over three-quarters of suburban walks were a 'means to an end' either walking all the way (56%) or accessing PT (21%). Just under a quarter were exercising or dog walking (22%).

Respondents were then asked to describe their selected walk. Table 2 lists the questions and gives the percentage response.

[4] Walks of under 5 minutes were screened out so the walk times were biased a little upwards.

Figure 4: Types of walk area (1,025 respondents)

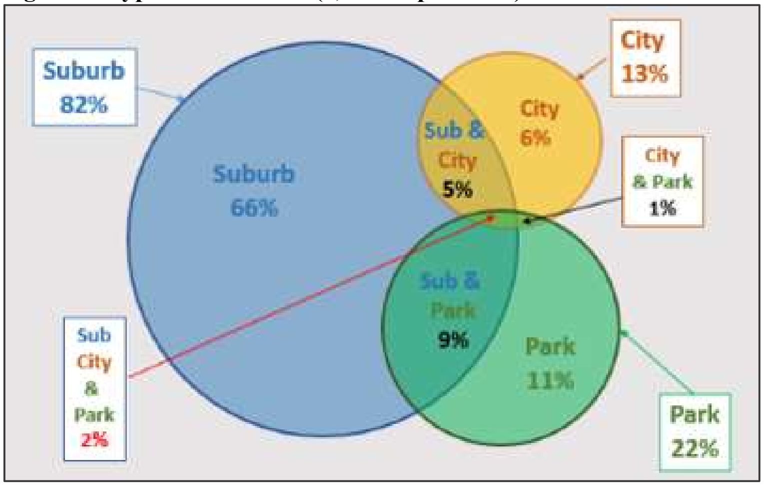


Table 2: Description of Selected Walk

#	Attribute	Response & Percentage			
1	Time of Day	1. Early morning / Quite Dark 10%	2. Daylight 77%	3. Early Evening / Getting Dark 12%	4. Night / Dark 1%
2	Weather^	1. Sunny 46%	2. Fine 49%	3. Overcast 23%	4. Windy 8%
		5. Light Rain 7%		6. Heavy Rain 0.2%	
3	Flatness	1. Reasonably Flat 74%		2. Some Steep Sections 26%	
4	Trees	1. No Trees 9%	2. Few Trees 58%	3. Lots of Trees 33%	
5	Road Traffic	1. Pedestrianized 13%	2. Light 45%	3. Moderate 31%	4. Heavy 11%
6	People About	1. Very Few 63%	2. Reasonable Number 36%		3. Crowded 1%
7	Road Crossings	1. No Road Crossings 32%	2. Wait for traffic gap 30%	3. Wait for Green Light 26%	4. Pedestrian Priority Zebra 11%
8	Under or Overpasses	1. None 85%	2. Underpasses 9%	3. Overpasses 5%	4. Both 2%
9	Pavement Edge	1. Kerb Edges 55%	2. Gradual Slope 34%	3. Don't Know 11%	
10	Smoothness	1. Smooth & Well-maintained 52%	2. Uneven in Places 41%	3. Rather Rough so Watch my Step 6%	
11	Street Art	1. No Street Art 88%	2. Yes, Street Art, Murals or Sculptures 12%		
12	Tidiness	1. Tidy 50%	2. Some Litter 37%	3. Graffiti 5%	4. Litter & Graffiti 8%
13	Public Seating	1. Yes 53%	2. No 44%	3. Don't Know3%	
14	Signage	1. Clear & Helpful 60%	2. Unclear / unhelpful 19%		3. No opinion 21%
15	Security Cameras	1. Yes 60%	2. No 19%	3. Unsure 21%	
16	Lighting	1. None so Dark 7%	2. Dim so Difficult to See 27%	3. Bright so Easy to See 45%	4. No Opinion 20%

^ Respondents could tick more than one box

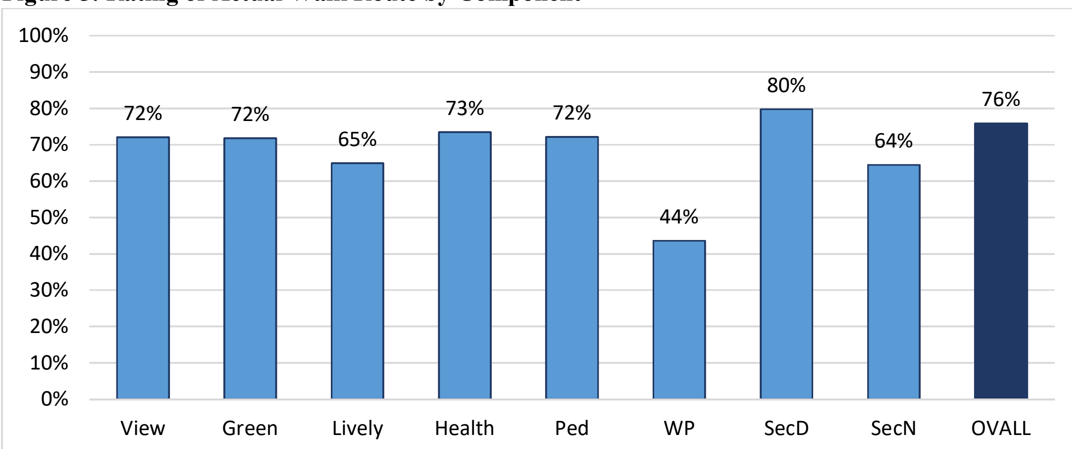
5. Ratings of actual and hypothetical walks

Respondents were asked to rate eight ‘components’ of their selected walk on a five-star scale then give an overall rating. For analysis purposes, the star rating was converted into a percentage score (R%) by subtracting 0.5 and dividing by 4.5 i.e. (R% = {STARS-0.5}/4.5).

The mean rating (R%) was 76% so generally, respondents were happy with their walk, Williams (2014). The median rating was a little lower at 72%. Only 10% gave a rating of less than 3 stars (an 'average' rating) and no respondent gave a rating of less than 1½ stars.

Seven of the eight attributes rated 60-80% as Figure 5 shows. Day time personal security rated the highest at 80%. Walking when dark reduced the personal security rating to 64%.[5] Weather protection from rain, wind and sun was the exception with a much lower rating of 44% than the seven other components.

Figure 5: Rating of Actual Walk Route by Component



View *'streetscape and landscape'*; Green *'green and peaceful'*; Lively *'lively and interesting' Health 'healthy'* Ped *'pedestrian friendly'* WP *'weather protection from rain, wind and sun'*; SecD *'feeling of personal security during daytime'*; SecN '*feeling of personal security at night & early morning'*; OVALL *'walking route overall'*

The next part of the survey asked respondents to rate six hypothetical walks. The six walks were selected from a pack of sixty cards made up of 20 suburban, 20 city and 20 park settings. Each of the three settings had 16 daytime and 4 night time walks. The sixty cards were dealt randomly into ten sets of six but with the deal controlled so that each set had 2 suburban, 2 city and 2 park walks. Respondents were allocated to one of the ten sets.

The day-time attributes were determined using statistical experimental designs so they were independent of one another (i.e. no pairwise correlations). The suburban and park designs had seven attributes and the city design had eight. Four of the suburban attributes took 3 levels (e.g. road traffic was either light, moderate or busy) and four took 2 levels (e.g. pavement width was either narrow or wide).Three of the park attributes took 3 levels (e.g. crowding: few people, quite a few and crowded) and four took 2 levels (e.g. other users: walkers only, cyclists and scooters allowed). Finally, three of the city attributes took 3 levels (e.g. road traffic was busy, moderate or pedestrianized) and five took 2 levels (e.g. tree lined or no trees). The total number of daytime attributes was 22 and the gross number of attributes was 54. There was some overlap in the attribute levels. Road traffic for example was an attribute in both the city and suburban designs.

There were also four night time walks under either bright or dim lighting for each setting. Each night time walk featured the same attributes as one daytime walk. The effect of night

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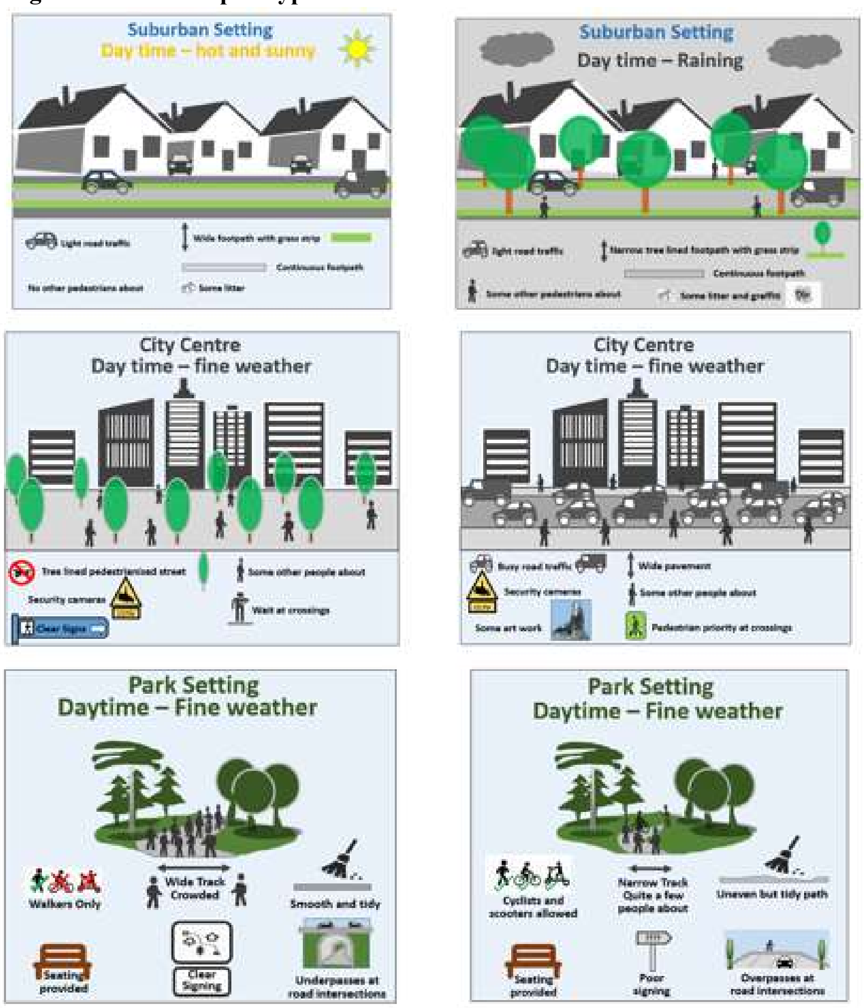
[5] Given only 11% had walked their selected walk at night, most respondents were rating 'dark-time' personal security for a walk other than that selected.

time and lighting could therefore be determined by comparing the ratings of the direct comparisons or via regression of all the combined daytime and night-time walks.

Figure 6 shows six example cards and gives the average rating of respondents. The top row shows two suburban walks with a walk in hot and sunny conditions without trees on the left which scored 70% and a walk when raining with trees on the right which scored 58%. The middle row shows two city walks with a pedestrianized tree-lined walk on the left which scored 72% and a walk next to a busy road with no trees on the right which scored 63%. The bottom row shows two park walks with a walk on a wide path with walkers only allowed on the left which scored 84% and a narrow path with cyclists and scooters allowed on the right which scored 69%.

Figure 6: Six Example Hypothetical Walk Show Cards



In total, the sixty walks provided 6,150 ratings for 1,025 respondents achieving a target of 100 observations for each of the 60 cards.[6] The highest average rating achieved over the sixty walks was 84% for a daytime park walk in fine weather with no cyclists or scooters allowed on a wide, tidy, crowded path with seats, clear signing and an underpass road crossing. The lowest rating was 48% for a night-time suburban walk in fine weather with dim street lighting

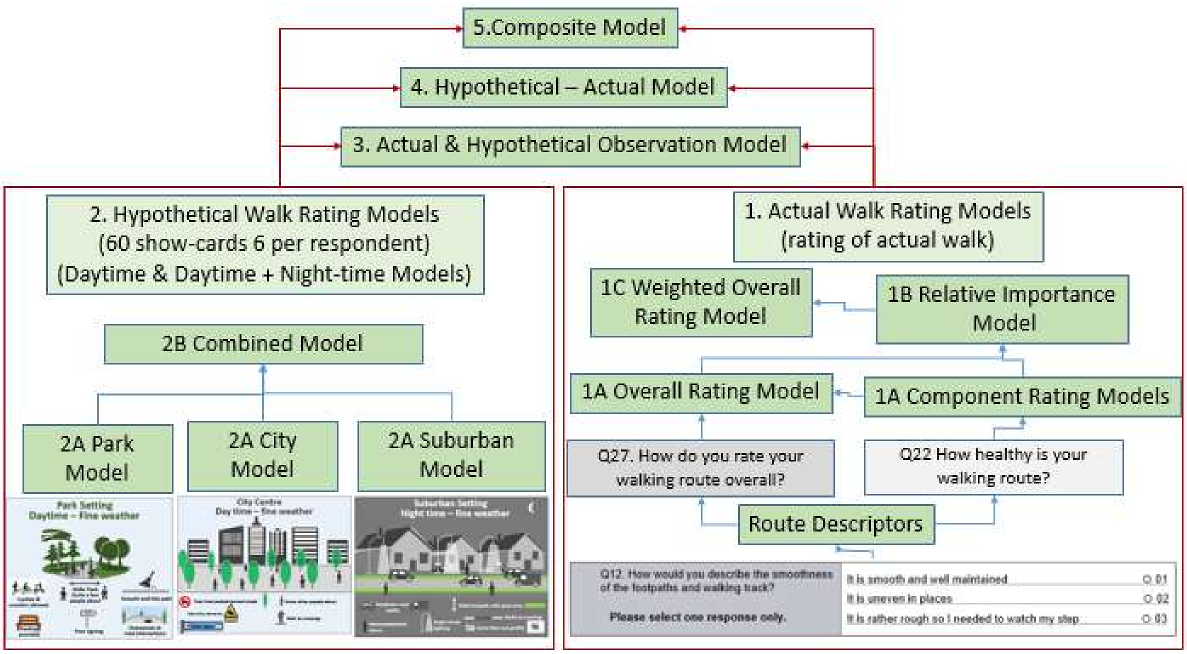
[6] The actual response per card ranged from 98 to 106. The standard error for the mean rating was around ±2% points.

on a narrow but tidy pavement with kerbs at road crossings, light road traffic and with nobody else about.

Regression models were fitted to the actual and hypothetical ratings.[7] The actual walks were analyzed first then the hypothetical walks. The two sets of ratings were then combined by either appending the observations or expressing them as differences (Hypothetical-Actual). Figure 7 shows a typology of the models fitted.

Theoretically, the actual walks should have provided the best evidence but insufficient variation and correlation between attributes hampered estimation of some attribute parameters. The larger samples for the hypothetical walks plus the underlying experimental design enabled parameters for many of the attributes to be estimated with statistical precision. However, they have the inherent drawback of being hypothetical.

Figure 7: Typology of Estimated Rating Models



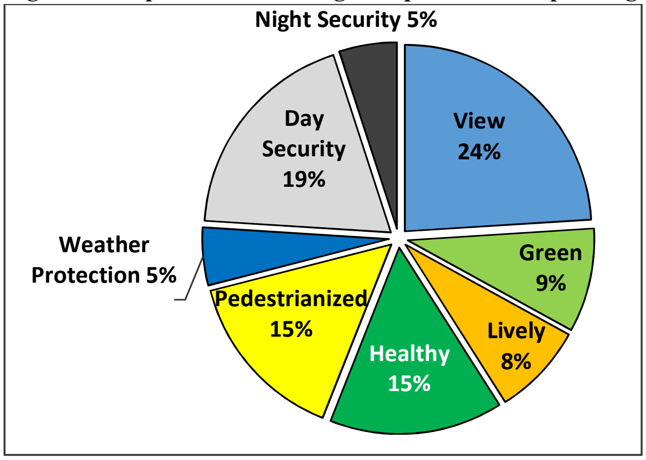
The rating component models (1A) were estimated first which explained each rating component (see Figure 5) in terms of the attributes of the respondent's walk. The overall rating was then explained in terms of the eight component ratings in a relative importance model (1B). The weights were used to construct an overall rating model (1C). A directly estimated overall rating model (1A) was also estimated (i.e. the same as the rating component models 1A).

Figure 8 presents a pie-chart of the importance of the eight rating components. 'View' was the most important explaining a quarter of the overall rating. 'Day Security' was second explaining a fifth with 'Health' and 'Pedestrianized' explaining 15% each. Least important were 'Weather Protection' and 'Night Security' at 5%.

[7] A full discussion is in Douglas (2022).

The best fitting rating component, judged in terms of adjusted R squared ($AdjR^2$) was Green at 0.28 with Night Security the least well explained with an $AdjR^2$ of 0.13. [8] For the overall rating (model 1A) the $AdjR^2$ was 0.24.

Figure 8: Importance of Rating Components in Explaining the Overall Rating



The combined model (1C) had 19 attribute included from the component models.[9] Eight of these were statistically weak however so that in the directly estimated overall model (1A) only twelve were statistically significant.[10]

For the hypothetical walks, some of the most statistically powerful estimates were produced when the three settings (suburban, city and park) were analyzed separately which reflected the three different experimental designs. Combining the three settings introduced correlations between attribute and setting (trees and park for example).

Goodness of fit was not high. $AdjR^2$ was 0.07 and 0.08 for the City and Suburban models and 0.13 for the Park model. The strongest parameters were rain in the suburban model (t=7.7) trees in the city model (t=4.2) and paths free from scooters/cyclists in the park model (t=4.4).

Combining the three settings produced 4,919 daytime and 6,150 daytime plus night-time observations. Goodness of fit $AdjR^2$ was 0.10 without any respondent explanatory variables and 0.15 when they were included. Park (daytime walks) and trees were the most powerful positive attributes that increased the rating. Rain, busy road, no cyclists/scooters, crowded, uneven and dim lighting were the most powerful negative attributes that decreased the rating.

Adding the actual ratings produced a sample of 5,936 daytime and 7,175 daytime plus night-time ratings. $AdjR^2$ increased a little on the hypothetical models to 0.13 without respondent characteristics and 0.17 when included. The estimates effects were similar to the hypothetical models but with more statistically significant variables. A noteworthy result was for respondents to rate their actual walk higher than the hypothetical ones. ‘Familiarity’ and self-selection (actual walks being better suited to their needs and preferences than the hypothetical

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[8] Adjusted R squared ($AdjR^2$) is the proportion of the variation in the dependent variable (in this case the rating R%) explained by the independent variables adjusted (downwards) for the number of variables.

[9] Stepwise regression was used for the component models that included variables with a t value of at least 1.96 independent of sign.

[10] All variables selected in the component rating regressions were included in the overall model irrespective of statistical significance.

walks) probably explain the uplift which averaged 6% for daytime walks and 8% with night-time observations added.

The fourth type of model compared the hypothetical and actual ratings. The difference in rating (hypothetical minus actual) was calculated. The resultant variation in rating difference was explained in terms of the difference in the attribute variables (similarly calculated). The number of observations was 4,887 for daytime ratings and 6,150 with night-time ratings included. AdjR^2 was 0.17 without respondent descriptors and 0.20 with them included.[11] Some of the strongest estimates were produced with this model. The highest t value was 14 for trees; 'a lot of trees' increasing the rating 9% points and 'a few trees' by 4.5%.[12]

Linear and logit (log odds ratio) models were fitted. Linear models were preferred since they have the advantage that the estimates are percentage point effects and so are easy to interpret. Logit model estimates need transformation but have the advantage of keeping predicted ratings within 0% and 100%.[13]

Table 3 presents the recommended estimates. As well as a central estimate, a range for the estimated effect is tabulated. Presented alongside are the estimates of Nunns and Dodge (2020) from their global review. In the top row of the table the rating for suburban walks during daytime is given. This was 72% and was for actual walks. It provides the 'base' for the percentage effects tabulated in the rows below which either add or subtract.

Night-time walking reduced the rating of park walks by 21% under dim lighting and 14% under bright lighting. For suburban and city walks, the reduction was less: 4% for bright lighting and 7% for dim lighting.

Moderate rain reduced the rating 10% compared to fine weather. Hot and sunny weather reduced the rating by 2%; for this attribute (and some others) the range of -5% to +1% straddled zero indicating that some walkers 'liked it hot'.[14]

Walking next to a busy road reduced the rating by 7% compared to moderate traffic whereas light traffic increased the rating by 2%. Pedestrianization raised the rating 4%. Crowded pavements paths reduced the rating 10% and allowing cyclists and scooters to use the footpath reduced it by 7.5%. Having a few pedestrians about rather than a reasonable number increased the rating 2% whereas having no other pedestrians about reduced it 3%.

A wide pavement increased the rating 5% whereas uneven paths reduced it 8%. Having a continuous footpath with no kerbs produced a 1% increase. Crossing facilities did not produce a marked increase: an overpass produced a 3% increase and an underpass 1.5%. A pedestrian crossing increased it 2%. These effects are net of any time spent waiting at crossings.

Tree lined walkways increased the rating 7% and having a few trees increased it 4%.

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[11] There was no difference in the daytime only and daytime plus night-time models.

[12] The variable could take a value of 1, 0.5, 0, -0.5 or -1 distinguishing between 'a few trees' (assigned 0.5 to walks with 'a few trees and 1.0 to 'a lot of trees'). The suburban and city hypothetical walks showed tree-lined pavements for which a value of 1.0 was assigned. A value of 1.0 was also given to park walks.

[13] For forecasting, a linear-logit transformation was developed so that for large improvements (or deteriorations) in rating, predicted ratings are kept within the 0% and 100% interval. The transformation is described in the main report (Douglas 2022).

14 Osgood tells Jerry that "*nobody's perfect"* at the end of the film 'Some Like it Hot" by Billy Wilder which makes estimating values for humans such a wonderfully challenging task.

Litter and graffiti reduced the rating by 3% and 4% respectively. Seats and clear signing increased the rating 4% with art works and security cameras producing a 2% increase.

Table 3: Effect of Walk Environmental Attributes on Overall Walk Rating (Percentage point effect)

Description	Attribute	Recommended Mean	Recommended Range	Nunns & Dodge^	Comment
Walk Setting	Suburb = Base	72	62 to 75	-	Actual ratings higher than hypothetical. Rating affected by respondent characteristics.
	City	-2	-6 to +4	Retail 35	Setting net of attributes e.g. trees and traffic whereas Nunns & Dodge is gross.
	Park	4	2 to 8	Park 20	
Weather (versus fine conditions)	Hot & Sunny	-2	-5 to +1	-	Survey undertaken in summer. Estimated based on hypothetical ratings.
	Raining	-10	-15 to -8		
Road Traffic (versus Moderate)	Busy Traffic	-7	-10 to -4	-5 per 1,000 AADT	Nunns & Dodge based on average annual daily traffic.
	Light Traffic	2	1 to 3		
	Pedestrianized	4	1 to 7		
Pedestrian and Cycle/Scooter activity	Crowded	-10	-13 to -7	-	Base was reasonable number. Aversion to crowds possibly increased by COVID. Pedestrians pavements without any cyclists/scooters
	Few Pedestrians	2	0 to 4		
	No Pedestrians	-3	-5 to 0		
	Cycle/Scooters	-7.5	-10 to -5	-10	
Road Crossing versus Wait at Junction	Overpass	3	0 to 6	-	Net of any time saving. Effect based on hypothetical walks.
	Underpass	1.5	-3 to 3		
	Ped Crossing	2	0 to 4		
Wide vs standard, continuous vs kerb at crossings, uneven vs smooth	Wide	5	2 to 8	7 - 14 /metre	Continuous pavement difficult to explain to respondents. Uneven path had strong negative effect for park walks. D&N estimated 7% for uncrowded and 14% for crowded pavement per metre of pavement.
	No Kerb	1	0 to 3	2	
	Uneven	-8	-12 to -6	-3	
Trees versus No Trees & Grass Strip vs no Grass Strip	Lots of Trees	8	4 to 12	20 for trees or plantings	Hypothetical walks showed mature trees lining suburban and city roads. Actual walks distinguished lots from a few trees. Grass strip on suburban walks produced weak rating increase.
	Some Trees	4	2 to 6		
	Grass Strip	1	0 to 2		
Litter / Graffiti versus Tidy / Graffiti free	Litter	-3	-8 to -1	-	Describing the amount of litter and graffiti is difficult.
	Graffiti	-4	-7 to -1		
Seats & Clear Signing versus No Seats & Unclear Signing	Seats	4	2 to 6	1	Based on hypothetical walks. Clear signing strong effect for parks but not city walks. Familiarity reduced value with visitors not surveyed.
	Clear Signing	4	2 to 8	2	
Art / Security Cameras versus non provision	Art	2	-1 to 6	-	Art increased actual but not hypothetical ratings.
	Security Cameras	2	-3 to 4	6	Correlation between Sec Cameras & City walks.
Night-time versus Daytime taking account brightness of lighting	Park - Bright Lighting	-14	-18 to -10	6	Night-time and lighting had powerful rating effect. Estimates based on hypothetical walks. Nunns & Dodge estimate is for lighting.
	Sub/City - Bright Lighting	-4	-6 to -2		
	Dim Lighting	-7	-10 to -4		
Pavement Quality	Decorative paving	4	-2 to 8	8	Not surveyed. Based on Nunns & Dodge estimate for decorative paving versus asphalt.
Provision of Pavement	Basic footpath versus none	50	25 to 75	159	Not surveyed. Pavement v roadside assumes 10-60% increase calibrated to Nunns & Dodge

^Nunns & Dodge (2020).

The survey did not estimate the effect of providing a pavement where none existed. Pavement quality (paving stones, coloured tiles etc versus asphalt), verandas/retail frontage and dog fouling were also omitted. Values for providing a pavement and high quality pavement have been included in the table by referencing the global review of Nunns and Dodge (2020). In fact, by far the biggest increase is for providing a basic footpath where none existed (50%).

The regression models also included socio-economic and demographic characteristics both as constants that raised or lowered the rating and as interactions with the walk environmental attributes. Those effects found statistically significant (at the 95% confidence level) are presented in Table 4.

Females rated night-time walking 4% lower for personal security concerns. Walks during work time were rated 5% higher for 'greenness' reasons (+8.5%). Exercise and dog walkers rated their walks 8% lower (with weather protection rated 5% lower) but rated park walks 12% higher than other respondents. Respondents aged over 64 rated their walks 3% lower than younger respondents. Over 64s rated the components lively, weather protection, night-time security and uneven v smooth paths lower. They also rated day time security higher than younger respondents.

Table 4: Statistically Significant Effects of Gender, Age and Type of Walk-on-Walk Rating

Attribute	Female Respondent	Non PT Walk	Walk During Work Time	Exercise & Dog Walk	Aged Over 64
Green Rating			8.5		
Lively Rating					-4
Weather Protection Rating				-5	-9
Daytime Security Rating					3
Night-time Security Rating	-5				-5
Uneven versus Smooth Path					-3
Park vs. Suburban/City Walk				12	
Night versus Day Walk	-4				
Overall Walk Rating		-5	5	-8	-3

6. Valuing walk quality

Having established how walk environmental attributes affect the quality rating of pedestrians' walks, the next task was to value the change in rating. This was done through a set of Stated Preference (SP) questions which valued walk quality rating in walk minutes. Two sets of SP questions were developed to cater for short and long walks (15 minute threshold). Each set had twelve questions. Two-thirds of respondents completed the short walk questionnaire set and one third the long walk set.[15]

The SP featured differences in quality (stars) and differences in walk time (minutes). There were four differences in quality and three differences in walk time. The quality and walk time differences were varied in a controlled way so that the two variables were uncorrelated.[16]

Two walk routes labelled A and B were shown to respondents. Figure 9 provides an example in which Route A is rated 4 stars in quality and takes 15 minutes to walk and Route B is rated 3 stars in quality and takes 10 minutes. So if route A is chosen, the respondent is indicating

[15] Exercisers and dog walkers were not asked the SP.
[16] A full factorial design was used (3x4).

they would walk five minutes longer to have a one star higher quality of walk. If the respondent chose B, the one-star difference in quality is valued less than 5 minutes of walking time. Respondents were asked to answer the choices in the context of the actual walk they had described earlier in the survey.

Figure 9: Example Stated Preference Show Card (Short Walk Design)

Figure 9 showed one of the 'short walk' choices. Those making long walks (over 15 minutes) were shown a walk ten minutes longer i.e. 25 for A and 20 minutes for B. The differences in walk time remained the same which meant responses could be combined without affecting orthogonality. The short and long designs also overlapped in terms of the absolute walk times shown.[17]

Each respondent completed six questions. The computer program ensured that total response was well balanced with 409 or 410 completing each of the twelve questions (262 short and 148 long) giving a total response of 4,914.

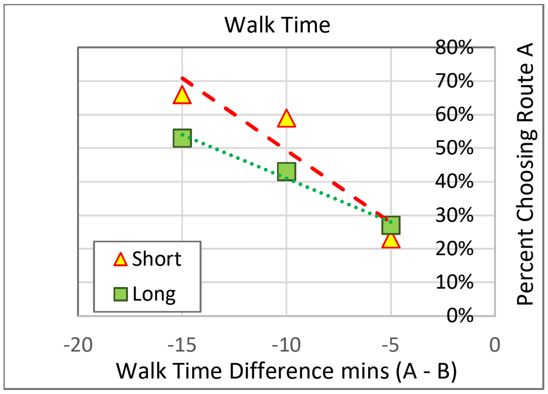
The aim of the SP was for respondents to vary their response (trade-off) by sometimes choosing the higher quality route and sometimes the shorter route. Over the full design, 60% 'traded-off'. However, 26% always chose the higher quality route and 14% always chose the shorter route. Thus, there was an underlying preference for the higher quality route that was unable to be explained by the rating and walk time differences. For the preferred model, non-traders were excluded which reduced the sample size to 2,946. It also meant that the estimated value of quality was lowered.

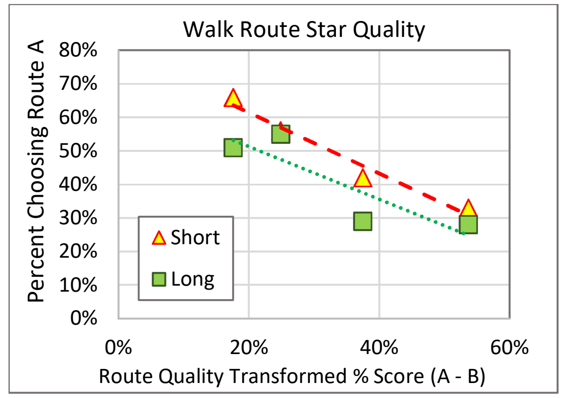
To allow for a diminishing sensitivity to improved quality, the rating measure (R%) was raised to the power of 0.7. The power function changed the path taken between 0% and 100% making it steep at first then gradually slackening off but did not affect the maximum value of quality (100%-0%). Alternative values were tested for goodness of fit with 0.7 providing a good fit. SP surveys of PT users in NSW had also used a value of 0.7 for stop and vehicle quality, Douglas and Jones (2018). By comparison, assessment of the UK PERS score implies a slightly higher value of 0.8 (flattening the curve towards a straight line), see Douglas (2022).

The transformed R% measure was subtracted from 1 so that the 'cost' of quality was measured. This changed the sign of the quality regression parameter from positive to negative so that the relationship was in the same direction as for walk time. Figure 10 shows the sensitivity of route choice to quality and walk time. The response slope for short walks is steeper than for long walks (indicating a percentage effect) but with the similar slopes for quality but a higher preference for higher quality for long walks.

[17] The longest walk shown in the short set was 20 minutes for route B (e.g. 10 versus 20 minutes) and the shortest walk shown in the long set was 15 minutes for route A (e.g. 15 versus 30 minutes).

Figure 10: Aggregate Response to Walk Time & Walk Quality





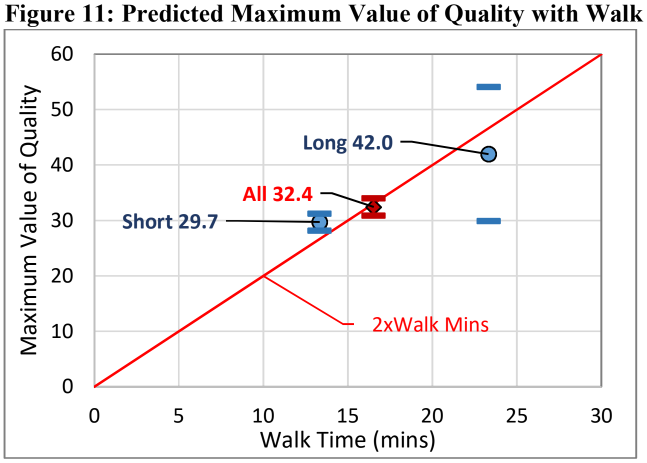
Linear regression and logit models (via maximum likelihood were fitted. There was virtually no difference in the estimated values of quality. Table 5 presents the fitted linear models. The parameters were statistically accurate with the lowest t value being 7.6 for walk time in the long walk model and the highest being 22.6 in the all-observations model. Dividing the quality estimate by the walk time estimate gives the maximum (0% - 100%) value of quality (MVQ) in equivalent walk minutes. For the all-observation model, MVQ was 32.4 minutes. For short walks MVQ was 29.7 minutes and for long walks it was 42 minutes.

Table 5: Model Estimates by Walk Length

Variable	Individual Observations Short	Long	All
Quality (%T)	-1.084	-0.890	-1.024
t	-20.1	-10.86	-21.0
Walk (mins)	-0.04	-0.021	-0.032
t	-20.4	-7.6	-22.6
Quality/Walk (mins)	29.7	42.0	32.4
STE (mins)	0.8	6.2	0.8
Observations	2,004	942	2,946

Figure 11 plots the MVQ against the average walk time in the SP designs. A proportional line (i.e. through the origin) fitted to the 'all observation' MVQ of 32.4 minutes at a walk time of 16.2 minutes is superimposed. The proportional relationship implies an MVQ that is 2 times the walk time (32.4/16.2).

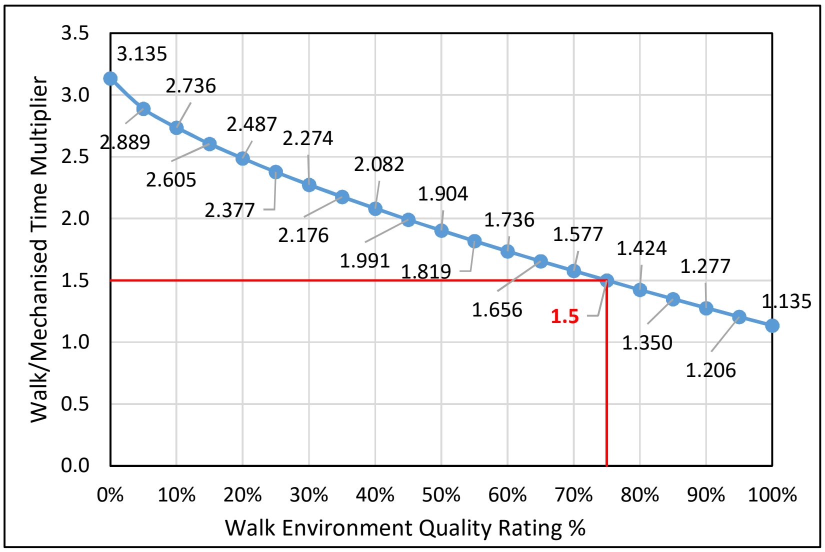
Figure 11: Predicted Maximum Value of Quality with Walk Time



A review of the demand parameters within the Strategic Travel Model (STM) of Sydney for walk as a main mode coupled with the recommended value in the Australian Transport and Planning Guidelines (ATAP) for public transport access/egress gave a value of 1.5 for walk time in mechanized travel time (i.e. car and PT). Thus a walk of 15 minutes would be equivalent to 10 minutes in a car or on a bus. The value would depend on the quality of the walk (and of PT and car). For walk, it was assumed that walk environmental quality was 75% (the average rating of actual walks in the survey).

Figure 12 graphs the quality – mechanized travel time multiplier. The graph takes into account the 0.7 power function for walk quality. The multiplier declines from 3.135 at the lowest 'very poor' quality of 0% to 1.135 at the highest 'very good' quality of 100%. The difference in multiplier is therefore 2 (3.135-1.135) which accords with the SP valuation. The curve has been positioned so that the multiplier is 1.5 at a rating of 75%.

Figure 12: Walk versus Mechanized Travel Time Multiplier with Walk Environmental Quality



The formula to calculate the Walk Time Multiplier (WTM) is shown in equation 1.

$$WTM = 1.135 + 2\,\{1 - WEQ^{0.7}\} \qquad \text{.....(1)}$$

Where: WEQ is the walk quality rating.

The multiplier (WTM) then needs to be multiplied by the walk time. As an example, if the walk time was 10 minutes and the WEQ rating was 60%, WTM would be 1.736 and the equivalent mechanized time (EMT) would be 17.36 minutes. If the walk environment was improved which increased WEQ to 70%, WTM would reduce to 1.577 and EMT to 15.77 minutes. The benefit would be worth 1.59 EMT minutes (17.36 - 15.77).[18]

To monetize the benefit, EMT is multiplied by the value of mechanized travel time (VOT) expressed in cents per minute (c/m). Based on surveys undertaken by TfNSW of public transport and car users in 2013-14, a value of time of $16 per hour or 27 c/m was calculated for 2022, (Douglas and Jones, op cit). Therefore, for the ten minute walk, an improvement in

[18] Note that the constant of 1.135 in equation 1 drops out meaning the change in walk time is equal to the change in equivalent mechanized travel time. This is unless walk time changes with the improvement.

rating from 60% to 70% would be worth 43 cents (27c x 1.59 mins or in total cost terms $4.69 – $4.26).

7. Forecasting demand response

It is surprising and somewhat disappointing that so little has been published on the demand effects of improving the walk environment. What studies have been published have tended to look at new paths and mostly cycling paths. Only one Australasian study was found that assessed demand response to improved quality; a 2011 Queensland study by SKM (2011).

The UK PERS methodology applies to existing walk trips and does not forecast changes in demand and its application to Sydney by Tsai (op cit) kept walk demand fixed. For New Zealand, Nunns and Dodge (op cit) assumed a 20% increase following a new pavement alongside a road where previously there was none and 30% for improving a basic footpath.

The gap in knowledge is perverse given the Cost Benefit evaluations of walking and 'place making' projects that have been undertaken to forecast the improvements in health, reduced car congestion and improved air quality.[19] Yet how can these benefits be estimated without forecasting the increase in the number of walk trips?

Unfortunately, it is not possible to rely on travel demand models because they are usually 'strategic' in nature and have spatial zones too large to describe walk trips with any accuracy.[20] An attempt was made to 'fill the gap' by developing a framework, using some of the results of the survey, other studies and by making some assumptions. Hopefully, in the not too distant future, some 'before and after' studies will be undertaken to assess changes in pedestrian demand resulting from improvements to the walk environment.

The approach estimates the likely demand impact of an improvement that raises the walk rating from 60% to 70% for a 10 minute walk (as assessed at the end of section 6). The forecast assessed three sources of walk demand (i) public transport access mode, (ii) main mode and (iii) exerciser and dog walker forecasts. The forecasts were produced for three walk areas: suburban, city and park.

For public transport access walks (e.g. walking to the bus stop) a generalized time elasticity was applied to a generalized time measure. Using a bus trip as an example and referencing TfNSW surveys, the average time between timetable buses was 18 minutes with time spent on the bus averaging 21 minutes at a fare of $3 with egress time taken at 17 minutes (from the survey).[21] Access times varied from 16 to 21 minutes according to walk area. After weighting the components, a 10 minute walk accounted for 15% of the generalized public transport trip cost.[22] The change in public transport demand from the 10 minute walk improvement was estimated by applying a generalized cost elasticity of -1.23 based on Dunkerly (2019).[23] The forecast increase in public transport trips was reduced by a fifth to allow for some of the extra

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[19] See for example ATAP (2016) which provides an extensive review of largely externality benefits but little information on forecasting demand changes from walking projects.

[20] Many walk trips are wholly within a 'zone' which means the modelled trip 'origin' is the same as the 'destination' so distances and times have to be 'assumed' as argued by Douglas, Bradley and Jones (2019).

[21] See section 7.2 in "*Passenger Service Values for Bus*", report by Douglas Economics for TfNSW dated October 2016 https://www.researchgate.net/publication/354739459_Passenger_Values_for_Bus_Use_in_NSW

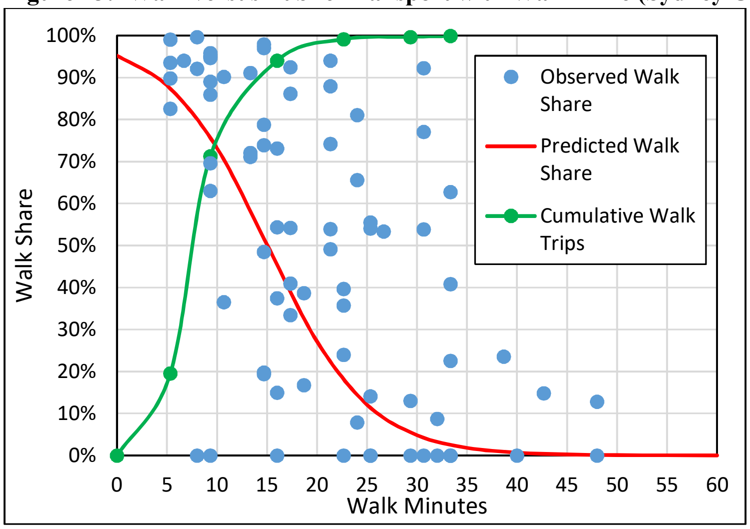
[22] Service interval minutes were weighted at 0.61 x in-vehicle time, fare at $16/hr and walk using equation 1.

[23] The elasticity sourced from the UK includes bus, wait and walk time but not fare so was increased an eighth.

bus trips to have diverted from walk as a 'main mode'.[24] The net increase was 1.6% for suburban, 1.4% for city and 1.5% for park walks.

For main mode walk trips (e.g. walking to the shop) a diversion model was used. Walk is likely to be the dominant mode for short trips of under a kilometre but lose its competitiveness rapidly to car, bus and train as distance increases. To forecast demand, a walk share model built to forecast demand for extending the Pyrmont/Ultimo LRT to Circular Quay in Sydney was used, BAH (1995). Walk trips were estimated using a 'moving observer' technique between a set of zones within the CBD (Central to Circular Quay and Darling Harbour to the Domain). Figure 13 shows the scatter in walk share observations for 77 zone pairs. Superimposed is the predicted walk share which fell from just under 90% at 5 minutes to close to zero percent at 40 minutes.

Figure 13: Walk versus Public Transport with Walk Time (Sydney CBD)



Equation 2 presents the diversion formula.

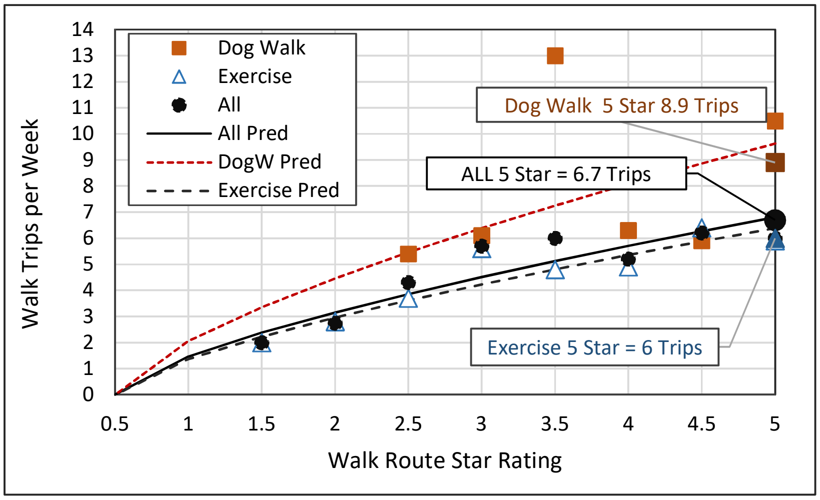
$$\Pr(WALK) = \frac{\exp(3 - 0.2 * WT)}{1 + \exp(3 - 0.2 * WT)} \dots\dots (2)$$

Equation 2 was applied using average walk times of 21, 22 and 27 minutes for suburban, city and park walks. These times gave walk shares of 23%, 20% and 8%. With the reduction of 1.59 minutes from the quality improvement (equation 1), the shares increased to 25%, 22% and 9%. The change in share equates to percentage increases of between 9% and 11%. Based on the SKM (op cit) survey, 67% of the increase was assumed to be from public transport and 33% from car for city areas. For suburban and park areas, the percentages were 87% from car and 13% from public transport.

The pilot surveys found exercisers and dog walkers generally happy with their length of their walk. Therefore, instead of the SP, the 205 exercisers and 67 dog walkers were asked a set of questions about whether they would walk more if their walk environment was improved. Figure 14 plots the response showing walk trips (all) to increase from around 5 walks per week to 6.7 if route quality was able to be increased from 3.5 to 5 stars.

[24] The assumption was that all 'main mode' walk trips that diverted to public transport walked along the affected stretch of walkway. The estimate of one fifth was sourced from Dunkerly (2018).

Figure 14: Walk Mechanized Time Multiplier with Walk Environmental Quality



Taking a power function with a value of 0.7 of the percentage rating (R%) gave a good fit to the data. The estimated slope parameters were 6.4 for exercisers, 9.6 for dog walkers and 8.8 for 'all' observations,

Forecasting the impact of a rating improvement from 60% to 70% for a ten minute walk involved multiplying the proportionate change in the transformed quality rating by the affected walk link length (10 minutes) and dividing by the total walking time which dampened the effect.[25] The change in the transformed rating was 11% and the dampening effect was 17% for parks (10/59 minutes) and 25% for suburb and city walks (10/40 minutes). The resultant percentage change in walk trips was 2.8% for city and suburban walks and 1.9% for park walks. All the additional trips were 'induced'.

The biggest increase in walk demand over the link is likely to be from existing pedestrians changing their route based on the SMK (op cit) Brisbane surveys. For the inner city, 70% walked a different route compared to 50% in 'other areas' (presumed to be suburban areas). Diversion from PT and car was 20% in the inner city and 10% in other areas. New walk trips labelled 'induced' accounted for 10% in inner city areas and 40% in other areas. If it is assumed that 70% of new trips re-routed from another street or walkway in city areas and 50% in suburban and park areas, a forecast can be made by multiplying diverted and induced trips by 2.33 for city areas and by 1.0 for suburban and park areas.

Table 6 combines the results showing city areas to be the most responsive with an increase of 26.6%. For suburban and park areas the increase was lower at 11.8% and 9.4% respectively due to less re-routing. The weighted average increase, (weighted by the walk trips for the three settings) was 13%. An elasticity is shown on the right hand column of the table, Elasticity is the percentage change in walk trips divided by the percentage change in the quality.[26] Elasticity was highest for city walks at 1.6. For suburb areas it was 0.71 and for park walks it was 0.56. The trip weighted average was 0.78.

[25] The beta parameters which estimate the number of walk trips for a given walk quality rating drop out since they appear in both the numerator and denominator.
[26] The percentage change in quality was 16.7% ({70%-60%}/60%) rather than the 10% point increase.

Table 6: Forecast Increase in Walk Trips (%)
From a 60% to 70% increase in the walk environment rating for a 10 minute walk link

Area	Re-routed	Induced	PT	Car/Taxi	Total	Elasticity
Suburb	5.9%	0.7%	0.8%	4.3%	11.8%	0.71
City	18.6%	0.3%	3.2%	4.4%	26.6%	1.60
Park	4.7%	1.1%	0.6%	3.0%	9.4%	0.56
ALL	7.1%	0.8%	1.1%	4.1%	13.0%	0.78

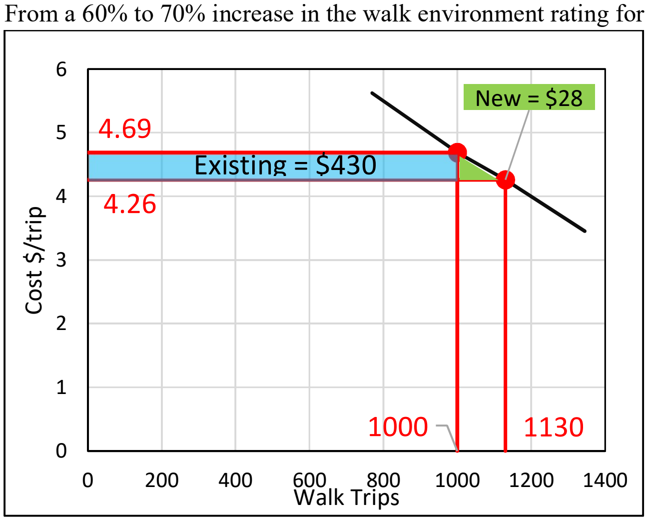
Table 7 shows the source of the forecast increase. The percentage changing their route (re-routed) was taken from the SKM survey. Induced demand is highest for park areas at 12% reflecting the survey results for exercise and dog walkers. Car/taxi diversion is around a third and public transport contributes 7%.

Table 7: Composition of New Link Walk Demand (%)
From a 60% to 70% increase in the walk environment rating for a 10 minute walk link

Area	Re-routed	Induced	PT	Car/Taxi	Total
Suburb	50%	6%	7%	37%	100%
City	70%	1%	12%	17%	100%
Park	50%	12%	6%	32%	100%
All	52%	7%	7%	34%	100%

Figure 15 shows the benefit to existing and new walk trips with new users benefiting by half the amount of existing users.[27]

Figure 15: Monetised Benefit of Walk Quality Improvement
From a 60% to 70% increase in the walk environment rating for a 10 minute walk



The improvement produced a benefit of 43 cents by reducing the cost from $4.69 to $4.26. The benefit for the existing 1,000 walk trips totals $430. On average, new walk trips benefit by half the amount (21.5 cents) so with walk trips using the link increasing 13%, trips increase from 1,000 to 1,130. The total benefit to new walk trips is $28 (130 x 21.5c). The

[27] Exercisers and dog walkers (who were not asked the SP questions) were assumed to benefit by the same as ‘means to an end’ walkers.

total benefit to existing plus new users is therefore $458 with existing users receiving 94% of the benefit and new users 6%.

8. Concluding Remarks

The 5 star scale to rate walk quality from a pedestrian's perspective was easy to understand and provided a way to measure the importance of attributes describing walk quality. A set of trade-off questions valued quality in walk minutes that was easy for respondents to complete. Overall the survey was well liked achieving a rating of 4.3 stars out of 5 (84%) by the sample of just over 1,000 respondents.

The resultant values are indicators of benefit and in doing so, the study helps fill a gap in current appraisal manuals that have focused on 'externality' benefits rather than the benefits to pedestrians themselves.

It is surprising and somewhat disappointing that so little has been published on the demand effect of improving the walk environment. To help fill this gap, a model was developed that estimated the percentage increase in walk trips from improving walk quality from 60% to 70% for a ten minute walk link (around 800 metres). Demand was forecast to increase 13% in response, implying a demand elasticity with respect to walk quality of 0.78. 94% of forecast benefit accrued to existing users and 6% to new users of the walk link.

It should be remembered that quantifying the quality of the walk environment is by its nature difficult. Using ratings provides an insight into the pedestrian's viewpoint but some artistry will always be required by the perceptive analyst.

To end on a positive note, the survey found NSW residents were happy with their walks. How happy are you with yours? Perhaps, the next time you are out and about rate your walk on a 5 star scale and consider what influenced your rating.

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