Walkability Evaluation of Streetscapes: Development of Prediction Equations for Walking Needs of Tourists

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Abstract: *Work presented here is a part of a comprehensive study which aimed at calculating the walkability levels of streets. The walkability levels are to be calculated based on five walking needs which have been identified in previous stages. In the work presented here, equations which can predict five walking needs were developed based on independent variables which represent the effect of physical environment.*

Keywords: *Walking needs, Walkability Evaluation, Landscape, Tourists*

1. INTRODUCTION

Provision of walkable spaces has become an important consideration for urban planners and designers (Alfonzo, 2004). With the present research mainly focusing on regular walkers, limited attention has been paid to the tourists. In order to cover such a research gap this work has focused on the walkability of tourists. Among different efforts of creating walkable spaces, evaluation of walkability levels of streets has a prime importance. Researchers around the world have attempted to propose walkability evaluation instruments to evaluate influence of elements of the physical environment. The influence of the elements of the physical environment on a walking decision is mediated through perceived amenities (Ewing et al., 2006). Thus an accurate walkability evaluation method predicts walkability after considering such mediation process.

Previous works on walkability evaluation have proposed walkability evaluation methods either in terms of individual physical elements or in terms of amenities. In order to reduce the complexity, methods based on individual physical elements use only a limited number of highly influential elements without considering some other influential elements. Methods based on the amenities are criticized for being subjective since the amenities reflect subjectively measurable parameters. Yet if a proper set of predication equations are developed to predict the amenities then such amenities can be predicted objectively.

The work presented here is a part of a research work which attempts to predict walkability incorporating the mediation process based on a research framework shown in Figure 1. The initial work (Samarasekara et al., 2011b) indicated that when people evaluate walkability their decisions are influenced by the street type such as whether it is a residential street or a shopping street. Accordingly a street classification consisting of four streets namely, Type A -Mixed use – high destination streets, Type B- Shopping streets, Type C - Mixed use – low destination streets and Type D- Residential streets was finalized with and objective distinction criteria. In the next stage based on the outcomes of a psychological experiment, five walking needs which would influence the walking decision of a tourist were identified (Samarasekara et al., 2011a). The present work addresses the next part of such work. For each identified walking need prediction equations were developed to calculate such walking needs based on a set of pre- identified physical elements.

2. MATERIALS AND METHODS

2.1. Research Approach

Prediction equations for each walking need were derived by systematically variation of parameters pre-identified parameters and evaluating how the subjects would perceive the walking needs for different conditions. Due to the practical difficulties of systematically varying several parameters within several standard conditions, photo retouching was used to produce stimuli. Separate prediction equations were produced for different streetscape types.

Based on previous research work, a set of potential parameters were identified which could influence each walking need. The base images for each type of walking need and each streetscape type were taken in standard conditions. The images were taken in summer using an 18mm camera showing the viewpoint of a pedestrian from the left side of the street looking in the forward direction. The camera was set at a 1.5m height and at a distance of 1.2m from the boundary demarcating the private and public land.

Each of the denotative parameter was systematically varied using multiple levels. For each connotative parameter one element was selected as the standard and it was systematically varied with other denotative parameters. After selecting one occurrence of the standard element, a set of stimuli were prepared by the replacement standard by the other connotative elements. By comparing the ratings of such stimuli against the stimulus with the standard element, the contribution of other connotative elements were calculated as a weight. For the walking need Shade, only one connotative parameter (Area of non-shade provision trees) existed. Therefore it was systematically varied.

2.2. Experimental work & Data Analysis

73 Saitama University students participated in the experiment. Experimental conditions: Participants viewed the images projected on to a screen. Their seating position was fixed after considering the dimensions of the projected image and the viewing angles of the camera so as to provide a similar view to that seen on the real site. They viewed individual images and rated them for the relevant walking need semantic scales on a 9-point Likert scale of –4 to +4. In order to familiarize respondents with tasks, 8 practice images was used prior to experimental tasks.

For each image, data of each walking need semantic rating obtained from all the 73 respondents was averaged to get the average rating scale values for a particular image. The prediction equations were developed by applying Hayashi's quantification method I (for Traffic safety in walking area & Comfort of walking area & Shade) and multiple regression (for Environmental appearance & Activity potential).

3. RESULTS

3.1. Outcomes of the experiment: Physical elements influencing each walking need

This work identified specific parameters influencing each walking need while quantifying the contribution of influential parameter. Many researchers using top down approach start by hypothesizing the main walking needs followed by the hypothesizing the individual elements influencing each walking need. In establishing the construct validity, they tend to use the approach of checking the correlation of such parameters to walkability. But in the instances where high multicolinearity exists this approach may lead to the identification of inconsequential parameters as being consequential. Thus proper identification of parameters had to be done by the systematic variation of each parameter. Considering such, this work identified influential parameters for each walking need, based on the systematic variation of potential parameters.

Outcomes confirmed that each need is influenced by a limited number of parameters while the other proposed parameters were found to be inconsequential. Tables 1 to 5 shows the outcomes of the experiment in terms of influential elements and their relative contribution to each walking need.

Table 1: Prediction equations for Traffic safety in walking area – Hayashi's Quantification Method I

Parameter	Statistical measure	Category description for different streetscape types		Streetscape type A	B	C	D
Model	a			0.979	0.954	0.976	0.935
Method of pedestrian separation	b			0.919	0.754	0.885	0.828
	p			0	0	0	0.00001
		Type A & B	Type C & D				
	cs	1- Separation by trees & Bollards	1- Separation by trees & Bollards or Only trees	1.168*	0.868*	0.674*	0.761*
	cs	2 Separation by trees	2 Separation by Bollards	0.633*	-0.206*	0.567*	1.226*
	cs	3-Seperation by Bollards	3- Mount up or Colored strip	0.828*	0.413*	-0.176*	-0.252*
	cs	4- Mount up or Colored strip	4-White line	-0.381*	-0.031*	-0.865*	-1.289*
	cs	5-White line	5-No separation	-1.075*	-0.556*	-1.572*	-1.071*
	cs	6-No separation		-1.336*	-0.757*		
Walking area width	b			0.958	0.931	0.955	0.825
	p			0	0	0	0.00001
		Type A,B,C & D					
	cs	1-Width below0.5m		-2.066*	-1.698*	-1.881*	-1.509*
	cs	2-Width 1m		-1.089*	-0.560*	-0.913*	-0.405*
	cs	3- Width 2m		0.310*	0.726*	0.074*	0.650*
	cs	4- Width 3m		0.896*	0.966*	0.941*	0.761*
	cs	5- Width 4m		1.261*		1.152*	
Number of lanes	b			0.314			
	p			0.0234			
		Type A					
	cs	1- 2 lane		-0.182			
	cs	2 -4 lane		0.182			
Pedestrian priority	b				0.146		
	p				0.36765		
	cs	Type D					
	cs	1- No pedestrian priority			0.064		
	cs	2- Pedestrian priority			-0.064		
Negative Connotation	b			0.182	0.163	0.243	0.326
	p			0.197	0.314	0.242	0.173
		Type A,B,C & D					
	cs	1- negative connotation : Absent		-0.102	-0.072	-0.080	-0.208
	cs	2- negative connotation : Present		0.102	-0.072	0.080	0.173
Positive connotations	b			0.197	0.406	0.230	0.026
	p			0.162	0.009	0.269	0.916
		Type A,B,C & D					
	cs	1- Positive connotation : Absent		-0.069	-0.188*	0.076	-0.016
	cs	2- Positive connotation : Present		0.069	0.226*	-0.076	0.013
Constant				0.751	0.544	0.960	0.378

a - Multiple correlation coefficient; b- Partial correlation coefficient; p – p value; cs – category scores; *- Value significant at 0.05 level; A: Mixed use High destinations; B:Shopping streets; C: Mixed use low destinations; D: Residential

Table 2 : Prediction equations for Comfort in walking area– Hayashi's Quantification Method I

Parameter	Statistical measure	Category description for all streetscape types	Streetscape type A	Streetscape type B	Streetscape type C	Streetscape type D
Model	a		0.998	0.900	0.991	0.993
Paving type	b		0.613	0.508	0.890	0.949
	p		0.023	0.134	0.000	0.000
	cs	1-Unit blocks	0.026*	0.413	0.415*	0.612*
	cs	2-Asphalt	-0.104*	-0.502	-0.508*	-0.286*
	cs	3-Concrete	0.098*	0.215	0.195*	-0.255*
Walking area width	b		0.998	0.849	0.989	0.992
	p		0..000	0.002	0.000	0.000
	cs	1-Width below0.5m	-2.443*	-0.665*	-2.004*	-1.391*
	cs	2-Width 1m	-0.962*	-1.468*	-0.857*	-0.284*
	cs	3- Width 2m	0.607*	0.244*	0.998*	0.869*
	cs	4- Width 3m	1.354*	2.111*	1.128*	1.270*
	cs	5- Width 4m	2.258*		1.404*	
Electric wires	b		0.933	0.547	0.736	0.570
	p		0.000	0.101	0.004	0.085
	cs	1-Level I (None)	0.086*	0.375	0.138*	-0.069
	cs	2-Level II	0.366*		-0.457*	0.146
	cs	3-Level III	-1.022*	-0.844	0.048*	-0.094
	cs	4 Level IV	-0.189*	-0.845	0.079*	0.048
Positive connotations	b		0.401	0.023	0.600	0.715
	p		0.174	0.949	0.030	0.020
	cs	1-Positive connotation : Absent	-0.043	-0.024	-0.175*	0.115*
	cs	2- Positive connotation : Present	0.043	0.011	0.136*	-0.185*
Constant			1.052	0.208	0.405	0.128

a - Multiple correlation coefficient; b- Partial correlation coefficient; p – p value; cs – category scores; *- Value significant at 0.05 level; A: Mixed use High destinations; B:Shopping streets; C: Mixed use low destinations; D: Residential

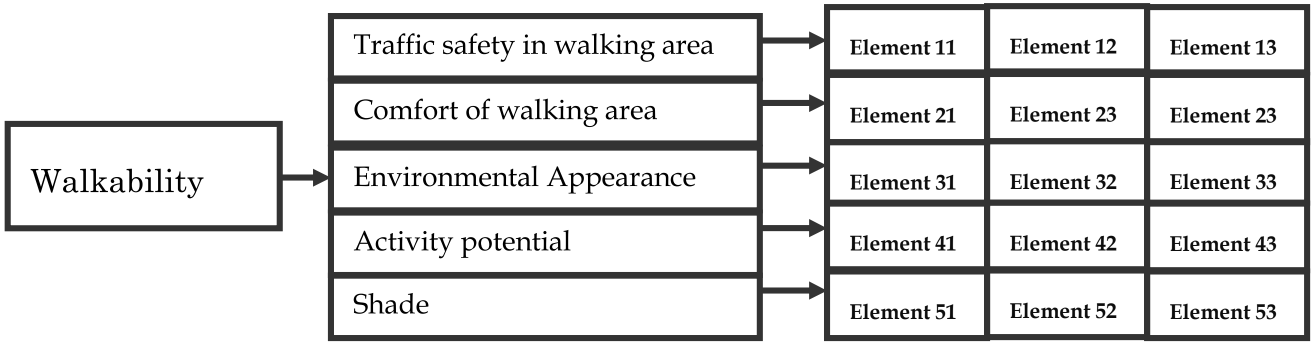

Figure 1: Conceptual framework for the evaluation of walkability

Table 3 : Prediction equations for Shade – Hayashi's Quantification Method I

Parameter	Statistical measure	Category description for all streetscape types	Streetscape type			
			A	B	C	D
Model	a		0.939	0.970	0.747	0.950
Volume of shade provision trees	b		0.934	0.969	0.713	0.949
	p		0.000	0.000	0.000	0.000
	cs	1-Level I (None)	-2.366	-2.257	-1.074	-2.323
	cs	2-Level II	-0.526	-0.149	-0.599	0.074
	cs	3-Level III	1.383	0.821	0.589	0.855
	cs	4 Level IV	1.509	1.586	1.083	1.394
Canopy shape	b		0.237	0.252	0.213	0.218
	p		0.113	0.091	0.156	0.146
	cs	1 - Pyramidical	0.208	0.006	0.096	-0.135
	cs	2 – Vase	-0.068	0.082	0.201	0.126
	cs	3 – Round	0.053	-0.127	0.001	0.078
	cs	4 - Columnar	-0.193	0.069	-0.299	-0.068
Positive Connotation – Volume of home vegetation	b		0.613	0.441	0.395	0.452
	p		0.000	0.002	0.007	0.002
	cs	1-Level I (None)	-0.666	-0.083	-0.498	-0.257
	cs	2-Level II	0.293	-0.167	0.115	-0.063
	cs	3-Level III	0.372	0.249	0.383	0.321
Constant			0.482	0.421	0.378	0.515
a - Multiple correlation coefficient; b- Partial correlation coefficient; p – p value; cs – category scores; *- Value significant at 0.05 level; A: Mixed use High destinations; B:Shopping streets; C: Mixed use low destinations; D: Residential						

Figure 2: Sample Images

Table 4: Prediction equations for Environmental Appearance –Multiple Regression

Parameter	Statistical measure	Streetscape type			
		A	B	C	D
	P value -model	0.018	0.009	0.004	0
	Adjusted R^2	0.54	0.367	0.849	0.900
	Constant	0.564	0.589	0.143	0.304
Trees	β	0.599	0.476	0.783	0.875
	B	2.44E-07	2.94E-07	7.02E-07	9.72E-07
Electric wires	β	-0.306	-0.285	-0.452	
	B	-2.62E-04	-3.98E-05		
Exposed service boxes	β				
	B				
Exposed Service lines	β				
	B				
Garbage	β	-0.373	-0.334	-0.218	-0.379
	B	-2.82E-06	-3.64E-06	-6.03E-06	-3.33E-06

β ; Standardized coefficient; B ; Unstandardized coefficient; Note: β values are shown only for those parameters contributing at 0.05 significance level ;A: Mixed use High destinations; B:Shopping streets; C: Mixed use low destinations; D: Residential

Table 5 Prediction equations for Activity Potential–Multiple Regression

Parameter	Statistical measure	Streetscape type			
		A	B	C	D
	P value -model	0.028	0.022	0.047	0.005
	Adjusted R^2	0.846	0.642	0.381	0.885
	Constant	0.037	-0.267	-0.431	0.051
Destinations	β	0.778	0.727	0.515	0.903
	B	4.34E-07	6.66E-07	5.26E-07	9.74E-08
Intermediate spaces	β	0.432	0.402	0.446	0.291
	B	-5.27E-07	1.40E-06	5.40E-07	7.75E-08
Positive Connotation	β				
	B				
Office	β				
	B				
Industry	β	-0.253			
	B	-1.40E-06			
Parking Area	β				
	B				

β ; Standardized coefficient; B ; Unstandardized coefficient; Note: β values are shown only for those parameters contributing at 0.05 significance level ;A: Mixed use High destinations; B:Shopping streets; C: Mixed use low destinations; D: Residential

Results related to traffic safety reveals identified width of walking area as the most influential parameter across all streetscape types. Method of pedestrian separation was also identified as highly influential across all types of settings. Also as expected in type A streetscapes, safety feeling decreased with the increase of number of lanes. Although positive connotative suggestion of presence of crosswalks could influence the safety feeling in type B streets, it did not have any influence in any other streetscapes.

Feeling of comfort was also highly influenced by walking area width across all streetscapes. Paving type while being influential on all setting types, were highly influential in type A and D streetscapes. Within the individual categories, the asphalt paving was disliked in all settings while the unit blocks were preferred over concrete paving in all settings except for type A. With comfort having a dominant influence on a walking decision, this shows that presence of unit blocks can be quite important in a encouraging a walker. Presence of electric wires exerted a higher influence on streetscapes C and D.

Among the three parameters investigated within shade, canopy shape was proved to have insignificant influence while the other two parameters had significant influence across all types of streetscapes. Both of the influential parameters expressed volume of vegetation. As expected the denotative parameter volume of shade provision trees had the highest influence on walkability across all types of settings. In addition the connotative parameter, non-shade provision trees also had a considerable contribution across all settings. This suggest that even those trees which may not provide any shade can still encourage a person to walk through the suggestion of shade.

The results for Environmental appearance show that trees, electric wires and garbage to have significant influence for all types of settings except for the non-significant influence of electric wires in type B streets. Outcomes related to vegetation here is easily explainable and is in line with many previous research works. Presence of electric wires had a significant influence on both Environmental appearance and Comfort of walking area.

The prediction equations related to activity potential had a heavy influential power from destinations and strong yet secondary influence by the intermediate spaces. Within the type D settings intermediate spaces showed influential power quite close to that of destinations. Improvement to activity potential through increase of destination may be less feasible in residential areas. In such a context the intermediate spaces provide some potential to improve activity potential.

4. CONCLUSIONS

The outcomes of this experiment identified set of influential elements for each walking need in the context of different streetscape types. Nevertheless results revealed a tendency for a similar set of physical elements to influence a particular walking need irrespective of the streetscape type. In general safety from traffic was influenced by method of pedestrian separation, and width of the walking area. Comfort was influenced by type of paving, width of walking area and the presence of electric wires. Shade was influenced by the presence of shade provision trees and non-shade provision trees. Environmental appearance was influenced by Presence of trees, electric wires and garbage. Activity potential was influenced by the presence of destinations and intermediate spaces. Connotative suggestions had a limited role except in the case of shade. Using the results a set of prediction equations were developed to calculate the values of each walking need based on the physical elements present in the streetscapes.

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