Modelling Pedestrian Crossing Behaviour based on Human Factor.

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Abstract. Research on pedestrian crossing behaviour in urban areas is extensive and has contributed to very useful insights into the role of road, traffic and pedestrian characteristics on the crossing decisions of pedestrians, their compliance with traffic rules and the related safety. However, human factors are rarely incorporated in pedestrian crossing behaviour research. The objective of this research is to analyse the development of pedestrian crossing choice models on the basis of road traffic and human factors. For that purpose, a questionnaire was distributed to 663 respondents among pedestrians in the Shah Alam district. The respondents were asked to fill in a questionnaire about their travel motivations, ability characteristics, risk perceptions and preferences with respect to walking and road crossing, as well as their opinion on drivers, etc. From the modelling analysis, the results showed that there is a significant relationship between Human Factor and Crossing Behaviour; there were two components of Human Factor that influenced pedestrian crossing behaviour to emerge, namely a "risk-taker" and a "rule-follower". Based on 'path coefficient' of Human Factor analysis, this study concludes that a 'risk-taker' component contributed more to Crossing Behaviour. The findings of this research can be used to evaluate the implementation of new pedestrian crossings and a redesign of existing pedestrian crossing environments.

1. Introduction

Unsafe pedestrian behaviour is a major factor in the injuries and fatalities of pedestrians. In the year 2013, the number of road accidents in Malaysia was 135,624 but increased to 141,808 in 2014 and 148,302 in 2015. Involvement in accidents in Malaysia was also alarming at 71% road death with approximately 11% being pedestrians. Pedestrian death rate per 100,000 population in Malaysia can be considered among the highest in the Southeast Asia region. Existing research on pedestrian crossing behaviour in urban areas is extensive and has contributed useful insight into the role of road, traffic and pedestrian characteristics on the crossing decisions of pedestrians, their compliance with traffic rules and the related safety.

2. Literature Review

The highest incidence of pedestrian accidents occurs mainly when the pedestrian crosses a road in non-authorized places [1]. However, the analysis is complex given that pedestrian crossing behaviour is influenced by multiple factors. They include aspects such as the road and traffic environment, socio economic and psychological characteristics of the individual, and the travelling conditions [2-4].The road infrastructure (i.e. number and width of lanes, the presence of signals for crosswalks, zebras, and bridges) and the purpose of the trip are two decisive factors for the pedestrians behaviour when they need to cross a road [5]. Other factors such as the composition of traffic flow passing through a pathway and the design of phases in the case of signalized intersections, can also affect the behaviour of pedestrians

[6]. In sum, the literature shows that pedestrian crossing behaviour is affected by socioeconomics (e.g. age, gender), traffic characteristics (e.g. speed and flow), the road environment (e.g. crossing walking distance, presence of traffic/pedestrian control devices and signals, presence of crossing facilities), and subjective factors (e.g. perceptions and attitudes). All of the above, except the subjective factors, are commonly found in reported pedestrian crossing studies.

However, human factors are rarely incorporated in pedestrian behaviour and safety models; therefore, the explanatory power of these factors on the observed behaviour should be tested. The objective of this research is to highlight the development of pedestrian crossing choice models whilst considering road, traffic and human factors. More specifically, to develop choice models in order to estimate the probability of crossing at each location along a pedestrian's trip in relation to roadway design, traffic flow, traffic control, and human factors. The analysis of pedestrian crossing behaviour in urban areas may assist in understanding the way pedestrians interact with the road and traffic environment, as well as with other pedestrians. It may also help to understand the way they balance the need for comfort and safety at the cost of delays, within the framework of existing traffic rules. This study therefore, expects to meet the government's strategy in reducing road accidents and creating more sustainable mobility environments in our cities.

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3. Data Collection & Questionnaire Design

For the questionnaire survey, a total of 663 respondents were selected randomly from among the residents of Shah Alam. Selected of the sample were calculated based on the total population of 336590 people, with a 99% degree of confidence, and 5% margin of error. For the development of the questionnaire, several questionnaires from the existing literature were studied. The questions were designed to be rated based on Likert Scales such as always/never or agree/disagree scales. The behavioural questionnaire of Papadimitriou et al, 2016 was used as a basis. The questionnaire was designed based on related crossing behaviour elements; for example, perception attitudes, beliefs, motivation etc. The questionnaire includes 4 sections, and the detail of section B and section C are shown in Table 1:

- Section A: Demographics
- Section B: Risk Perception and Value of Time (Human Factors)
- Section C: Pedestrian Crossing Behaviour
- Section D: Pedestrian Perception of Drivers

Table 1.Questionnaire Design

B	Risk Perception and Value of Time (Human Factor)
	As a pedestrian, how much would you agree with each one of the following statements:*
B_1	Crossing roads is easy.
B_2	Crossing roads at designated locations reduces the risk of accident.
B_3	Crossing roads outside designated locations is wrong.
B_4	Prefer routes with signalized crosswalks.
B_5	Trial to make as few road crossings as possible.
B_6	Trial to take the most direct route to the destination.
B_7	Willingness to make a detour to find a protected crossing.
B_8	Willingness to take any opportunity to cross.
B_9	Crossing roads outside designated locations saves time.
B_{10}	Crossing roads outside designated locations is acceptable because other people do it.
B_{11}	Willingness to make dangerous actions as a pedestrian to save time.
C	Pedestrian Crossing Behaviour
	As a pedestrian, how often do you adopt each one of the Following behaviours:**
C_1	Cross at designated crosswalk when there is no oncoming traffic.
C_2	Cross at designated crosswalk when in a hurry.
C_3	Cross at designated crosswalk when there is a shop on the other side.
C_4	Cross even though the pedestrian light is red.
C_5	Cross between vehicles stopped on the roadway during traffic jams.
C_6	Cross without paying attention to traffic.
C_7	Absent-minded while walking.
C_8	Cross while talking on cell phone.
C_9	Cross while listening to music with headphones.
C_{10}	Cross even though obstacles (parked vehicles, buildings, trees, etc.) obstruct visibility.
C_{11}	Cross despite seeing oncoming vehicles.
C_{12}	Cross at designated crosswalk when observing other people doing the same.
C_{13}	Cross at designated crosswalk when company prompts to do it.
C_{14}	Prompt company to cross at designated crosswalk.

* (1: strongly disagree, 2: disagree, 3: agree, 4: strongly agree)
** (1: never, 2: rarely, 3: sometimes, 4: often, 5: almost always)

The field survey design consisted of three walking conditions and several places were identified as a survey area according to these three crossing conditions.

• Crossing a main urban road with signal-controlled and uncontrolled crosswalks.

For this particular crossing condition, Section 7, Shah Alam was identified as a survey area which involved students of UiTM crossing the road in order to access commercial facilities near the campus. As well as this, crossing facilities near Shah Alam Hospital were also surveyed in order to measure the effectiveness of crossing pedestrian provided and its relation to crossing behaviour.

• Crossing a minor (residential) road with or without marked crosswalks.

Several schools located near residential areas were chosen as a survey area. For example, Section 6, Section 7, Section 9, Section 15 and Section 19. In addition, an area that facilitates public transport was also chosen as a survey area, such as Section 15 (Padang Jawa) and Section 19.

• Crossing a major urban arterial with signal-controlled crosswalks.

For this particular crossing condition, a high capacity urban road was chosen as an area of study. This included the crossing pedestrian needed to access the bus station at Section 13, close to the Federal Highway. This crossing pedestrian is also used to access AEON Mall.

The model's development consists of three steps, each serving a different purpose, namely (i) to determine the road and traffic variables that effect pedestrian crossing choice, (ii) to estimate human factors as latent variables, and (iii) to test whether these variables reflecting human factors, add to the explanatory power of the models. This study will introduce two components of pedestrian crossing behaviour as explanatory variables, namely a ''risk--taker'' component reflecting the tendency to cross at mid-block to save time, etc., and a ''rule- follower'' component, which represents a very rule-obedient pedestrian. The introduction of these components as explanatory variables into the choice models are expected to improve the modelling results and will help to prove

that human factors have additional explanatory power over the road and traffic factors of a pedestrian.

4. The Result

4.1 Confirmatory Factor Analysis (CFA) in Measurement Model

Table 2 shows the summary of confirmatory factor analysis (CFA) for every construct in the measurement model. Based on Table 2, the value of factor loading for each item was greater than 0.60. Item B6 was deleted due to low factor loading of less than 0.60. The requirement for unidimensionality. was achieved through the item deletion procedure for low factor loading items.

The value of AVE obtained from every construct was greater than 0.50. Thus, the Convergent Validity for the measurement model was achieved since all the values for AVE were greater than 0.50 as suggested by Fornell and Larcker [7].

Table 2. Summary for Confirmatory Factor Analysis (CFA) in Measurement Model

Construct	Component	Item	Factor Loading	CR	AVE
Human Factor	Component 1	B2	0.74	0.89	0.68
		B3	0.87		
		B4	0.81		
		B5	0.86		
	Component 2	B8	0.87	0.93	0.81
		B9	0.86		
		B10	0.96		
Crossing Behaviour	Component 1	C1	0.61	0.84	0.65
		C2	0.94		
		C3	0.83		
	Component 2	C6	0.93	0.95	0.87
		C7	0.91		
		C8	0.96		
	Component 3	C9	0.90	0.93	0.80
		C10	0.88		
		C11	0.91		

Based on Table 3, when the three Fitness Indexes; Absolute Fit, Incremental Fit and Parsimonious Fit, achieved the requirements, the Construct Validity is achieved. CFI is equal to 0.90 or higher, RMSEA is equal to 0.08 or lower, and the ratio of Chisq/df is less than 5.0. [8]

Table 3. Summary for the Assessment of Fitness Indexes

Category	Fit statistics	Recom-mended	Obtain	Comment
Absolute Fit	RMSEA	<0.08	0.085	Satisfied
Incremental Fit	CFI	>0.90	0.954	Achieved
Parsimonious Fit	Chisq/df	<3.0	5.722	Satisfied

4.2 Relationship between Human Factor and Crossing Behaviour

Table 4 shows the standardized regression weight for the structural model. Based on the table, the path coefficient of Human Factor to Crossing Behaviour is 0.49. This value indicates that for every one-unit increase in Human Factor, its effects will contribute to a 0.49 unit increase in Crossing Behaviour. Since the p-value is less than 0.05 (p=0.0001 < 0.05), we can conclude that there is a significant relationship between Human Factor and Crossing Behaviour.

Table 4. Relationship between Human Factor and Crossing Behaviour.

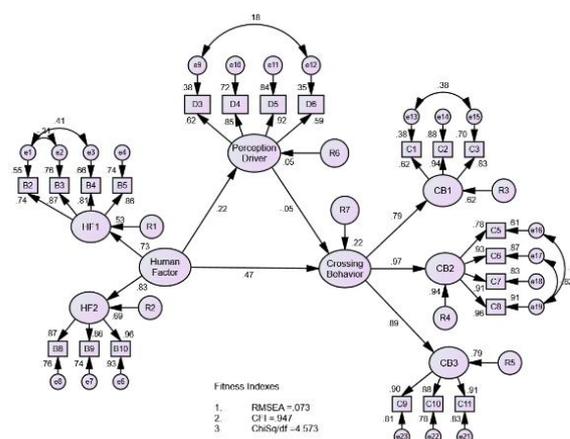| Path Coefficient			Estimate	P value	Comment
Human Factor	to	Crossing Behaviour	0.49	0.0001	Significant

Figure 1. Structural Model

4.3 Contribution Dimension Human Factor To Crossing Behaviour.

From the modelling analysis, the results showed that there were two components of Human Factor that influenced pedestrian crossing behaviour, namely a "risk-taker" and "rule-follower". Based on the 'path coefficient' of Human Factor analysis, this study concludes that a 'risk-taker' component contributed more to Crossing Behaviour.

Table 5. Contribution Dimension Human Factor To Crossing Behaviour

Based on Table 5 above, the path coefficient of Human Factor -Component 1 (HFC1) to Crossing Behaviour was 0.11 and the path coefficient of Human Factor - Component 2 (HFC2) to Crossing Behaviour was 0.25. The value of beta estimate for HFC2 to Crossing Behaviour was higher than the value of beta estimate for HFC2 to Crossing Behaviour which was 0.25 > 0.11. Therefore, we can conclude that HFC2 contributes more to Crossing Behavior.

Path			Estimate	P value	Comment
HFC 1 (Rule-Follower)	to	Crossing Behaviour	0.11	0.029	Significant
HFC2 (Risk-Taker)	to	Crossing Behaviour	0.25	0.0001	Significant

pedestrians interact with road and traffic environment, as well as with other pedestrians. It may also help to understand the way they balance the need for comfort and safety at the cost of delays, within the framework of existing traffic rules [6]. Incorporating attitudinal and behavioural data (human factors) in describing motivations, preferences and perceptions of pedestrians emerges as an effective approach to model crossing behaviour. This study introduced two components of pedestrian crossing behaviour as explanatory variables, namely a 'rule- follower' and a 'risk taker' component. This was applied to reflect the urban pedestrian in Shah Alam, Malaysia. The introduction of these components as explanatory variables into the choice models resulted in improvement of the modelling results, which indicates that human factors have additional explanatory power over traffic and road factors of pedestrian behaviour.
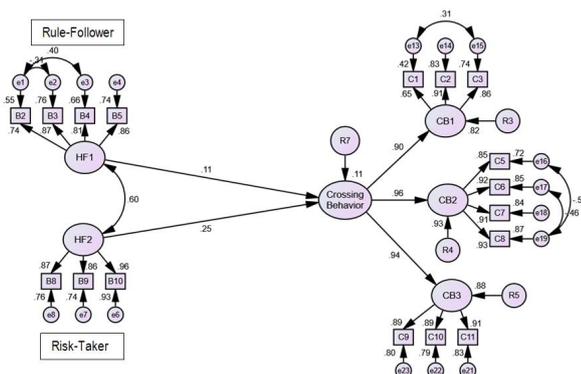

Figure 2. Contribution Dimension Human Factor to Crossing Behaviour

The two group components of the Human Factor that influenced pedestrian crossing behaviour can be described as follows:

- "Rule-Follower" pedestrians in this group have rather positive attitudes, perceptions and behaviour, as they have low scores for risk-taking (i.e. 'crossing roads at designated locations reduces the risk of accident', crossing roads outside designated locations is wrong', 'prefer routes with signalized crosswalks', and 'trial to make as few road crossings as possible')
- "Risk-Taker" pedestrians in this group have negative attitudes, perceptions and behaviour, as they have high scores for risk-taking behaviour ('willingness to take any opportunity to cross', 'crossing road outside designated locations saves time', and 'crossing roads outside designated locations is acceptable because other people do it').

5. Conclusion

The analysis of pedestrian crossing behaviour in urban areas may assist in understanding the way

5. Acknowledgments

6. References

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