HKICSS-112
Visitors' Perceptive Agent (VPA) on Museum Indoor Environment

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Abstract
This research is made to investigate what effect the museums' indoor environmental quality (IEQ) has had upon visitors' satisfaction and their temporal discomfort symptoms (TBS) perceptively. Eight historical and air-conditioned museums mainly located in Peninsular Malaysia were selected. A total of valid 546 respondents completed the questionnaire based on convenience sampling. Derived from modified existing IEQ models, this study analysed the proposed factors and their relationships in a structural equation model (SEM) to suit with museum indoor environment. The hypothesised relationships are subsequently tested by means of the partial least squares (PLS) path modelling approach. SEM path model represents the hypotheses acceptance for the direct effect of all environmental factors on visitors' satisfaction except for the deletion of thermal environment. Only two TBS supported the direct effect hypotheses on visitors' satisfaction; emotion and eyes. Whereas the environmental factors that affect visitors' on few discomfort symptoms are exhibition environment on eye and IAQ on emotion, NSB and throat.

Keywords: indoor environmental quality, museums' visitors, structural equation modelling, satisfaction

Introduction
A visitors' satisfaction model on the physical environment of a museum has been established which investigated the indirect effect of lighting and thermal environment on overall satisfaction via fatigue as a mediating variable (Jeong & Lee, 2006). However, this model would have been more interesting and holistic if it was supported with holistic indoor environment parameters.

There is a well-established model on museum indoor environment known as Cultural Property Risk Analysis Model (CPRAM) but the discussion was merely focused on the effect to the preservation of artefact (Waller, 2003) rather than to the people. It would be beneficial for this research if the model can be adapted on people satisfaction but to limit only on environmental generic risks, specified as contaminants, light and radiation, incorrect temperatures and incorrect relative humidity.

There are also numbers of IEQ satisfaction models which have been developed in other type of buildings including offices, residential, public buildings and educational institution (Cao et al., 2012; Lai, Mui, Wong, & Law, 2009; M. C. Lee et al., 2012; L T Wong, Mui, & Hui, 2008; L.T. Wong, Mui, & Hui, 2006). Even though subject of studies, methods and approaches were different, but those models aimed to achieve building users' satisfaction and acceptance on the overall indoor environmental performance. Therefore, it is optimist that extending and adjusting these models to suit museum environment is necessary.
Table 1 indicates some of the previous literatures which discussed more or less the same factors as in the other IEQ models but the discussion were limited to the museum indoor environment. Since there are too few previous literatures to account for all the relevant

variances in the proposed model, these literatures were compiled based on their indirect analyses from other than structural equation modelling such as regular factor analysis, regression and multivariate analyses.

Table 1: Relevant literatures on the relationship of constructs based on previous research on museum environment (refer note for *).

Relationship	**Relevant literatures**
Exhibition environment → Satisfaction	(Guler, 2009) based on (S. C. Bitgood & Loomis, 1993) , (Stephen Bitgood, 2002) , (Mey & Mohamed, 2010a),(Mey & Mohamed, 2010b), (Jeong & Lee, 2006)
Thermal environment → Satisfaction	(Hao, Cao, Wang, & Wang, 2006), (Jeong & Lee, 2006), (La Gennusa, Lascari, Rizzo, & Scaccianoce, 2008), (Camuffo, Pagan, Bernardi, & Becherini, 2004)
Indoor air quality → Satisfaction	(Hao et al., 2006)
Lighting → Satisfaction	(Newsham et al., 2009), (Stephen Bitgood, 2002), (Hunt, 2009), (Jeong & Lee, 2006), (Balocco & Frangioni, 2010), (Camuffo et al., 2004)
Visual comfort / eyes → Satisfaction	(Hunt, 2009), (Kesner, 1997)
Emotion → Satisfaction	(Bitgood, 2009; Davey, 2005; Jeong & Lee, 2006; Lee, 2010; Rojas & Camarero, 2008)
*Throat/Nose/Skin/breath → Satisfaction	-

* *Note: As to date, studies on the prevalence of sick building syndrome other than thermal and visual comfort in museum indoor environment are very insufficient and likely that they are yet to be investigated. More often it appears that the dominant subject in visitors' studies and museum curatorial area would be the 'museum fatigue' which normally affects visitors' emotion. Therefore, the discussions for these items are based on literatures from other type of buildings.*

The paper is dedicated to investigate a model in which museum visitor satisfaction is perceptively indicated by indoor environmental performance and temporal discomfort symptoms. Figure 1 representing the connection between exhibition environment, ambient environment and temporal discomfort symptoms in general.

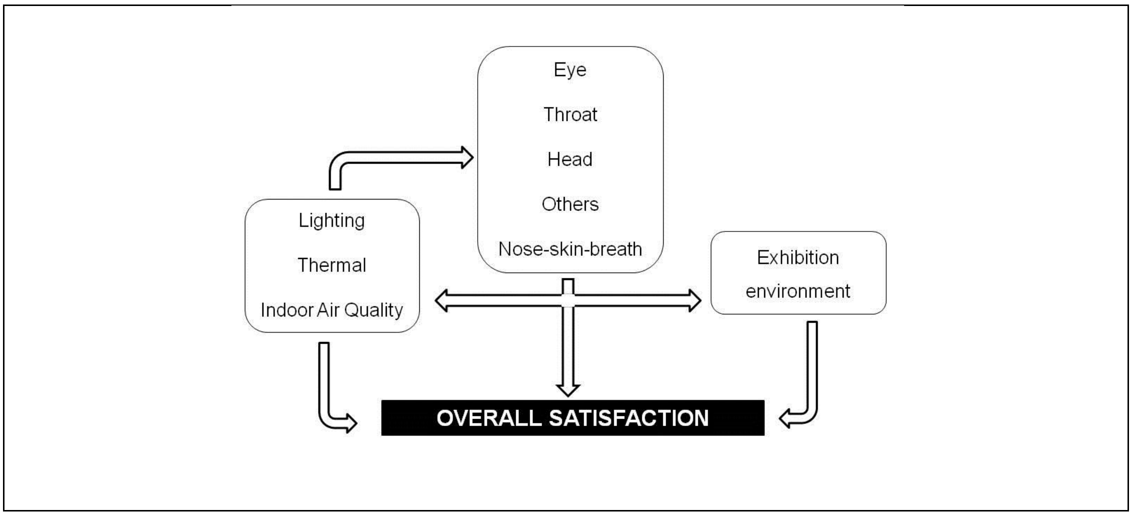

Figure 1: Detail theoretical framework of the proposed Visitors' Perceptive Agent for museum visitors

1.1 Museum Indoor Environment

The identification of a single 'museum indoor environment' has been critically synthesised in Sulaiman, Kamaruzzaman, Salleh, & Mahbob (2011). Based on this definition, the environment perception is constructed by two main constructs. The construct of 'exhibition environment' is adapted from Jeong & Lee (2006) while the construct of 'ambient environment' is adapted and synthesized from Fördergemeinschaft Gutes Licht (2000), Jeong & Lee (2006), Kamaruzzaman, Egbu, Ahmad Zawawi, Ali, & Che-Ani (2011), Kesner (1997), Levermore & Leventis (2000), Lighting Research Center (1998), Yau & Chew (2009) and Skov, Valbjorn, & Pederson (1990).

1.2 Exhibition environment

Steve Bitgood & Patterson (1987) described the principles of exhibit design and visitor behaviour and their relationship between the characteristics of the objects, architecture and visitors their selves. Effective exhibits environment is essential in order to grasp visitors' attention throughout their visitation. The exhibition areas are the place where their experiences are directly engaged with the objects in a given space (Jeong & Lee, 2006). Exhibition space will provide the environment of exploring and enjoying the museums' exhibit as a whole. Explanation on the chosen indicators, the principal in the selection of the exogenous constructs for formative indicators:

H1a: *There is positive relationship between exhibition environment and overall visitor satisfaction.*

H1b: *The exhibition environment of the museum gallery gives effect to visitors' temporal discomfort symptoms with regards to eyes and emotion.*

1.3 Ambient Environment

i. Thermal

The atmosphere and ambience components are the major contribution of museum indoor environment. Museum in particular must adhere to a strict indoor climate system in order to preserve the valuable work of arts. In some situation, this means that air conditioning will run continuously for 24 hours a day. Comfort for people generally relies on the air temperature, mean radiant temperature, air velocity and relative humidity. Thermal comfort is one of the variables in the ambient museum environment which contribute to fatigue and affect people emotions, implying an indirect effect on their satisfaction (Jeong & Lee, 2006).

H1c: *There is positive relationship between thermal environment and visitor satisfaction.*
H1d: *The thermal environment of the museum gallery environment gives effect to visitors ' temporal discomfort symptoms with regards to eyes, emotion, nose-skin-breath, throat and head.*

ii. Lighting

Lighting plays a significant role in the communication between people and artefact in a confined space (Hunt, 2009). Good lighting encourages people to get close to the artefact when the surrounding environment is comfortable. In particular, the visual ambience must not cause fatigue; indications of poor lighting include eye fatigue, blurred vision, dryness and headache. Depending on people's sensitivities and health, and the provision of light level in the space, these symptoms can be felt from within a few minutes to few hours. Studied done by Kesner (1993, 1997) indicated that the galleries were lit far below the recommended levels in terms of visual quality:

H1e: *There is positive relationship between lighting environment and visitor satisfaction.*
H1f: *The lighting environment of the museum gallery environment gives effect to visitors' temporal discomfort symptoms in terms of visual discomfort (eyes), emotion and head.*

iii. Indoor air quality (IAQ)

Indoor air quality on the other hand can be polluted and their possible effects on people are reported in Bluyssen (2009). In museum, the sources can be classified as either indoor (i.e. Formaldehyde, dust) or outdoor (i.e. ozone, nitrogen dioxide, sulphur dioxide, dust) and their concentrations are found either macro (the gallery) or micro (in the showcase) environment. Formaldehyde concentrations was found to be the highest level in the museum (Saraga, Pateraki, Papadopoulos, Vasilakos, & Maggos, 2011) compared to printer industry and offices. This study also reported that there was inconsistent suspension of particulate matter when there were people around. Other indoor air seems to be low and did not exceed limit value. Risk of higher level of formaldehyde to the visitors in the gallery may include irritation of eyes, respiratory tract and altered respiratory function (Bluyssen, 2009).

H1g: *There is positive relationship between indoor air quality environment and visitor satisfaction.*
H1h: *The indoor air quality environment of the museum gallery environment gives effect to visitors ' temporal discomfort symptoms ' which consist of eyes, emotion, nose-skin-breath, throat and head.*

1.4 Temporal Discomfort Symptoms

Due to poor IEQ, psychological discomfort has been largely investigated and reported either as a museum fatigue (MF) phenomena (Bitgood & Loomis, 1993; Bitgood, 2002, 2009; Davey, 2005); or known as sick building syndrome (SBS) on other buildings (Cao et al., 2012; Lee et al., 2012; Meir, Garb, Jiao, & Cicelsky, 2009;Wong et al., 2008; Wong et al.,2009). Interestingly, SBS and MF explained the same symptoms such as fatigue due to temperature, lighting, eye, nose, headache, nausea and dizziness. However, studies on MF is much known related to the decreased of the attention-across-exhibit to the visitors which started since 1928 by Robinson (Stephen Bitgood, 2002).

The MF closely affected the emotion of the visitors (Jeong & Lee, 2006). Cold temperatures and dim lights as representing poor IEQ have also been reported as the cause of visitors' motivation, frustration, discomfort and fatigue (Stephen Bitgood, 2010; Wollard, 2004). So do SBS can be due to those causes.

SBS is frequently related to the length of time a person spends at work in a particular building (Jansz, 2011); but authors disagree about how long is required to qualify, from

8-hours daily for the past three months (Norback & Edling, 1991) to a year (Raw & Roys, 1996). Meanwhile MF was resulted from the level of interaction between people and artifacts in the gallery (Rohloff, Psarra, & Wineman, 2009), during their visits which up to the maximum of 150 minutes (Tang, 2008).

Neither do SBS nor MF seems suitable to be used for this proposed model due to the different characteristics on time spent as well as the effect and causes of these phenomena. Therefore, adapting the existing model of IEQ from other types of buildings and extending the definition of museum fatigue in museology derived the terms 'temporal discomfort symptoms' and the evaluation is:

H1i: *There is positive relationship between temporal discomfort symptoms which constructed of eyes, emotion, head, throat and nose-skin-breath with visitors' satisfaction.*

1.5 Perceived overall satisfaction

Different from the other constructs, the overall satisfaction (OS) is operationalised by a single item that is related to the following question in the survey; 'State your overall level of satisfaction on your overall satisfaction of museum indoor environment'. The single indicator is measured with a 7-point scale indicating the respondents' degree of satisfaction (-3 = strongly not satisfied; 7 = strongly satisfied). The single item is used due to practical considerations in an effort to decrease the overall number of items in the questionnaires. As it has only one item measuring overall satisfaction therefore whether it is a formative or reflective is of no concern (Hair, Hult, Ringle, & Sarstedt, 2014).

2.Development of a measurement model for Visitors' Perceptive Agent

The VPA model is based on the main hypothesis which is 'visitors' satisfactions have a positive influence from their perception on indoor environment with condition related to the prevalence of temporal discomfort symptoms'. Figure 2 represents the full hypothesis of the relationship between ambient environments, exhibition environment, and temporal discomfort symptoms on overall satisfaction. It illustrates the fundamental indicator for each construct and the established concept of relationship among constructs from literature reviews. The overall ideas show the connection and the interaction among all constructs on a single dependent variable which is the visitors' satisfaction.

3.PLS path model analysis of the VPA

3.1 Overview of data collection

A total of 567 questionnaires were distributed at eight museums and directly to the potential respondent towards the end of their visits. A brief introduction on the survey was prepared in a handy piece of paper which was then placed at the reception or ticket counter. Therefore, museum visitors were not being informed directly about the survey and some of them might not aware with the environment of the galleries. This is due to the restriction given by the museum management that researcher and the assistants could not interrupt the freedom of the visitors' exploration and enjoyment when entering the museum.

Selection of respondents was based on convenience sampling. The determination of adults' category was based on their maturity look, size of body and appearance. This was validated against their answer on age whether it falls within range of 18 – 59 years old. The voluntary respondents were given two options to complete the survey; either by their selves or with the assistance of the research team. The results from them were not meant to be compared across the selection museums as the aimed was to indentify in general the overall perception of museums' visitors on the main variables of the research. Besides, all museums were more or less having similar characteristics.

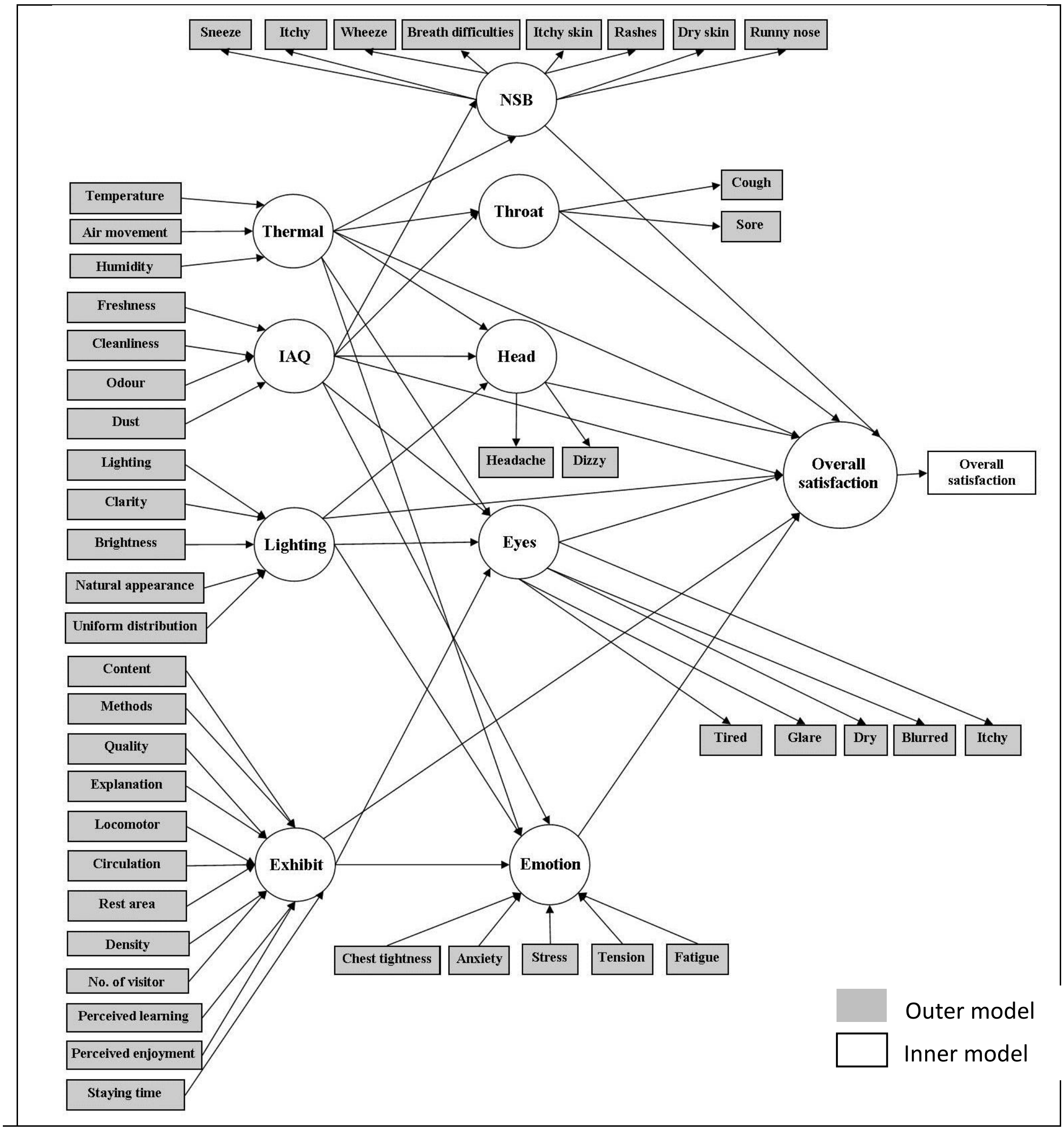

Figure 2: Overall Hypothesised Path Model of the Visitors' Perceptive Agent

Among all 567 respondents, only 546 set of questionnaires were analysed. This was after taking into account the outliers and extreme missing values. They were from the most incomplete answers from the respondents in the set of the questionnaires. Minor missing values were treated by using specific command in SPSS v 19.0. After the data cleaning were successfully done, the quantitative analysis was ready to be further investigated.

3.2 Path model and results assessment

At this stage, these statistical analysis were involved the multivariate analysis that simultaneously analyze multiple variables, which represent indicators associated with the causal relationship between the situation of museum indoor environment and the visitors' well being. The constructs were developed based on the comprehensive literatures analyses on the overall Theoretical Framework (TF) of IEQ performance in museum indoor environment as partially reported in Sulaiman, Kamaruzzaman, Salleh, & Mahbob, (2011) which this model is part of the overall TF.

Based on the above discussion, it is elaborated that there is no or only little prior knowledge on whether the prevalence of sick building syndrome can be associated with museum indoor environment and influence visitors' satisfaction or to remain the existing term of museum fatigue which seems to be unclear in describing their well-being.

On the other hand previous discussions on SBS were mainly related to the theories of 8 hours exposures. However museum visitors were only spent up to more or less 150 minutes for the whole museum galleries. Therefore, it is again little knowledge is known on whether the times spent in the galleries give impact in determining the relationship of museum indoor environment, the temporal health symptom and visitors' satisfaction.

Based on the above arguments, PLS-SEM or also known as PLS path modelling will be applied as to explore the relationships between all constructs in the model and to expand the theories involved in the previous paragraph.

The statistical software application SmartPLS (Ringle, Wende, & Will, 2005) was used to compute the PLS path model. Based on the rationale presented above, the exogenous latent variables for constructs 'exhibit', 'lighting', 'iaq' and 'thermal' are operationalised formatively. In contrast, the other five endogenous constructs; 'eyes', 'nose-skin-breath', 'throat', 'head' and 'emotion' were manifested by their respective indicators and therefore were treated as reflective model. All of the constructs were linked to the final outer model of 'overall satisfaction' formatively. A single item gained in respect of this construct was identified as exchangeable indications of its underlying construct and was thus treated reflectively. Even though the final end construct is a single-item measure, it is a compromise to balance the problems of questionnaire length and the need to validate it (Hair et al., 2014).

Paths connected to the constructs either formatively or reflectively will be the basis of a structural model. The connections of the structural models represent the underlying theory and/or concept of the path model. The assessments of the structural model are developed from the results of the standard model estimation, the bootstrapping routine, and the blindfolding procedures (Joseph F. Hair et al., 2014).

The insights evaluations of the reflective and formative models in the measurement model are shown in the final hypothesized model as in Figure 3. The whole formative constructs of 'thermal' is deleted due to issues on collinearity and significance testing results. The other constructs either formative or reflective are remained with their relevant and accepted indicators; after a rigorous evaluation suggested by Höck et al., (2010), Hair et al. (2014) and Jr., Ringle, & Sarstedt (2013).

As can be seen, each exogenous formative constructs which represent the overall holistic museum environment contributed to the acceptance of the hypotheses partially with the only exception of 'thermal'. Among others are the effect of exhibition on eye; and IAQ on emotion, NSB and throat.

The effects of lighting on the expected temporal discomfort symptoms were completely a null hypothesis. The direct effect of all constructs to the single measured dependent variable were supported by all constructs of museum environments but only two variables of temporal discomfort symptoms support the hypotheses. In Figure 3, the path analyses using SmartPLS displays the effects of different constructs to the hypotheses stated earlier along with their path coefficients.

Within the scope of structural equation modelling, model assessment requires the reliability and validity of the measured used. Given the lack of global goodness-of-fit measures in PLS path modelling, Chin (1998) put forward a catalogue of non-parametric criteria to assess partial model structures.

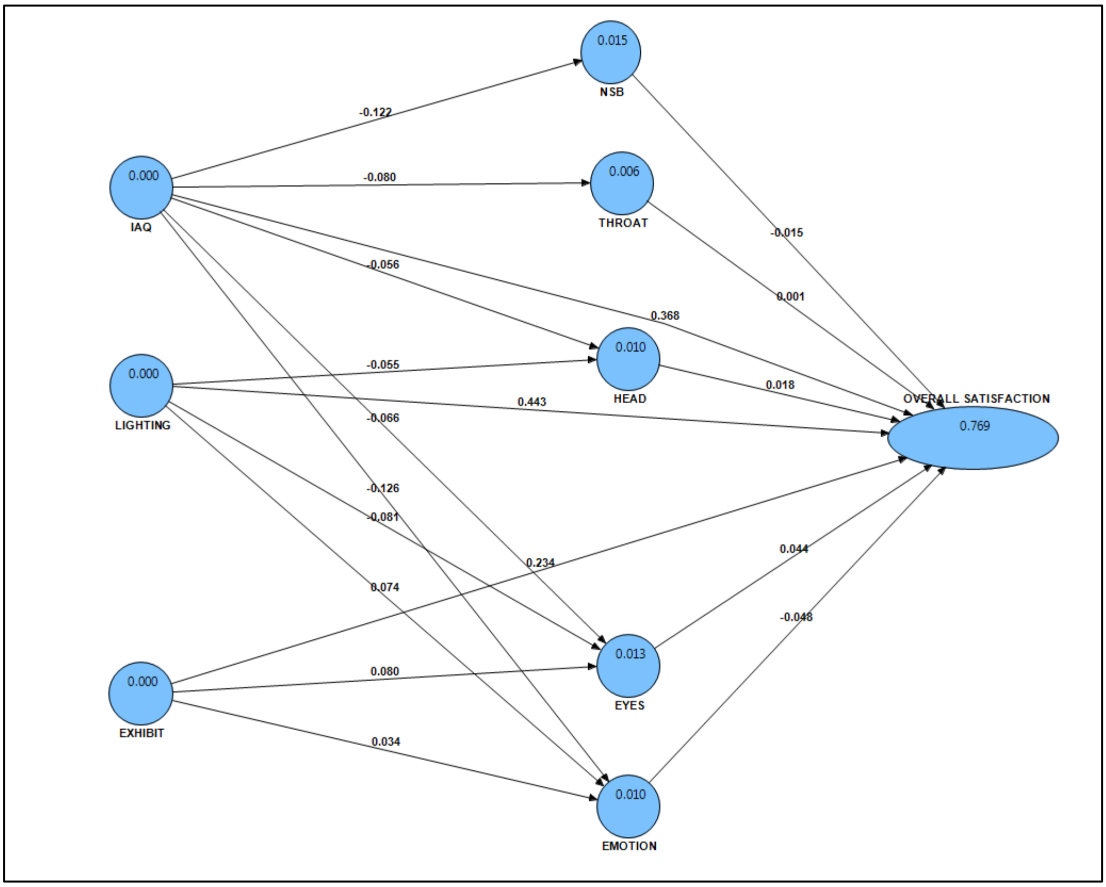

Figure 3: Final PLS-SEM of people perceptive agent on museum environment with the path coefficients

A systematic application of these criteria requires a two-step process (Henseler, Ringle, & Sinkovics, 2009). This assessment includes the predictive power of the PLS path models. The PLS path model evaluation steps are:

- Outer model (measurement model) evaluation with regard to the reflective and formative constructs' reliability and validity

Inner model (structural model) evaluation in respect of variance accounted for, path estimates and predictive relevance of the inner model's explanatory **variables for the endogenous latent variables.**

3.3 Results of reflective measurement model

Based on PLS-SEM Rules of Thumb (Hair et al., 2011 and Hair et al.,2014), all the requirements with regard to the reflective measurement model must met the systematic stages consist of 4 steps; (1) internal consistency (composite reliability) should be higher than 0.708, (2) indicator reliability which is the square root of the standardized indicators' outer loading should be higher than 0.708, (3) convergent validity (average variance extracted –AVE) should be higher than 0.50, and (4) discriminant validity must meet criteria of: 1) higher AVE for each latent construct than the construct's highest squared correlation with any other latent construct (Fornell-Lacker criterion) and 2) indicator's loadings should be higher than all of its cross loadings.

The temporal discomfort symptoms in this model are constructed with five latent variables with reflective measurement models together with a single item construct (overall satisfaction). For the reflective measurement models, it needs to estimate the relationships between the reflective latent variables and their indicators (i.e., outer loadings). The following subheading will illustrate further on their results.

i. Indicator reliability

All outer loadings of the reflective constructs are well above the threshold value of 0.708 except for the runny nose in 'NSB' (outer loading: 0.493) and fatigue in 'EMOTION' (outer loading 0.680). Consideration whether or not to remove these indicators will depend on their AVE values which need to be higher than 0.50. Results show that their AVEs were 0.591 and 0.583 respectively. Taking into account that the outer loading for them were low, therefore these indicators will be considered for removal only if the deletion leads to an increase composite reliability and AVE.

ii. Internal consistency

Traditional criterion for internal consistency is the Cronbach's alpha as what have been reported previously. In PLS-SEM, the measurement models are assessed by their composite reliability. The composite reliability values of 0.907 (EYE), 0.919 (NSB), 0.926 (HEAD), 0.899 (THROAT) and 0.891 (EMOTION) demonstrated that all five reflective constructs have high level of internal consistency reliability. The composite reliability might be changed if runny nose and fatigue were to be deleted.

iii. Convergent validity

Convergent validity assessment builds on the AVE values as the evaluation criteria. The AVE values of 'EYE' (0.663), 'HEAD' (0.862), 'NSB' (0.591), 'THROAT' (0.818) and 'EMTION' (0.583) are all well above the required minimum level of 0.50. However, 'EMOTION' shows lower AVE than other constructs due to the lower loading of fatigue at 0.680. This is similar to the 'NSB' with low AVE and low loading at 0.493 loading (runny nose). Therefore, these two indicators have not met the PLS-SEM Rules of Thumb and need to be deleted. The deletions of these indicators have increased the AVE and CR values for both constructs (0.641 and 0.788 respectively).

iv. Discriminant validity

Overall, the square roots of the AVEs for the reflective constructs are all higher than their correlations with other latent variables in the path model. Therefore, all of the reflective constructs confirm their discriminant validities. All the reflective constructs showed convergent and discriminant validities after deletion and modification of indicators with low loadings as explained above.

3.4 Results of formative measurement model

The validation of the results for the formative measurement model will be based on PLS-SEM Rules of Thumb by Hair et al. (2014) and Hair et al. (2011). The convergent validity based on Chin (1998) in Hair et al. (2014) should be between 0.80 to 0.90. However, this research has not specified the use of the global single-item measurement in the survey and therefore the assessment will be continued with the evaluation steps done by Höck et al.(2010). His study was to evaluate the visitor satisfaction on stadiums' environment and atmosphere. Therefore it would be the best reflection of steps of evaluation needed for the proposed model of museum environment. The indicator's variance inflation factor (VIF) value should be less than 5. Based on the above arguments, the next steps of assessment is to identify the indicators' weight and loading of the indicators by using bootstrapping to assess their significance. In normal condition, low weights indicate insignificance t-value. For one-tailed test, the following critical values from the z-distribution will be significant if the empirical t-value is above 1.280 ($p<0.1$), 1.645 ($p<0.05$) and 2.330 ($p<0.01$).

i. Convergent validity

Convergent validity is also known as redundancy analysis (Hair et al., 2014). These analyses show path coefficients of 0.805 (EXHIBIT), 0.898 (IAQ), 0.941 (LIGHT) and 0.954 (THERMAL). All values are above threshold of 0.80 thus show confirmatory and sufficient degree of formative constructs' convergent validity.

ii. Collinearity issues for formative measurement model

Collinerity of the indicators were checked in SPSS v19.0 in linear regression analysis. After the deletion of 'THERMAL' due to non-compliance of the PLS-SEM Rules of Thumb, collinearity issues have been treated and the end results do not reach critical levels in any of the formative constructs.

iii. Significance and relevance of the formative indicators

The study uses directional hypotheses to achieve the main objective of the paper. The outer weights of the formative indicators are the results of a multiple regression (Hair et al., 2014). In this analysis, the latent variable 'IAQ' is regarded as of major importance with the highest weight of 0.451 (freshness) and 0.336 (cleanliness). In overall, nearly all weights of the latent variables are significant.

3.5 Assessment of the structural model

Table 2 concludes the process of verifying relevant assessment criteria in respect of the PLS approaches. An analysis of the inner model path coefficient shows that all exogenous latent variables exerts the strongest influence on visitors satisfaction with $p<.01$; one-tailed test. 'LIGHT' was the highest at 0.435, followed by 'IAQ' at 0.372 and 'EXHIBIT' at 0.236. The direct effects of temporal discomfort symptoms on visitors' satisfaction did not strongly influenced their satisfaction except for 'EYES' at 0.044 ($p<0.1$) and 'EMOTION' at -0.048 ($p<0.05$). Meanwhile, only the exogenous latent of environmental parameters of 'IAQ' affected visitors' temporal discomfort symptoms on their 'EMOTION' (ρ_c -0.126; $p<0.05$), 'NSB' (ρ_c -0.122; $p<0.05$), and 'THROAT' (ρ_c -0.080; $p<0.1$).

Our analysis indicates that indoor environmental parameters are reliable and valid to be included in the model of VPA. The deletion of 'THERMAL' might be due to the characteristics of the chosen museums which were air-conditioned galleries. This would be the reason that thermal was absolutely not significant affected their comfort.

Table 2: Summary of hypothesis testing

Hypotheses	Path	Path Coefficient	t-Value	Significance Levels	P Values
H1b	**Exhibition Eyes**	**0.080**	**1.594**	*****	**0.056**
	Exhibition Emotion	0.034	0.511	NS	0.305
H1f	Lighting Eyes	-0.081	0.853	NS	0.197
	Lighting Emotion	0.074	1.007	NS	0.157
	Lighting Head	-0.055	0.696	NS	0.243
H1h	IAQ Eyes	-0.066	0.853	NS	0.197
	IAQ Emotion	**-0.126**	**1.824**	******	**0.034**
	IAQ NSB	**-0.123**	**1.762**	******	**0.039**
	IAQ Throat	**-0.080**	**1.554**	*****	**0.060**
	IAQ Head	-0.056	0.726	NS	0.234
H1i	**Eyes Overall satisfaction**	**0.044**	**1.451**	*****	**0.074**
	Emotion Overall satisfaction	**-0.048**	**1.810**	******	**0.035**
	Head Overall satisfaction	0.018	0.672	NS	0.251
	Throat Overall satisfaction	0.000	0.031	NS	0.488
	NSB Overall satisfaction	-0.015	0.548	NS	0.292
H1a	**Exhibition Overall satisfaction**	**0.236**	**8.887**	*******	**0.000**
H1e	**Lighting Overall satisfaction**	**0.435**	**13.308**	*******	**0.000**
H1g	**IAQ Overall satisfaction**	**0.372**	**11.724**	*******	**0.000**

Note: NS = not significant (*p< 0.1, **p<0.05, ***p<.01); one-tailed test

4 Conclusion

The People Perceptive Agent model has five latent variables with reflective measurement models. Several modification and relevance testing have been made by deleting any undesirable indicator; which in these analyses runny nose fatigue are needed to be deleted. With the outer loading of 0.493 and 0.680 respectively, the deletion of these two indicators have increased the AVE and the composite reliability of both constructs.

Runny nose is part of respiratory infections and is happen due to the irritation of the mucus membranes and the prevalence may sometimes last for a week (Wahab, 2011). In the case of the museum, the visitors will be exposed to the indoor environment only up to 150 minutes (Chang, 2008). Therefore, it is quite hard to relate whether the museum environment does give effect to the indicator of ‘runny nose’.

Air temperature plays a significant role in determining the intensity of nose running and the time-course effect where results proved that this symptom tended to increase as temperature was lowered (p<0.09 and 0.08) (Willem, 2006). Air temperature and humidity level were the indicators to measure the construct of ‘thermal’ which is part of the formative measurement model. However, it shows that 'thermal needed to be deleted due to its low significance and relevance. Therefore, these explanations can relatively justify the deletion of indicator 'runny nose'.

The deletion of 'fatigue' shows different tendency with the discussion of the infamous museum 'fatigue' in other museology literatures. The effect of museum environment on museum 'fatigue' as mentioned by Davey (2005) was explained hypothetically based on exhibit architecture and museum setting. But, he defined museum environment as the arrangement of displays and exhibit architecture which no explanation on 'thermal' and indoor air quality either direct or indirectly except for lighting.

Path analyses show that there are nine paths in the proposed perceptive agent model have significant effect on visitors' satisfaction, ten relationships have not supported the initial hypotheses while one construct need to be removed.

This paper has contributed to the knowledge of museology by including the latent variable of 'iaq'. It is seems to be a new paradigm in the perspective of ambient environment of a museum where previously vast discussion were only focused on micro-climate of the showcase and display. The interesting part is the constructs of 'temporal discomfort symptom' which elaborate more or less the same symptoms as sick building syndrome. However, due to the exposure of the visitors in the museum environment; which of course shorter than 8-hours as in normal buildings, this term is introduced to portray the duration of visitors spent in the gallery.

References

[1] Balocco, C., & Frangioni, E. (2010). Natural lighting in the Hall of Two Hundred. A proposal for exhibition of its ancient tapestries. *Journal of Cultural Heritage*, *11*(1), 113–118. doi:10.1016/j.culher.2009.02.005

[2] Bitgood, S. (2002). Environmental Psychology in museums, zoos, and other exhibition centers. In R. Bechtel & A. Churchman (Eds.), *Handbook of Environmental Psychology* (pp. 461–480). Pp. 461-480.: John Wiley & Sons.

[3] Bitgood, S. (2009). Museum Fatigue: A Critical Review. *Visitor Studies*, *12*(2), 93–111. doi:10.1080/10645570903203406

[4] Bitgood, S. (2010). *An Attention-Value Model of museum visitors*. *Visitor Attention*. Washington, DC: The Center for the Advancement of Informal Science Education.

[5] Bitgood, S. C., & Loomis, R. J. (1993). Environmental Design and Evaluation in Museums. *Environment and Behavior*, *25*(6), 683–697. doi:10.1177/0013916593256001

[6] Bitgood, S., & Patterson, D. (1987). PRINCIPLES OF EXHIBIT DESIGN. *Visitor Behavior*, *2*(1), 4–5.

[7] Bluyssen, P. M. (2009). *The indoor environment handbook: how to make buildings health*. London: Earthscan & RIBA Publishing.

[8] Camuffo, D., Pagan, E., Bernardi, A., & Becherini, F. (2004). The impact of heating, lighting and people in re-using historical buildings: a case study. *Journal of Cultural Heritage*, *5*(4), 409–416. doi:10.1016/j.culher.2004.01.005

[9] Cao, B., Ouyang, Q., Zhu, Y., Huang, L., Hu, H., & Deng, G. (2012). Development of a multivariate regression model for overall satisfaction in public buildings based on field studies in Beijing and Shanghai. *Building and Environment*, *47*, 394–399. doi:10.1016/j.buildenv.2011.06.022

[10] Chang, T. J. (2008). *Effects of Design Features on Visitors' Behavior in a Museum Setting*. University of Kansas.

[11] Chin, W. W. (1998). The partial least squares approach to structural equation modelling. In G. A. Marcoulides (Ed.), *Modern Methods for Business Research* (pp. 295–358). Mahwah: Lawrence Erlbaum Associates.

[12] Davey, G. (2005). What is Museum Fatigue ? *Visitor Studies Today, 8*(3), 17–21.

[13] Fördergemeinschaft Gutes Licht. (2000). *Good Lighting for Museums, Galleries and Exhibitions* (18th ed.). Frankfurt: Fördergemeinschaft Gutes Licht.

[14] Guler, O. K. (2009). *A simulation application for visitor circulation in exhibition environments*. Bilkent University.

[15] Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a Silver Bullet. *The Journal of Marketing Theory and Practice*, *19*(2), 139–152. doi:10.2753/MTP1069-6679190202

[16] Hao, X., Cao, G., Wang, Y., & Wang, J. (2006). Investigation and Analysis of the Indoor Air Environment of a Large-scale Art Exhibition Hall in Beijing Yahui Wang Beijing Institute of Civil Engineering and Architecture. In *Sixth International Conference for Enhanced Building Operations* (Vol. I). Shenzhen, China: Energy Systems Laboratory.

[17] Henseler, J., Ringle, C. M., & Sinkovics, R. R. (2009). The use of partial least squares path modeling in international marketing. In R. R. Sinkovics & P. N. Ghauri (Eds.), *Advances in International Marketing* (pp. 277–319). Emerald Group Publishing Limited.

[18] Höck, C., Ringle, C. M., & Sarstedt, M. (2010). Management of multi-purpose stadiums : importance and performance measurement of service interfaces. *International Journal Services Technology and Management*, *14*(2/3), 188–207.

[19] Hunt, E. G. (2009). *Study of Museum Lighting and Design*. Texas State University-San Marcos. Retrieved from http://ecommons.txstate.edu/honorprog/99

[20] Jansz, J. (2011). Theories and knowledge about sick building syndrome. In S. A. A. Wahab (Ed.), *Sick building syndrome: in public buildings and workplaces* (pp. 25–58). Springer.

[21] Jeong, J.-H., & Lee, K.-H. (2006). The physical environment in museums and its effects on visitors' satisfaction. *Building and Environment*, *41*(7), 963–969. doi:10.1016/j.buildenv.2005.04.004

[22] Joseph F. Hair, Hult, G. T. M., Ringle, C. M., & Sarstedt, M. (2014). *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. Singapore: SAGE Publication.

[23] Jr., J. F. H., Ringle, C. M., & Sarstedt, M. (2013). Partial Least Squares Structural Equation Modeling: Rigorous Applications, Better Results and Higher Acceptance. *Long Range Planning*, (0), -. doi:10.1016/j.lrp.2013.01.001

[24] Kamaruzzaman, S., Egbu, C., Ahmad Zawawi, E., Ali, A., & Che-Ani, A. (2011). The effect of indoor environmental quality on occupants' perception of performance: A case study of refurbished historic buildings in Malaysia. *Energy and Buildings*, *43*(2-3), 407–413. Retrieved from http://dx.doi.org/10.1016/j.enbuild.2010.10.003

[25] Kesner, C. W. (1993). Museum exhibition lighting: effectiveness of subjective and objective evaluation measures. *Lighting Research and Technologies*, *25*(2), 45–47.

[26] Kesner, C. W. (1997). Analysis of the Museum Lighting Environment. *Journal of Interior Design*, *23*(2), 28–41. doi:10.1111/j.1939-1668.1997.tb00247.x

[27] La Gennusa, M., Lascari, G., Rizzo, G., & Scaccianoce, G. (2008). Conflicting needs of the thermal indoor environment of museums: In search of a practical compromise. *Journal of Cultural Heritage*, *9*(2), 125–134. doi:10.1016/j.culher.2007.08.003

[28] Lai, A. C. K., Mui, K. W., Wong, L. T., & Law, L. Y. (2009). An evaluation model for indoor environmental quality (IEQ) acceptance in residential buildings. *Energy and Buildings*, *41*(9), 930–936. doi:10.1016/j.enbuild.2009.03.016

[29] Lee, J. (2010). *The Museum Experience in the Environment of the Japanese Collections*. The Florida State University.

[30] Lee, M. C., Mui, K. W., Wong, L. T., Chan, W. Y., Lee, E. W. M., & Cheung, C. T. (2012). Student learning performance and indoor environmental quality (IEQ) in air-conditioned university teaching rooms. *Building and Environment*, *49*, 238–244. doi:10.1016/j.buildenv.2011.10.001

[31] Levermore, G. J., & Leventis, M. (2000). Occupant feedback using a questionnaire importance of up to 24 factors. In *Proceedings of Clima 2000 Conference* (pp. 1–10). Brussels.

[32] Lighting Research Center. (1998). *Museum Lighting Protocol Project*. New York.

[33] Meir, I. a., Garb, Y., Jiao, D., & Cicelsky, A. (2009). Post-Occupancy Evaluation: An Inevitable Step Toward Sustainability. *Advances in Building Energy Research*, *3*(1), 189–219. doi:10.3763/aber.2009.0307

[34] Mey, L. P., & Mohamed, B. (2010a). Measuring service quality, visitor satisfaction and behavioral intentions: pilot study at a museum in Malaysia. In *International Conference on Business and Economic Research (ICBER 2010)*. Retrieved from http://www.internationalconference.com.my/proceeding/icber2010-proceeding/PAPER-127-ServiceQuality.pdf

[35] Mey, L. P., & Mohamed, B. (2010b). Service quality, visitor satisfaction and behavioral intentions: pilot study at a museum in Malaysia. *Journal of Global Business and Economics*, *1*(1), 226–240.

[36] Newsham, G., Brand, J., Donnelly, C., Veitch, J., Aries, M., & Charles, K. (2009). Linking indoor environment conditions to job satisfaction: a field study. *Building Research & Information*, *37*(2), 129–147. doi:10.1080/09613210802710298

[37] Norback, D., & Edling, C. (1991). Environmental, occupational, and personal factors in related to the prevalence of sick building syndrome in the general population. *British Journal of Industrial Medicine*, 451–462.

[38] Raw, G. J., & Roys, M. . (1996). Questionnaire Design for Sick Building Syndrome: An empirical comparison of options. *Environment International*, *22*(1), 61–72.

[39] Ringle, C. M., Wende, S., & Will, A. (2005). SmartPLS 2.0 (Beta). Retrieved from http://www.smartpls.de

[40] Rohloff, I. K., Psarra, S., & Wineman, J. (2009). Experiencing Museum Gallery Layouts through Local and Global Visibility Properties in Morphology: An inquiry on the YCBA , the MoMA and the HMA. In D. Koch, L. Marcus, & J. Steen (Eds.), *7th International Space Syntax Symposium* (pp. 1–14). Stockholm: KTH.

[41] Rojas, C. de, & Camarero, C. (2008). Visitors' experience, mood and satisfaction in a heritage context: Evidence from an interpretation center. *Tourism Management*, *29*, 525–537.

[42] Saraga, D., Pateraki, S., Papadopoulos, a., Vasilakos, C., & Maggos, T. (2011). Studying the indoor air quality in three non-residential environments of different use: A museum, a printery industry and an office. *Building and Environment*, *46*(11), 2333–2341. doi:10.1016/j.buildenv.2011.05.013

[43] Skov, P., Valbjorn, O., & Pederson, B. V. (1990). Influence of indoor climate on the sick builindg syndrome in an office environment. *Scandinavian Journal of Work Environment Health*, *16*, 363–371.

[44] Sulaiman, R., Kamaruzzaman, S. N., Salleh, N., & Mahbob, N. S. (2011). Can we achieve a balanced indoor environmental Malaysian historical museum building? In *2nd International Conference on Environmental Science and Technology* (Vol. 6, pp. 402–406). Singapore: IACSIT Press.

[45] Tang, T. . (2008). *Effects of Design Features on Visitors' Behavior in a Museum Setting.* University of Kansas.

[46] Wahab, S. A. A. (Ed.). (2011). *Sick Building Syndrome in Public Buildings and Workplaces*. Heidelberg: Springer.

[47] Waller, R. R. (2003). *Cultural Property Risk Analysis Model: development and application to preventive conservation at the Canadian Museum of Nature*. Goterborg: Acta Universities Gothoburgensis.

[48] Willem, H. C. (2006). *Thermal and indoor air quality effects on physiological responses, perception and performance of tropically acclimatized people*. National University of Singapore.

[49] Wollard, V. (2004). Caring for the visitor. In P. J. Boylan (Ed.), *Running a museum: a practical handbook* (pp. 105–118). France: ICOM- International Council of Museum.

[50] Wong, L. T., Mui, K. W., & Hui, P. S. (2006). A statistical model for characterizing common air pollutants in air-conditioned offices. *Atmospheric Environment*, *40*(23), 4246–4257. doi:10.1016/j.atmosenv.2006.04.005

[51] Wong, L. T., Mui, K. W., & Hui, P. S. (2008). A multivariate-logistic model for acceptance of indoor environmental quality (IEQ) in offices. *Building and Environment*, *43*, 1–6. doi:10.1016/j.buildenv.2007.01.001

[52] Wong, S.-K., Wai-Chung Lai, L., Ho, D. C.-W., Chau, K.-W., Lo-Kuen Lam, C., & Hung-Fai Ng, C. (2009). Sick building syndrome and perceived indoor environmental quality: A survey of apartment buildings in Hong Kong. *Habitat International*, *33*(4), 463–471. doi:10.1016/j.habitatint.2009.03.001

[53] Yau, Y., & Chew, B. (2009). Thermal comfort study of hospital workers in Malaysia. *Indoor Air*, 500–510. doi:10.1111/j.1600-0668.2009.00617.x