An Investigation of a Modified Formula of Daylight Glare and Limiting Daylight Glare Indices in the Thai Elderly

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ABSTRACT

Discomfort glare is perceived differently by the young and the elderly. However, the existing daylight glare formulae do not take the effects of age into account and the current limiting glare index was obtained from non-elderly subjects. To create lighting suitable for the Thai elderly, especially in terms of glare, two objectives were addressed. The first explored a modified formula of daylight glare for the Thai elderly, while the second investigated the limiting daylight glare index for the Thai elderly in particular areas of residential and public buildings. Both laboratory and field studies were undertaken. The former investigated a daylight glare formula modified for the effect of age of the Thai elderly. Experiments were carried out in a controlled chamber at Kasetsart University, Bangkok, Thailand. The latter explored the limiting daylight glare index for particular areas of residential and public buildings for the Thai elderly with studies conducted in the real environment. A modified formula was proposed to predict daylight glare for the Thai elderly. Limiting daylight glare indices for particular areas of both residential and public buildings for the Thai elderly were also proposed, and the recorded values were found to be higher than the existing limiting daylight glare indices.

Keywords: *discomfort glare, daylight, glare index, Thai elderly*

INTRODUCTION

Glare is visual noise. Discomfort glare is a phenomenon arising from high luminance contrasts or unsuitable luminance distributions in the visual field that cause discomfort (CIE, 1995). There have been many studies on glare predictions for both small-source and large-source glare. The Unified Glare Rating (UGR) (CIE, 1995), Daylight Glare Index (DGI) (Hopkinson, 1972) and Daylight Glare Probability (DGP) (Wienold & Christoffersen, 2006) are the most commonly used methods for quantifying glare predictions.

For small-source glare calculation, the Unified Glare Rating (UGR) and Illuminating Engineering Society glare index (IES-GI) systems are internationally recommended for evaluating the degree of discomfort glare from indoor lighting installations. Both UGR and IES-GI systems have been applied to small sources of glare and electric lighting installations (IES, 1967). Glare indices that are developed for electrical lighting (UGR and IES-GI) are not suitable for daylight because daylight openings have a significantly higher solid angle.

The daylight glare index (DGI) was developed many years ago, and is recognised as a well-known method to predict the amount of discomfort glare from windows or large sources (Hopkinson, 1972). Nazzal (2005) proposed a modified index called DGI_N which aimed to overcome some of the limitations of the standard DGI. In this formula, sources of luminance and solid angles are modified to include the effect of the observer's position. In 2007, Tuaycharoen and Tregenza proposed DGI' as a daylight glare index modified for the effects of luminance variation (RML) and view interest (IV).

In 2006, another daylight glare prediction was proposed by Wienold and Christoffersen as the Discomfort Glare Probability (DGP). This formula showed a stronger correlation with the user's response regarding glare perception. The UGR and DGI indices, previously analysed, only focused on the contrast in the ratio between the background average luminance and the glare source luminance. However, DGP included an evaluation of the level of illumination perceived by the observer by means of the term E_v. Moreover, in a subsequent study, Wienold (2007) proposed a simplified version of DGP (DGPs) where no logarithmic term depended on the local quantities (luminance and solid angle of the source seen from the observation point). Finally,

in 2009, Wienold proposed the Enhanced Simplified DGP (eDGPs) for use in the case of direct sun transmission into a room.

Recently, the number of elderly people aged 65 and above has dramatically increased in Thailand. This has caused serious problems for the Thai Government who are tasked with providing appropriate infrastructure and living accommodation. Since sunlight is strong in Thailand, daylighting is one of the important factors to consider when creating a suitable environment for the Thai elderly, especially in terms of glare prevention from the window. Due to age-related changes in vision, the elderly are more sensitive to glare than younger adults (IESNA, 2016). However, none of the current daylight glare formulae in use take the effects of ageing into account. There are no different requirement between limiting glare index values for young and older people. Moreover, many recent studies have also revealed differences in visual perception in Caucasians and Asians (Bergamin et al., 1998; Van Den Berg et al., 1991). Therefore, to create lighting suitable for the Thai elderly, especially in terms of daylight glare, it is necessary to develop a modified formula to predict discomfort glare from window and limit daylight glare index values that accurately represents the particular visual features of the Thai elderly.

To develop the above-mentioned formula and index, two main studies were conducted. The first study investigated a modified formula of discomfort glare from a window for the Thai elderly. This experiment was carried out in a controlled chamber at the Faculty of Architecture, Kasetsart University, Bangkok, Thailand. The second study was undertaken to establish limiting daylight glare indices for the Thai elderly in particular environments in residential and public buildings. A field survey of nine nursing homes was carried out. Finally, a modified glare formula for the Thai elderly was proposed together with limiting daylight glare indices of particular environments in residential and public buildings.

METHODOLOGY

Study I: Thai elderly daylight glare formula

The main objective of this study was to investigate a modified formula of discomfort glare from a window for the Thai elderly. In this study, the daylight glare

index (DGI) developed by Hopkinson (1972) was used as a reference as this formula is the most well-known method to predict discomfort glare for large sources.

Experimental setting

Many studies have shown that there is no difference between the glare results from a simulated environment and a real daylighting condition (Iwata et al.,1992a,1992b). Since there was a need for control over many extraneous variables, this study was conducted in a simulated closed environment rather than real daylighting condition.

The first study was conducted in a controlled test chamber at the Faculty of Architecture, Kasetsart University, Bangkok, Thailand. The test chamber was located on the ground floor of the building and had no windows, consequently providing complete control over the lighting conditions. A 3.00 m wide by 3.00 m high by 3.00 m deep testing chamber was built. The ceiling of the chamber was painted matt white with reflectance (ρ_c) of 0.8, while the reflectance of the walls (ρ_w) was 0.5 and that of the floor (ρ_f) was 0.2, as reflectance values for standard ceiling, wall and floor.

A projector connected with a laptop was used to project image glare sources with various luminance on a wall as a simulated window. Fixation was marked at the centre of the images of the glare source. The subjects sat facing the projected wall two metres from the images and the viewing distance for each subject was constant. This maintained a constant visual size of the image (Figure 1).

Experimental equipment and measurement

A projector was placed on one side of the subject and manipulated by one experimenter, while a cone was located on the other side of the subject to measure light levels. One experimenter stood slightly behind the subject to record the vertical illuminance to obtain the mean luminance of the glare source using a photocell with a conical mask. The experimenter also recorded the vertical illuminance to achieve the mean luminance of the background using a photocell outside the cone (Figure 2). These monitoring procedures followed the method proposed in the IEA SHC Task 21 (Christoffersen, 2001).

Figure 1:
Apparatus settings used in this experiment

Figure 2:
Cone and lux meters

At the back of the chamber, a projector cast the image of a scene onto the opposite wall creating various glare sources. These consisted of a square 50 x 50 cm area as a large glare source. To change the luminance levels of the glare source, various images containing several levels of brightness were prepared for projection. Illumination inside the testing chamber was provided by light reflecting from the projected images.

Experimental procedure

Testing was conducted during June-July 2016. Forty-six Thai elderly subjects, aged between 61 and 76 years with no colour blindness and/or other eye problems that effects the results, participated in the experiment. This number of subjects was chosen because the same number was used in many previous glare studies (Rodriguez et al., 2017), while the number of 30 observations was devised by Bechtel (1987) as the minimum number required to obtain a statistically significant result. Half of the subjects were male and half were female. In the experiment, no significant difference was found between observers with and without contact lenses or between male and female subjects. Therefore, data were analysed without any discrimination (Kim & Koga, 2004; Kim et al., 2008).

Previous research showed that subjective assessments of glare tended to produce a wide scatter in the results. For this reason, a pretest period for controlling extraneous variables was added to the experiment. There were two periods of experiment as a pretest period followed by the real experiment.

In the pretest period, when first arriving at the test chamber, the subject was required to position himself or herself in a chair facing the wall screen. The experimenter then gave a brief explanation of the purpose of the study, during which, the subject completed the informed consent form. Each subject first completed the pre-study questionnaire, and was then given instructions containing the definition of glare, the meaning of criteria, and the trial procedure used in the real experiment. The experimenter then demonstrated her own evaluation on a test image. After, subjects performed one evaluation trial with similar procedure of the real experiment. This method was used in previous glare studies (Velds, 2002; Tuaycharoen, 2006). Then, the subject was allowed to relax for about five minutes before the real experiment was begun. This time period was for the subject to re-adapt his/her eyes in mesopic vision (Plainis et al., 2005).

In the real experiment, the subject was asked to look at the centre of each image. After 30 seconds of adaptation, the presenter asked the subjects to evaluate glare level on the questionnaire for each projected image as well as send a verbal signal by saying 'yes' to the two experimenters to record the light levels and change the stimuli. All image sequences were randomly assigned for each subject. Subjects participated in one session of approximately one hour in length.

Subjective assessment of discomfort glare

In previous studies, different subjective criteria were used for assessing glare discomfort. These included Hopkinson's multiple criterion scale, Glare Sensation Vote (GSV), Percentage Persons Dissatisfied (PPD) and Borderline Comfort Discomfort (BCD). The Glare Sensation Vote (GSV) by Wienold and Christoffersen (2006) was used as a subjective assessment in this study because this method was used in many previous glare studies (Iwata et al., 1992a, 1992b) and has been adopted as the reference standard

used in the development of current glare indexes (Fotios, 2015). The GSV was also modified as a continuous scale and was developed and linked to the time span for which the subject could withstand their sensation of discomfort to allow the subject to better understand the scale (Kent et al., 2014, Osterhaus, 1998; Rodriguez et al., 2015; Tuaycharoen, 2006; Velds, 2002). Thus, the variance of glare results was reduced. In this experiment, the definition of each point of the glare scale was described to the subject and a printed sheet of paper that included these definitions was available during the experiment. These four thresholds were described to all subjects. Also, the experimenter suggested to them to think that they have to pursue some visual tasks in the working environment while evaluating these criteria of discomfort glare. The Glare Sensation Vote (GSV) is shown as Figure 3 below.

This study aimed to modify the DGI formula according to age factor. Therefore, after obtaining all the results of GSV, the data were converted to the same scale as the DGI scale. In this study, this converted GSV data was called Glare Response Vote (GRV) following the method according to Tokura et al. (1996) (GRV was derived as follows: GRV= 4GSV+16). After that, to obtain the best fit function of the modified DGI formula (DGI_a), all the data, which were GRV (dependent variable, called later as DGI_a), DGI and Age (independent variables), were analysed using Multiple Linear Regression.

Study II: Limiting glare indices for the Thai elderly

The main objective of the second study was to investigate limiting daylight glare indices for the Thai elderly in particular areas of residential and public buildings. There were two parts in this study. The first part aimed to investigate the limiting daylight glare indices for particular environments in residential buildings. The second study was to explore the limiting daylight glare indices for particular environments in public buildings.

Limiting glare indices for the Thai elderly in residential building

Survey

In the first part, a comprehensive survey of nine nursing homes in Thailand was conducted with glare assessments of 326 residents in these homes (Figure 4). Data were gathered from seven areas with daylight condition only. The areas examined were 1) corridor, 2) active area or lounge, 3) bedroom, 4) dining room, 5) bathroom, 6) living room, and 7) main entrance.

Figure 3:
The Glare Sensation Vote (GSV) used in the subjective assessment of this experiment

Ban Lopburi Older Persons House

Nakhon Pathom Residential Home

Chalerm Ratchakumaree Elders Aid Centre (Luangpoh Pern Patronage)

Tharnnukro Foundation Bangkhen Nursing Home

Chalerm Ratchakumaree Elders Aid Centre (Luangpoh Lamyai Patronage)

Watsanawet Social Welfare Development Centre for Older Persons

Ban Bang Khae Social Welfare Development Centre for Older Persons

Pathumthani Social Welfare Development Centre for Older Persons

Waiwattananiwat foundation

Figure 4:
Investigated nine nursing homes

Experimental equipment and measurement

In order to find the limiting glare indices for a particular area, the participants were asked to evaluate their glare sensation, and simultaneous photometric measurements of the luminous environment were recorded to calculate the daylight glare index (DGI_a) using the formula obtained from the first part of this study.

To measure factors relating to the DGI_a formula, a digital CCD camera equipped with a fisheye lens was used to 'instantaneously' capture the luminous environment of the observer. The camera was mounted on a tripod and pointed towards the centre of the window, which was the visual fixation area for the subject. Then, nine images with different exposure values were taken for each subject evaluation to create a high-dynamic-range (HDR) image. To calculate luminance values, a Photolux software version 1.3.5 developed by the Lighting Research Group of l'Ecole Nationale des Travaux Publics de l'Etat (ENTPE) in Lyon, France was used. The software combined all the images of the same scene to create a HDR image and produced a luminance map with values of source luminance and background luminance. This method was used due to the fact that instant luminous environments have to be recorded at the same time as the subject glare evaluation and many previous glare studies use this methods (Tuaycharoen, 2006; Velds, 2002). And, in a preliminary experiment assessing the accuracy of the Photolux software under interior daylit conditions, it was found that the average error compared to

a Konica Minolta LS-100 luminance meter was found to be only 5%. To evaluate the sensation of discomfort glare from the window, a GSV scale similar to the first experiment was used.

Experimental procedure

Testing was conducted in nine nursing homes during November - December 2016. The nursing homes were selected because they contained similar environmental characteristics for the Thai elderly. A total of 326 Thai elderly participants were included in this experiment. All subjects were aged 61- 70 years old. Participants with colour blindness and other eye problems affecting the results were excluded from the study. Fifty percent of the subjects were male and 50% were female. In this experiment, no significant difference was found between observers with and without contact lenses or between male and female subjects. Therefore, data were analysed with no discrimination between male and female or between those with and without contact lenses.

Similar to the first experiment, there were two periods in this experiment as a pretest period and the real experiment. The pretest followed the same procedure as the first experiment. In the real experiment, each subject was required to look at a previously marked fixation in an investigated area (a normal visual task for each activity) for 30 seconds (Tuaycharoen, 2006) and evaluated the glare sensation using the GSV scale. At the same time an 'instantaneous' capture of the luminous environment of the subject was also recorded by a digital CCD camera equipped with a fisheye lens. All the areas, site visits and the time of day to be explored were

randomly evaluated. All the results of GSV were then converted to GRV scale. And, after obtaining all the data of DGI_a indices and GRV data, a Simple Linear Regression analysis was conducted to fit the relationship between GRV data and DGI_a indices. The limiting daylight glare indices for each area were obtained from the DGI_a indices at the 95th percentile of the GRV results with increasing or decreasing within ±5% of the values (Yonemura, 1981).

Limiting glare indices for the Thai elderly in public building

In the second part, there were two types of public building investigated. The first type was a Thai temple and the second was a hospital. The reason for choosing these two types of the building due to the fact that these areas were most frequently used by elderly compared to other types of public buildings. For a study of glare in Thai temple, a survey of seven Thai temples was conducted with glare assessments of 142 Thai older adults during February - March 2017 (Figure 5). All subjects were aged 61-70 years old with no colour blindness and/ or other eye problems that effects the results. Data were gathered from two areas with daylight condition only. These two areas were 1) temple body (hall and circulation) and 2) worship seating area. The same procedure and analysis as the part of a residential building was carried out for this part of the research.

For a study in hospital, two hospitals were explored in terms of glare by 203 Thai elderly during April-May 2017, which were Chakkarat hospital and Chokchai hospital (Figure 6). All subjects were aged 61-72 years old with no colour blindness and/or other eye

Samian Nari Temple

Wat Phra Meru Rachikaram

Figure 5:
Examples of investigated Thai temples

problems that effects the results. Glare assessments were carried out in five areas of the hospitals with daylight condition only. These areas were 1) waiting room, 2) corridor (during the day), 3) examination room (general lighting), 4) treatment room (massage and radio therapy), and 5) ward (general lighting). The similar procedure and analysis as the part of a residential building was carried out again for this part of the study.

Chakkarat hospital

Chokchai hospital

Figure 6:
Two investigated hospitals

RESULTS

Daylight glare formula for Thai elderly

As seen from Equation 1, Hopkinson (1972) proposed a Hopkinson-Cornell equation (DGI) to predict a large glare source as follows:

$$\text{DGI} = 10\log_{10} 0.478 \sum_{i=1}^{n} \left[\frac{L_S^{1.6} \; \Omega^{0.8}}{L_b + 0.07\omega^{0.5} \, L_S} \right] \dots\dots\dots\dots\dots\dots(1)$$

Where: L_s = Luminance of the source (cd m^{-2})
L_b = Luminance of the background (cd m^{-2})
ω = Solid angle of the source (sr)
Ω = Solid angular subtense of the glare source, modified for the effect of its position in the field of view by means of position index, P (sr)
P = Position index of the source (sr)

An empirical equation was fitted to the results to examine the relative magnitude of the age factor of Thai elderly that influenced glare discomfort using Multiple Linear Regression analysis. The author modified the Hopkinson-Cornell equation (DGI) by adding supplementary terms or correction factors. Table 1 shows the best fit equation for predicting glare from a window for the Thai elderly.

Table 1: Equation for predicting glare from a window for the Thai elderly

Equation DGI_a = C1 x DGI + C2 x Age + C3			
	Correction factor	**Standard error**	**p-value**
C1	0.399	0.025	0.000[**]
C2	0.100	0.019	0.000[**]
C3	10.134	1.231	0.000[**]
R-squared (r^2) = 0.670*			

** Highly significant at the 0.01 level; * Significant at the 0.05 level

The best fit daylight glare formula for the Thai elderly
is shown as follows:

$$DGI_a = 0.399\ DGI + 0.100\ Age + 10.134 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (2)$$

Where: DGI_a = Daylight glare index for the Thai elderly modified for the effect of Thai elderly's age
   DGI = Daylight glare index calculated from the Hopkinson-Cornell equation
   Age = Age of the Thai elderly (years)

The study also investigated if there is a significant correlation between other daylight glare metrics and the subjects' glare sensation in this study (the first study). The coefficient of determination (r^2) was calculated for this purpose. The coefficient of determination (r^2) for other daylight glare metrics and the results of the subjects' glare sensation (GRV) in this study are shown in Table 2. It was found that other daylight glare metrics as DGI, DGI_N and DGP were not significantly correlated with the results of the subjects' perceptions of glare (r^2 = 0.330, r^2 = 0.251, and r^2 = 0.232 respectively). Table 2 is also noteworthy because none of the other daylight glare metrics calculated achieve a correlation to discomfort sensation from window of Thai elderly higher than 0.5. When compared to the result in Table 1, DGI_a formula can improve a much higher correlation to the discomfort sensation from window of Thai elderly (r^2 = 0.670) than other existing daylight glare metrics.

Table 2: The coefficient of determination (r^2) for different daylight glare metrics and the subjective glare sensation

Metric	Subjective glare sensation	
	r^2	**p-value**
DGI	0.330	0.082
DGI_N	0.251	0.092
DGP	0.232	0.111

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Limiting daylight glare indices for Thai elderly

Table 3 shows the limiting daylight glare indices for the Thai elderly in each area of residential building. Overall, results showed that the values of limiting daylight glare indices for the Thai elderly were higher than the existing limiting daylight glare index (DGI).

Table 3: Limiting daylight glare indices for the Thai elderly in each area of a residential building

Area	Daylight Glare Indices from linear regression at the 95th percentile	Limiting Daylight Glare Indices for the Thai elderly (DGI$_a$)	Limiting Daylight Glare Indices (DGI)[i]
Corridor	22.80	23	20
Active area or lounge	22.20	22	20
Bedroom	27.82	28	n/a
Dining room	27.76	28	n/a
Bathroom	27.80	28	n/a
Living room	24.02	24	n/a
Main entrance	26.04	26	20

Note: [i]   *Limiting Daylight Glare Indices (DGI) are derived from limiting Unified Glare Rating (UGR) (CIBSE, 1994) and were converted by using DGI = 2/3 x (UGR+11) (Bellia et al., 2008; Cai & Chung, 2013)*
    n/a   means no limiting Unified Glare Rating (UGR) proposed (CIBSE, 1994)

Table 4 shows the limiting daylight glare indices for the Thai elderly in each area of public buildings. Overall, results showed that values of limiting daylight glare indices for the Thai elderly in each area both Thai temple and hospital were higher than the existing limiting daylight glare index (DGI). In general, the Thai elderly seem to display more tolerance on glare from a window than young Caucasian population from which DGI was originally derived (Hopkinson, 1972).

Table 4: Limiting glare indices of a large source for the Thai elderly in each area of a public building

Area	Daylight Glare Indices from linear regression at the 95th percentile	Limiting Daylight Glare Indices for the Thai elderly (DGI$_a$)	Limiting Daylight Glare Indices (DGI)^i
Temple			
Temple body (hall and circulation)	24.98	25	24
Worship seating area	25.85	26	22
Hospital			
Waiting room	25.86	26	22
Corridor (during the day)	27.77	28	22
Examination room (general lighting)	25.80	26	20
Treatment room (massage and radio therapy)	24.79	25	20
Ward (general lighting)	24.81	25	20

Note: ^{i} *Limiting Daylight Glare Indices (DGI) are derived from limiting Unified Glare Rating (UGR) (CIBSE, 1994) and were converted by using DGI = 2/3 x (UGR+11) (Bellia et al., 2008; Cai & Chung, 2013)*

CONCLUSIONS AND DISCUSSIONS

Theoretical implications

Based on the results, a modified glare formula for the Thai elderly was proposed, taking into account the effect of age. Limiting daylight glare indices of the Thai elderly in a particular environment in both residential and public buildings were also introduced.

Results in the first study yielded a modified glare formula for the Thai elderly (DGI$_a$) and showed a strong magnitude of the age effect. Moreover, when the correlation between other daylight glare metrics and the data sets of glare sensation of Thai elderly were made, none of the metrics had a significant correlation to discomfort sensation from window of Thai elderly. And, DGI$_a$ formula can improve a much

higher correlation to the discomfort sensation from window of Thai elderly. This situation implied that the existing daylight glare formulae are a poor predictor of discomfort glare from window for the Thai elderly. This also re-emphasised the difference in glare sensitivity between the elderly and young people in the case of Thai people. Findings were consistent with research conducted in other countries by Kuhn et al. (2014) who indicated that glare may be more frequently reported by older observers (Kuhn et al., 2014).

Moreover, results in the last study showed that despite an age effect, the Thai elderly still displayed more tolerance on glare from windows of both residential and public buildings than young Caucasian. This finding was demonstrated by higher values of limiting daylight glare indices of the Thai elderly from most areas in these two types of buildings than the

existing limiting DGI (the results obtained by young Caucasian). Normally, when people getting old, their eye lens become opaque causing scatting light in their eye balls. This results in higher glare sensitivity in elderly than young people (IESNA, 2016). The results in our study seems to indicate that even though there was an age effect, in glare perception from daylight in residential and public building context, the effect of culture would still be stronger. Results in this part correlated with many studies showing different glare sensations between Asians and Caucasians. Asian people always display more tolerance to glare than Caucasians. Tuaycharoen (2013) found that when subjected to a severe degree of glare sensation, Thai people felt the same degree of discomfort glare at a higher window luminance (Tuaycharoen, 2013). Pulpitlova & Detkova (1993) established a higher tolerance to glare in Japanese than European subjects, while Akashi et al. (1996) and Cai & Chung (2013) suggested that glare sensitivity may not be consistent across cultures.

Practical implications

The results of this study yield benefits to designers to manipulate glare from windows for the Thai elderly in residential and public buildings as follows:

1) A modified daylight glare formula for the Thai elderly (DGI_a) taking into account the effect of Thai elderly's age could be used to predict glare from window in living environment for the Thai elderly more accurately. An increase in discomfort glare from window was found to be related to an increase in age of the Thai elderly.

   Therefore, in the areas used by the Thai elderly, the designer needs to take more consideration in the aspects of higher glare perception, such as increasing protection against daylight by using extra curtains or lower glass transmission by the windows.

2) A high-quality lighting environment is an important aspect to maintain environments that are supportive of the ageing process, promote wellness and reduce accidents in nursing homes. Necessary light for older eyes in nursing homes can be provided by 1) substantially raising light levels, 2) balancing natural light and electric light to achieve even light levels and 3) eliminating glare as much as possible (Lizabeth & Noell-Waggoner, 2003). To maintain supportive environments in Thai nursing homes, both DGI_a formula and limiting daylight glare indices identified in this study can be used as a guideline to design a suitable visual environment for older eyes in particular areas. Moreover, these DGI_a formula and limiting daylight glare indices for the Thai elderly can be applied as a design guideline to other public buildings, such as Thai temple and hospital.

Limitations of the study

There are two limitations in this study. Firstly, findings presented here are contingent on the experimental characteristics and conditions considered in this study only. Secondly, the subjects who participated in this study were Thai elderly people who represented a distinctive culture and background.

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