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Effect of music tempo on duration of stay in exhibition spaces

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ABSTRACT

Investigations have been made into the effect of music tempo on the duration of stay in commercial spaces, but not in exhibition spaces. Previous research has frequently used the duration of stay as an indicator of exhibition learning. To understand how music tempo may influence this learning, this study investigated the effect of music tempo on the duration of stay in exhibition spaces. Because the density of visitors, exhibit elements, or music or exhibit element preferences may affect the duration of stay in exhibition spaces, further investigation was conducted to determine which factors had an impact on the duration of stay in exhibition spaces and which factors had the greatest impact. An online experiment was conducted with a virtual representation of the famous White Cube Gallery in London. To investigate the influence of three factors on the duration of stay in exhibition spaces, 36 scenarios were generated for objective evaluation: music tempo (fast, medium, slow, none), exhibit element density (high, medium, low), and visitor density (single, crowded, uncrowded). Then subjective evaluation was used to investigate whether music preference or exhibit element preference influenced the duration of stay during the above 36 scenarios. Additionally, through subjectively and objectively exploring all the factors affecting participants' duration of stay (music tempo, exhibit element density, visitor density, music preference, exhibit element preference), this study sought to determine which factors exerted the greatest impact. The objective results revealed that participants stayed longer (by approximately 30 s) with slow-tempo music than with fast-tempo music. Moreover, when the influence of music tempo (fast, medium, slow, none), exhibit element density (high, medium, low), and visitor density (single, crowded, uncrowded) were considered, the results showed that when the visitor density reaches crowded conditions, fast- or slow-tempo music will exert an impact on the duration of stay. The subjective results revealed that, when the effect of exhibit element density or visitor density were considered alongside the effect of music tempo on participants' duration of stay, exhibit element preferences will also exert an impact on the duration of stay. The subjective and objective results revealed that of all the factors that influence participants' duration of stay, music tempo (fast or slow) exerted the greatest impact.

1. Introduction

Music tempo has primarily been shown to influence the duration of stay in the commercial context [18]. Slow music tempo can influence consumers to shop [30] and stay longer in malls [39], compared with fast music tempo, which can make customers more willing to wait for a longer time in restaurants [31]. Research has also shown that people prefer to listen to slow-tempo music when they stay longer in shops [39]. Eating duration can also last longer with music of a slower tempo [28]. In contrast, fast-food restaurants play fast-tempo music to clear customers quickly and maintain sufficient seating [39]. Soh [39] claimed that music tempo had a 5% positive effect on the duration of stay in restaurants and supermarkets. Down [12] confirmed this relationship in terms of the time spent by consumers in bars. Duncan [14] also supported this idea, finding that both the duration of stay and amount of spending of shoppers in stores were affected by music, but the effect of tempo was not studied. Music tempo has not been studied in other contexts, such as florists, bookstores, or clothing stores. Music tempo has also not been studied in an exhibition space, which is the focus of this paper.

Previous studies have investigated how music influences human behaviour in museums. Music characteristics in this context have involved mainly the presence of music, its content, and

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its properties [16]. Music can help exhibition visitors feel more comfortable [5] and distract them [8,38]. Visitors to an exhibition with music may stay longer than those in an exhibition without music [5]. Music has also been seen as enhancing the message conveyed in exhibitions, such as in Woltman's (1994) study. Background music content can enhance visitor experience [7]. More content in background music, however, is more likely to distract listeners from verbal comprehension tasks [43] compared with low-content music. Music can also enhance performance on cognitive tasks [9,19]. Some musical properties can influence human behaviour, such as music loudness and music genre. Mehrabian [29] indicated that overly loud museum background music will affect visitors' mood. In an experiment, Kottasz [23] showed that over 55% of individuals were negatively affected by loud music; furthermore, older people are more sensitive than younger people to loud music. In terms of music genres, previous studies have indicated that relaxing music induces a slower visit pace [43], enhances visitors' mood [5], and evokes warm and relaxed feelings [7]. It also optimises museum visitors' levels of attention and emotional arousal [43]. Classical music can significantly raise visitors' perceived knowledge level [17]. Among all the music properties that affect human behaviour, however, music tempo has not been studied.

Regardless of the function of a museum, the duration of stay in it is related to exhibition size and the exhibits' elements. In the largest galleries with the most components, Serrell [36] and Korn [21] have found that visitors spend less time in large exhibitions than in small exhibitions. Visitors usually spend 14–30 min in a museum, with 80% of visitors staying, on average, less than 20 min [20,22,36]. However, there is still insufficient quantitative research on exhibition scale and exhibit elements to precisely define their impact on duration of stay. Visitors' duration of stay in museums can reveal the influence of each exhibit element in the exhibition [4,13,15,33], help diagnose the value and quality of existing or new exhibitions [44], and provide an initial idea of exhibition attraction indicators ,[40]. There is still a lack of detailed and combined comparative studies on visitors' duration of stay in museums and galleries, including examinations of exhibition scale and exhibit elements. Crowded conditions in exhibitions can affect visitors' duration of stay, causing pressure and resulting in unfulfilled learning agendas for visitors to exhibitions. Individuals may behave differently in small groups than in large groups. For example, there may be a tendency to spend less time in a crowded exhibition [3]. Weekend family visitors may not adequately fulfil their learning agendas if there are too many visitors in a museum [34]. Compared to weekdays, when crowding is less of a problem, crowded weekend conditions result in visitors' inability to complete their learning agendas [34]. In a crowd, visitors feel pressure to move quickly from one exhibit to another [34]. When visitors were asked how they would improve an exhibition at the National Air and Space Museum, 25% suggested that the gallery needed more space or fewer visitors due to its excessively crowded conditions [34]. Nevertheless, such findings do not imply that crowds of all sizes lead to negative museum experiences. However, what constitutes crowded conditions and their relationship to the scale of the exhibition space has still not been explored adequately.

In summary, there is a lack of research on the influence of music tempo on duration of stay in the context of museums and gallery exhibitions. Since duration of stay is an important indicator of exhibition learning in museums, we believe it is important to explore it in a deeper way. Various music properties can influence human behaviour in museums. However, previous studies have addressed behaviours that focus more on mental than physical activity, and research on the music property of tempo is still limited. Moreover, studies on the duration of stay in museums, particularly detailed comparative studies, and analyses of duration of stay in different spaces with different functions, scales, and exhibit elements, are still lacking. What constitutes crowded conditions needs to be defined, and there is a lack of detailed research on how crowding affects human duration of stay in exhibition spaces.

Therefore, this study aimed to (1) determine the relationship between different music tempos (fast, medium, slow, none) and duration of stay in exhibition spaces by examining music tempo as a single variable, as one of two variables (alongside exhibit element density or visitor density), and as one of three variables (alongside both exhibit element density and visitor density); (2) discuss whether the relationships that emerged in the findings were influenced by music and exhibit element preferences. In addition, this study also sought to determine (3) which of the factors that affect participants' duration of stay (music tempo, exhibit element density, visitor density, music preference, exhibit element preferences) exerts the greatest impact. The hypothesis was that music tempo would affect participants' duration of stay and that participants would have a shorter duration of stay with fast-tempo music than with slow-tempo music. Furthermore, it was hypothesised that music tempo, exhibit element density, and visitor density would all influence the duration of stay in exhibition spaces. Finally, it was hypothesised that, among all the variables that affect participants' duration of stay in exhibition spaces (music tempo, exhibit element density, visitor density, music preference, exhibit element preferences), music tempo would exert the greatest impact.

To achieve these objectives, this study used both objective and subjective evaluations to examine the effects of different music tempos on duration of stay in exhibition spaces with one, two, or three variables at play, and the effect of exhibition elements and music preference on duration of stay, with visitor density, exhibition element density, and music tempo as variables. Then, considering all factors (music tempo, music preference, exhibit element density, exhibit element preference, visitor density), we investigated which exerted the greatest impact on the duration of stay based on the objective and subjective evaluations.

2. Material and methods

This section focuses mainly on the experimental set up and methods. The set up includes the case site, participants, sound source, and variables. The description of the methods focuses on two methodological aspects. One is the methodology of the evaluation system, which provides the main structure of the paper through an in-depth analysis of the research question from subjective and objective perspectives. The other aspect is a discussion of more detailed statistical methodology and the design of the questionnaire and online study, which aims at a further detailed and in-depth analysis of the data under the evaluation system.

2.1. Case site

An experiment was conducted online with a virtual representation of an exhibition at the White Cube Gallery in London. The virtual exhibition was based on a past exhibition at the gallery. This site was chosen for the following two reasons. First, the case site was based on an existing exhibition space; the scale, lighting, and other factors fully corresponded to the actual situation in the exhibition space to minimise unrealistic aspects of the scene for the participants. Second, it is well known that this exhibition does not make participants feel overly disconnected from the environment, and it avoids extreme spatial situations such as organic polygon-shaped spaces, complex spatial layout, or an extremely uncomfortable atmosphere.

Participants were invited to tour the virtual gallery using a mouse and a keyboard to move. The participants could regulate the direction of their virtual tour and the number of steps they moved. Directionally, the participants could move their mouse to look around the environment and use their keyboards' up, down, left, and right keys to go forwards or backwards or to turn left or right. To move more than one step, the participants could press these buttons more than once, e.g., twice to move two steps in that direction.

2.2. Participants

The research was conducted in accordance with UCL Research Ethics Procedures. The participants were provided an information sheet and a consent form to participate. They declared that they were voluntarily participating in the experiment and that they had been informed about the experimental task, the procedures, and the data collection. They understood that the data about their duration of stay and the data from the questionnaires would be used for scientific purposes only. Once they had submitted data, they were not allowed to withdraw their data from the study afterwards. If they did not want to submit data, they could close the webpage after reading the information sheet and consent form before the experiment began. There were no high risks foreseen for participation in this experiment.

To avoid participants' exploring too many scenarios of similar virtual environments and losing interest in continuing the tour, each participant was allowed to experience only one random scenario out of the 36 scenarios. This experiment was performed on adults over 18 years old without hearing or vision problems. This was an important criterion because the hearing systems of older adults may decay with age. The approximate age range of the participants was 18–70 years. Each scenario needed 30 valid samples, and in total, there were 36 scenarios. In summary, at least 1,080 participants participated.

2.3. Sound source

There are five potential musical factors that may influence the relationship between music tempo and human duration of stay, including genres [3], loudness [29], sound comfort [5], mood [7], and musical context [43]. To control the influence of the above factors, this experiment used the same song without lyrics (a piano version of the Canon in D) in all scenarios, and its intensity was set at a neutral level to ensure that participants had a neutral mood (not too calm or too excited). Before the experiment started, the participants were asked to adjust the volume to their comfort level and to keep the volume constant for the subsequent virtual tour. Because loudness was kept within the range of sound comfort, sound comfort had no dramatic effect on the other factors in the experiment. After the experiment, the participants were asked to rate how much they liked the music on a five-point scale: 1. Fully like, 2. Somewhat like, 3. Neither like nor dislike, 4. Somewhat dislike, and 5. Fully dislike. As a result, the only variable was the tempo of the music.

2.4. Variables

2.4.1. Music tempo

Based on music theory [16], the music tempo was divided into three categories: fast music tempo of 120 beats per minute (bpm); medium music tempo of 75 bpm; and slow music tempo of 50 bpm. The reason for the division was because testing revealed that a music tempo below 50 bpm struck listeners as bizarre, and many would not consider such a piece to be real music. Similarly, when the music tempo was above 120, it was too fast, which made listeners overreact in both physical and psychological ways. The original tempo of this piece of music was 75; when the original tempo of a piece of music is less than 60 bpm, 50 bpm is subjectively acceptable, and more than 120 bpm is subjectively unacceptable. Therefore, I decided that to obtain a clear and decisive result, in this research, the slow music tempo would be 50 bpm, the medium music tempo would be 75 bpm, and the fast music tempo would be 120 bpm.

2.4.2. Visitor density

Visitor density in exhibition spaces can affect the duration of stay, resulting in pressure and unfulfilled learning agendas for visitors [3,34]. However, there is a lack of literature on how visitor density reaching crowded conditions is classified. In this experiment, I took crowd density as the benchmark to define the level of crowded conditions, dividing it into high- and low-density conditions and testing them in the same environment. The high- and low-density conditions of visitor densities were defined in this experiment through subjective evaluation in the form of a questionnaire. In this virtual exhibition space, the total number of visitors in the high-density condition (crowded condition) was 70, and the total number of visitors in the low-density condition (uncrowded condition) was 15. The crowd was static in this experiment.

2.4.3. Exhibit elements

Exhibit elements have been shown to impact duration of stay in museums, but details are lacking [10,22]. In this study, we focused on exhibit element density. Through the regular placement of exhibits in the exhibition, exhibits were displayed on all vertical walls. Additionally, in this study, exhibit element density was divided into high, normal, and low density. The density of the high-density exhibit elements was four times that of normal-density exhibit elements, and the density of low-density exhibits was half that of the normal density. The normal-density exhibit condition had 33 exhibits, and the location, size, and content of these exhibits were highly reflective of the actual exhibition at the White Cube Gallery. The exhibit densities are evenly distributed on the vertical walls.

2.5. Experimental procedure

There were three variables in this study: music tempo (fast, medium, slow, none), exhibit element density (high, medium, low), and visitor density (single, crowded, uncrowded). This study included three virtual experiments with a total of 36 scenarios. Experiment 1 had only one variable (music tempo). Through subjective and objective evaluation, it examined the effect of different music tempos (fast, medium, slow, none) on participants' duration of stay and whether this process was influenced by music and exhibit element preferences. Visitor density and exhibit element density existed as fixed variables in Experiment 1. The density of the experiment's exhibit elements was set at a medium level, and the number of exhibits and their content completely replicated the actual exhibition in the exhibition space. This experiment recreated the experience of participants who had visited this exhibition in real life on their own. Experiment 2 had two variables (music tempo and either exhibit element density or visitor density); through subjective and objective evaluation it examined the effect of exhibit element density, visitor density, and music tempo on participants' duration of stay and whether this process was influenced by music and exhibit element preferences. Experiment 2 was divided into two conditions in total: In one condition, the variables were music tempo (fast, medium, slow, none) and exhibit elements' density (high, low); in the other conditions, the variables were visitor density (crowded, uncrowded) and music

tempo (fast, medium, slow, none). Experiment 3 had three variables: music tempo (fast, medium, slow, none), exhibit element density (high, medium, low), and visitor density (single, crowded, uncrowded). It examined all the factors that affected participants' duration of stay (music tempo, exhibit element density, visitor density, music preference, exhibit element preference) to deter-

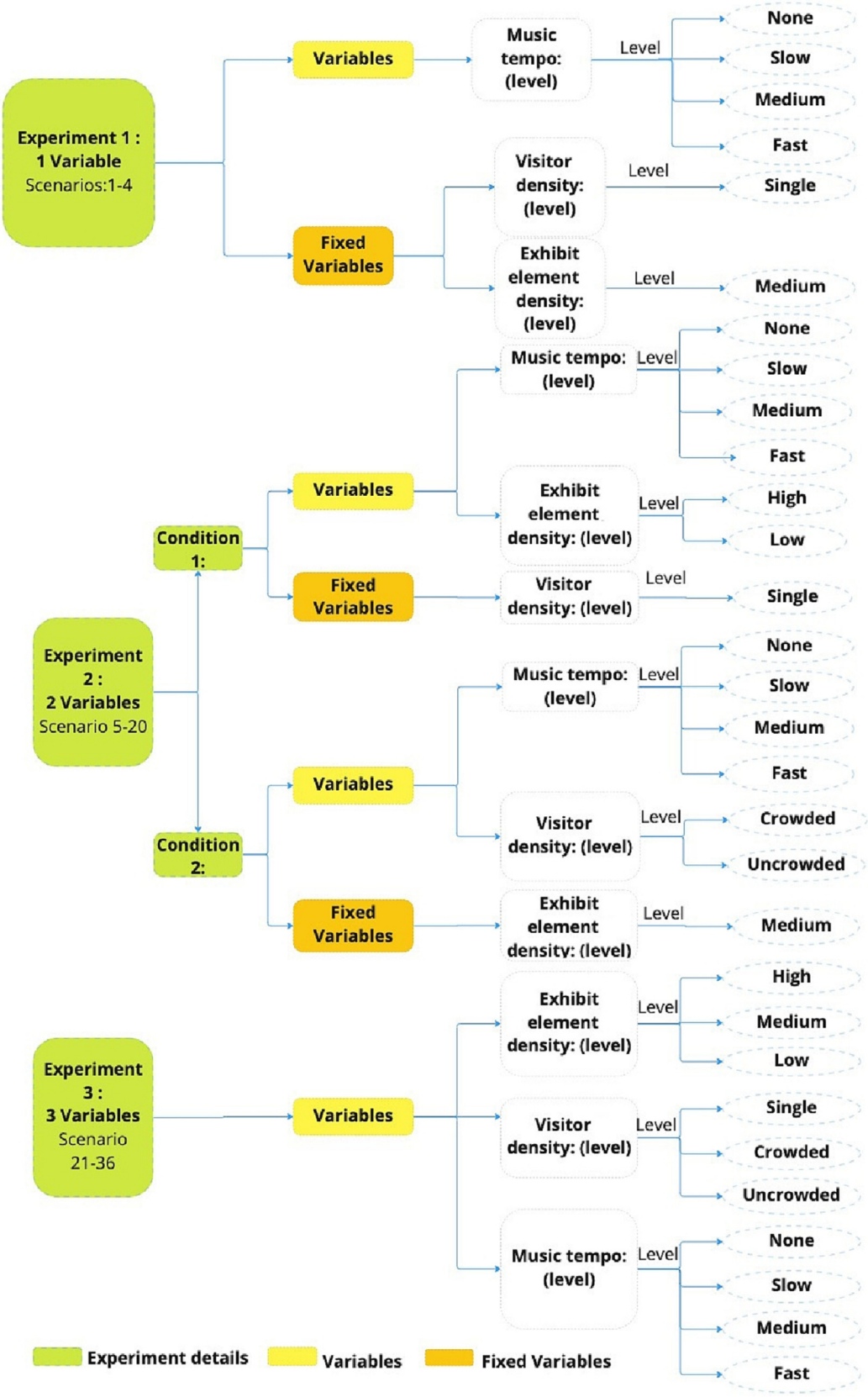

Fig. 1. Experimental framework diagram.

mine which exerted the greatest impact on participants' duration of stay (Fig. 1).

The participants were recruited through two online platforms that help researchers recruit participants for online experiments: https://www.xrdrn.org/ and https://researcher-help.prolific.co/hc/en-gb/.

The experiment was conducted in a location of the participants' choice, in a quiet rather than a noisy environment. Participants needed to have access to a computer with internet and also needed to wear earphones (Fig. 2). The main equipment for this experiment consists of a headset and a monitor, as well as a computer that can be connected to the internet. The headphones and monitor are provided by the participants.

The whole process for the participants of browsing the experimental website consisted of the following steps: general introduction, information sheet, consent form, virtual environment introduction, sound level adjustment, virtual tour, and questionnaire. In general, each participant was invited to a virtual tour that indicated the relationship between music tempo and human behaviour in exhibition spaces.

This study was conducted online to better control the parameters. There was no time limit during the experiment for performing the tasks.

Participants were directed to the information sheet section after finishing the general introduction. The information sheet provided participants with a general understanding of the project as well as detailed information to help them better understand the context, the project purpose, the reason why they were selected, what to expect if they participated, potential risks, and so on. The participants were then transferred to the consent form session. In this session, participants were asked to read all the consent forms and decide whether they agreed to share their specific data. If they felt comfortable sharing the data, they were officially invited to participate in the virtual experiment.

Fig. 3 presents the layout of the virtual exhibition space. Participants in virtual exhibition spaces consistently begin at a designated entry point, ensuring a cohesive user experience. By initiating the virtual tour via the "Start the Virtual Tour" button, users are directed to a precise location, identified as a gap in the north wall (Fig. 3). This method guarantees a uniform spatial orientation for all attendees within the virtual environment. Upon entering a virtual exhibition space (Fig. 4), participants could explore by moving the mouse to look around and using their keyboards' up, down, left, and right keys to move forward or backwards and turn left or right. Participants pressed the button twice to move two steps in a given direction. Then, participants were asked to adjust their volume to their comfort level and to wear headphones to protect them from outside interference. Finally, participants were allowed to start their virtual tours with no time limitation. Each participant's duration of stay in the virtual space was recorded automatically. After the participants finished the tour, they were asked to complete the questionnaire and close the website.

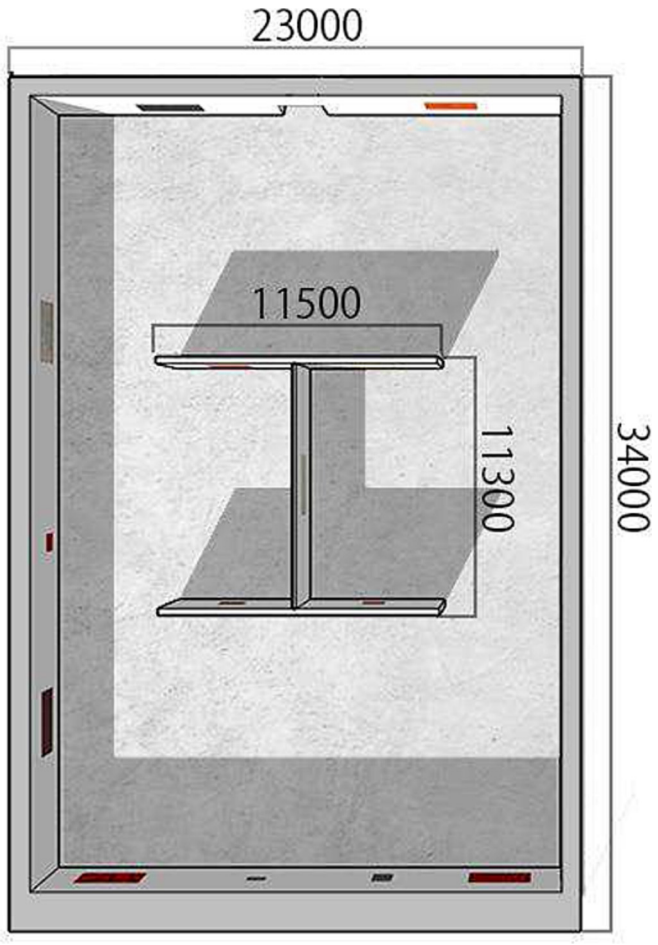

Fig. 3. Virtual environment plan (mm).

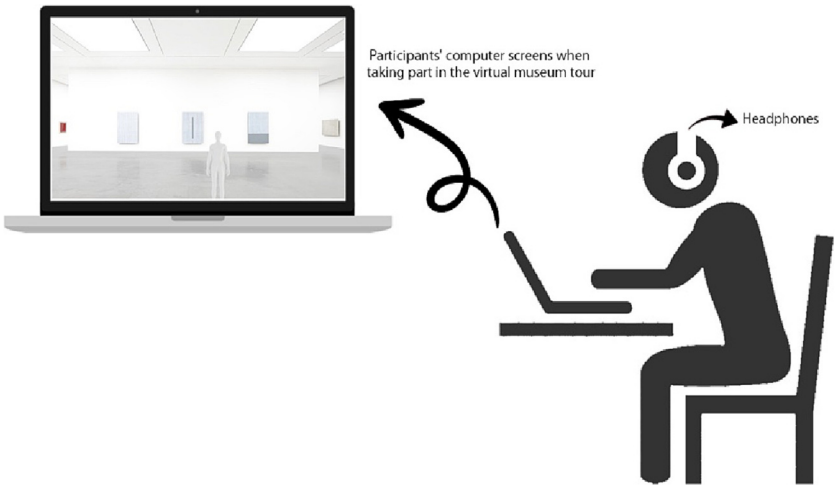

Fig. 2. Diagram of the environment for visitor participation in the experiment.

During the experiment, the participants' duration of stay was collected in step 6 (virtual tour). Their duration of stay was only recorded during the virtual tour session. There was no extra software for them to install.

2.6. Methodology

2.6.1. Evaluation assessment

This study mainly used subjective evaluation, objective evaluation, and comprehensive subjective and objective assessment (Fig. 5).

2.6.2. Subjective and objective evaluation

In this study, all the experiments used subjective and objective evaluation. Objective evaluation was used to analyse the effect of music tempo on duration of stay when there were different variables, while subjective evaluation was used to analyse the effect of music preference and preference for exhibition elements on duration of stay.

2.6.3. Comprehensive subjective and objective assessment

Comprehensive subjective and objective assessment was used to answer the research question focused on which factors that influenced participants' duration of stay exerted the greatest impact (Section 3.3).

2.6.4. Questionnaire design

During this study, subjective evaluation was done using a questionnaire. In the three experiments, scaled response was used to quantify the subjective responses. In practice, the combination of quantitative and qualitative methods to substantiate research findings is common. Likert Scale methods support shaping open-ended and opinion-based answer-seeking questions in a summative format, with the arrangement of opinions from extremely negative to extremely positive [1]. The questionnaire was used in all scenarios (Table 1). To detect the effect of music preference on duration of stay, participants in all scenarios were asked how much they liked the music: 1. Fully like 2. Somewhat like, 3. Neither like nor dislike, 4. Somewhat dislike and 5. Fully dislike.

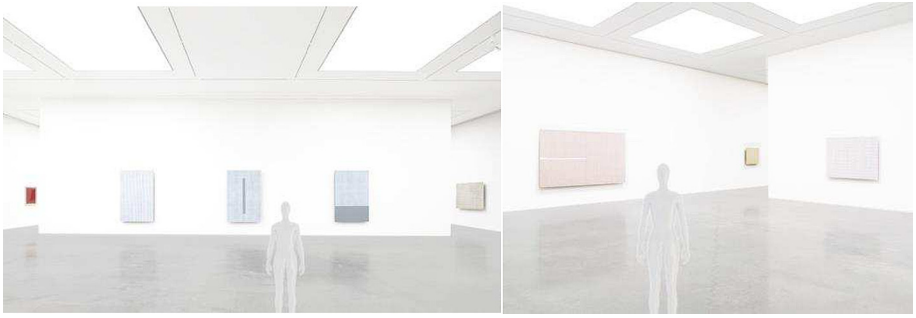

Fig. 4. Virtual environment for participant to tour in the experiment. These pictures show the virtual exhibition, which was based on a previous exhibition at the White Cube Gallety in London.

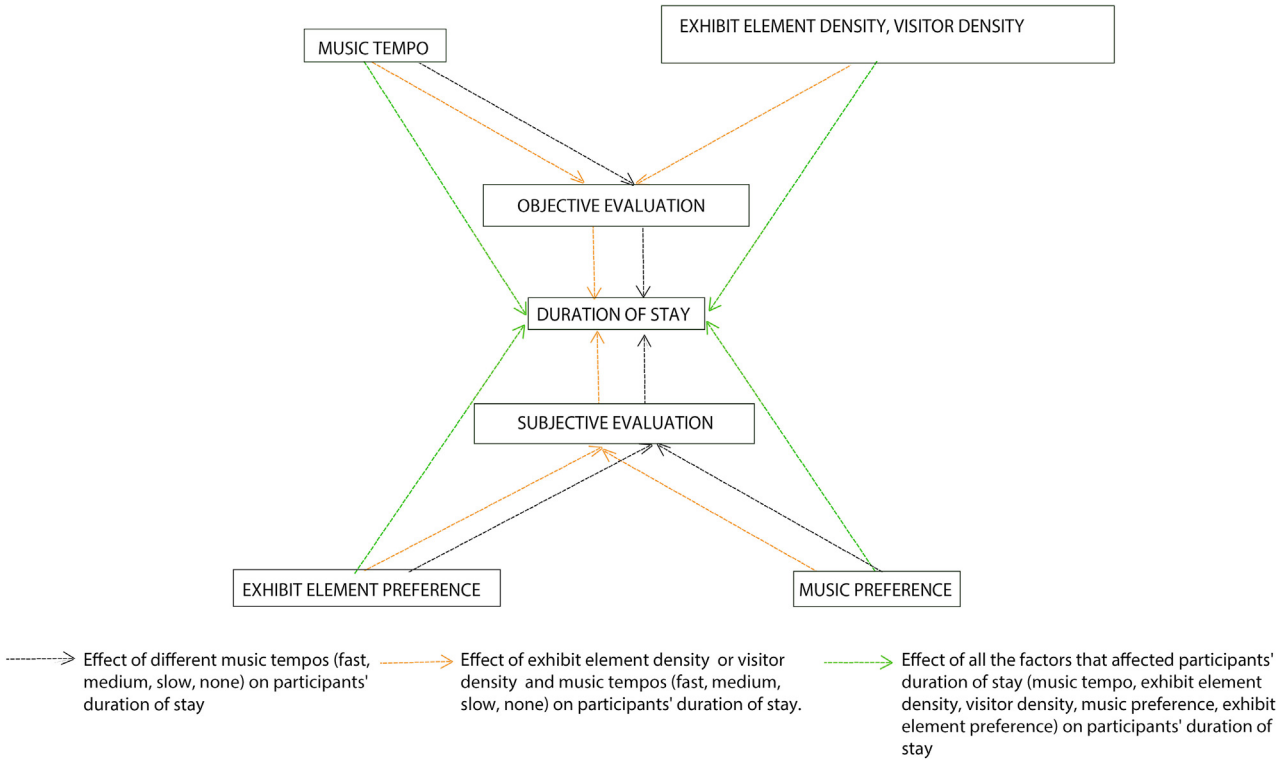

Fig. 5. Evaluation assessment diagram.

Table 1
Questionnaire in experiment.

		Questions	Percentage
Exhibit element preference	Quantity	What percentage of the exhibit elements do you like?	100% 75% 50% 25% 0%
	Quality	How much do you like the exhibit elements in the exhibition?	Fully like Somewhat like Neither like nor dislike Somewhat dislike Fully dislike
Music preference		How much do you like the music?	Fully like Somewhat like Neither like nor dislike Somewhat dislike Fully dislike
Visitor density in crowded condition		On what scale is the level of crowdedness in the space?	Extremely crowded Somewhat crowded Neither crowded nor uncrowded Somewhat uncrowded Fully uncrowded

To detect the participants' perspectives on visitor density in crowded conditions, participants were asked to evaluate the level of crowdedness in the space on a five-point scale: 1. Fully crowded, 2. Somewhat crowded, 3. Neither crowded nor uncrowded, 4. Somewhat uncrowded, 5. Fully uncrowded.

The questionnaire investigated the effect of exhibit element preference on duration of stay from a quantity perspective and a quality perspective. From a quantity perspective, participants in all scenarios were asked what percentage of the exhibit elements they liked: 100%, 75%, 50%, 25%, 0%. From a quality perspective, participants in all scenarios were asked how much they liked the exhibit elements in the exhibition: 1. Fully like, 2. Somewhat like, 3. Neither like nor dislike 4. Somewhat dislike, 5. Fully dislike.

2.6.5. Online study

Numerous studies have shown that online study is an acceptable methodology, particularly after COVID. Li and Huang [26] used a 360-degree panoramic online study to demonstrate that, like physical exhibitions, virtual exhibitions can involve immersive senses, good storytelling, interactive learning, and peer sharing, transforming passive visitors into active explorers. Cevik et al. [6] discussed the effectiveness of the perception of museum space in simulations or virtual-based environments using various virtual experiences. Li et al. [25], through an online virtual museum tour, create a comprehensive evaluation to ensure the effectiveness of important museums. Resta et al. [32] focused on the level of engagement in museums through a virtual museum tour with representation of architectural space, representation of artifacts, and ease of use as potential correlated factors. Stefan et al. [41] proposed a Virtual Learning Environment (VLE) of online 3D platforms as a blended-learning tool for pandemic situations and investigated alternative e-learning solutions within it. Therefore, this study conducted a virtual experiment, based on past exhibitions at the White Cube Gallery in London, with virtual presentation of an exhibition.

This paper conducted a relative comparison of different music tempos on the duration of stay in exhibition spaces. The focus was on the effect of fast or slow music tempos on the duration of stay. However, there may have been inconsistencies in comparing the results obtained from different speakers. Nevertheless, the participants were expected to be comfortable with the sound and visuals of the virtual exhibition. To ensure sound comfort, the participants were asked to adjust the loudness to their comfort level prior to the virtual tour and to keep it constant during the experiment. To ensure visual comfort, the participants were also allowed to choose the model and size of their displays and were not subjected to extremely uncomfortable brightness levels during the virtual tour. These measures were taken to ensure the validity of the relative comparison of the effect of music tempo on the duration of stay.

2.6.6. Statistical analysis

ANOVA, correlation, random forest, decision tree, support vector machine, and the neural network model were the main statistical tests used in this study.

This study used the direct-discarding method to filter out outliers. When the abnormal degree is relatively small in statistics for an entire data set, discarding a relatively small part of the outliers does not cause much loss to the entire data set, and the processing effect is better when the direct-discarding method is used [42]. Prior to using the direct-discarding method, outlier analysis is required. This is a process that determines whether the data set contains input errors or unreasonable values [35]. Commonly used simple statistical analysis methods include the descriptive method [45], quartile method with the 3 σ principle [46], or box plots [42].

Data that captured the participants' duration of stay (s) were automatically collected throughout the experiment for objective evaluation (Section 3.1). Data from the questionnaires that captured the participants' preferences for exhibit elements and music preferences were automatically collected throughout the experiment for subjective evaluation (Section 3.2). Comprehensive objective and subjective assessment (Section 3.3) used data from both objective and subjective sources.

For the objective evaluation of duration of stay (Section 3.1), the effect of music tempo on duration of stay (s) under different variables was mainly explored. Data on participants' duration of stay (s) was collected automatically, and time data recording the duration of their stay was collected and stored in text form after participants left the experiment. A one-way ANOVA, as the main ANOVA method, was conducted using SPSS (Statistical Product Service Solutions).

For the subjective evaluation, participants' music and exhibit element preferences and their perspectives on whether visitor density reached crowded conditions or not were collected. The results were analysed using SPSS 15.0, considering linear and nonlinear correlations with Pearson/Spearman correlations (two-tailed).

The comprehensive subjective and objective evaluations aimed to predict the relationships among the influencing factors and the

duration of the stay. The dependent variables were numerical (duration of stay) and categorical independent variables (participants' music and exhibit element preferences, music preference, exhibit element preference). Since the dependent variable was numerical, and the independent variables were categorical, there were four methods for predicting the relationship between influencing factors and duration of stay; this study compared the four prediction models and selected the one with the highest accuracy for use. The methods were random forest, decision tree, support vector machine, and neural networks. In terms of the accuracy of the prediction model, R was used to compare the four prediction models, and the most accurate model, based on the highest R2 value and lowest RMSE (Root Mean Square Error) value, was chosen.

3. Results

The main aim of the tests in this section was to use objective evaluation to identify whether music tempo affected the duration of stay in the virtual White Cube Gallery environment. Additionally, both objective evaluation and subjective evaluation were used separately to test whether there was a correlation between exhibit element density, visitor density, and the duration of stay. Finally, we combined objective and subjective evaluations to investigate which of the factors influencing the duration of stay exerted the greatest impact.

3.1. Objective evaluation

3.1.1. Effect of fast, medium, slow, and no music tempo on duration of stay

The main aim of Experiment 1 was to investigate whether music tempo affected the mean duration of stay based on objective evaluation. The density of the exhibit elements was considered normal and fully replicated a previous exhibition at the London White Cube Gallery. Each participant toured the entire space individually. The only dynamic variable in this experiment was the music tempo, which was classified according to music theory into three categories: Fast music had a tempo of 120 bpm; medium music had a tempo of 75 bpm; and slow music had a tempo of 50 bpm [16]. To better address the research goal, this experiment also included the no music condition for comparison. There were four scenarios; each scenario had 30 valid data points (participants' duration of stay). In total, 120 data points were analysed. The data referred to the participant's duration of stay.

The test of normality showed that all four scenarios (no music and slow-, medium-, and fast-tempo music) met the normal distribution. The results of one-way ANOVA comparing the no music scenarios and the music scenarios (slow, medium, fast) showed that $p < 0.05$, $F(3, 116) = 14.130$, $\eta 2 = 0.21$. These results illustrated a significant difference in the partial or integrated effect of music tempo on the mean duration of stay.

Furthermore, the results of comparisons of different music tempo scenarios (slow, medium, fast) showed that there were only significant differences between slow and fast music tempo, $p = 0.016 < 0.05$, $F(2, 87) = 4.342$, $\eta 2 = 0.08$. As shown in Fig. 6, the mean duration of stay for the no-music condition was 34.06 ± 19.35 s; for slow-tempo music, it was 88.93 ± 43.36 s; and for fast-tempo music, it was 60.50 ± 31.27 s.

Thus, music affected participants' mean duration of stay in the exhibition space. Furthermore, people tended to stay longer when listening to slow-tempo music compared to fast-tempo music. There were no significant differences between medium-tempo music and slow- and fast-tempo music.

3.1.2. Effect of exhibit element density or visitor density and music tempo on duration of stay

The primary aim of Experiment 2 was to investigate whether exhibit element density or visitor density, in combination with music tempo affected the duration of stay. There were two variables in this experiment: The first variable was either exhibit element density (high, medium, low) or visitor density (single, crowded, uncrowded). One of these two variables was combined with music tempo (fast, medium, slow, none) to test its relationship with duration of stay.

The second variable was music tempo, which was classified into three categories based on music theory: fast, medium, and slow. To better address the research goal, the comparison also included a "no-music" condition. As the previous experiment already covered the case when exhibit element density was medium and visitor density was single with different music tempos, these conditions were not repeated in Experiment 2. Four groups were formed based on the variables (Table 2). Due to the different tempos of

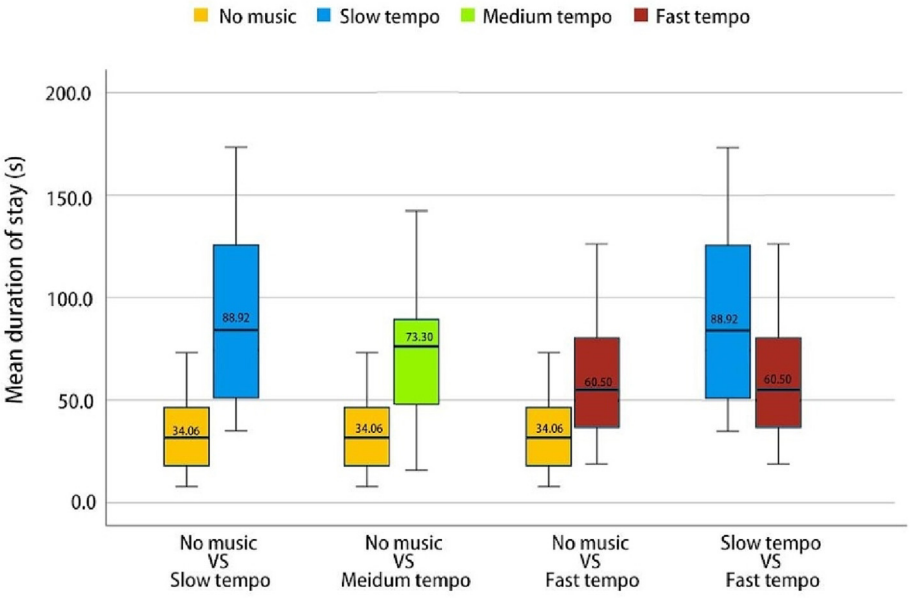

Fig. 6. Mean duration of stay between no music and slow-, medium-, and fast-tempo music.

Table 2
Detailed group variables.

Group variables	Music tempo	Group variables	Music tempo
Group 1:	No music	Group 2:	No music
Exhibit element density (high)	Slow-tempo music	Exhibit element density (low)	Slow-tempo music
Visitor density (single)	Medium-tempo music	Visitor density (single)	Medium-tempo music
	Fast-tempo music		Fast-tempo music
Group 3:	No music	Group 4:	No music
Exhibit element density (medium)	Slow-tempo music	Exhibit element density (medium)	Slow-tempo music
Visitor density (crowded)	Medium-tempo music	Visitor density (uncrowded)	Medium-tempo music
	Fast-tempo music		Fast-tempo music

the background music, each group contained four scenarios (Table 2). As a result, 480 valid data points were analysed in four groups involving 16 scenarios. The data referred to the participants' duration of stay.

Tests of normality were conducted for all four groups, and all met the normal distribution. As a result, a one-way ANOVA was conducted to examine the effects of music tempo on duration of stay when the other variable was exhibits elements' density or visitors' density. Only Group 3 was found to be significant, Sig = 0.0 4 < 0.05, demonstrating that visitor density (crowded) affected participants' duration of stay with different music tempos. In detail, there were significant differences between slow and fast music tempos, F (3, 116) = 4.671, η2 =.10p = 0.004 < 0.05. According to the preliminary results shown in Fig. 7, the mean duration of stay for the visitor density (crowded) condition with slow-tempo music was 89.57 ± 49.04 s and for fast-tempo music was 55.59 ± 30.71 s. Participants' duration of stay was longer with slow-tempo music than with fast-tempo music under visitor density (crowded) conditions.

Notably, only visitor density (crowded) conditions with slow- or fast-tempo music exerted an effect on participants' duration of stay. Under visitor density (crowded) conditions, people tended to stay longer when listening to slow-tempo music than for fast-tempo music. There were no significant differences between visitor density (uncrowded) conditions and participants' duration of stay when music was played at different tempos.

Figs. 6 and 7 are two descriptive presentations of box plots, which are a way of displaying the distribution of a set of data. The whiskers are reasonably large and extend from the box to show the entire range of the data. The ends of the whiskers represent the minimum and maximum values of the data, while any data points outside of the whiskers are considered outliers [24]. Outliers were removed during data processing. We considered the ranges of percentage of whiskers in previous studies, such as Majetic et al. [27], who analysed the box plots of scent emission rates for purple Hesperis matronalis plants grown in common garden environments in terms of (A) aromatics, (B) terpenoids, and (C) total scent, and Cooper et al. [11], who investigated the impact of symbiont type on the lipid fraction ratios of (a) P. speciosa and (b) S. hystrix at South Scott Reef. The percentage of whiskers in these studies commonly ranged from 31.5% to 54.1%, which was similar to the percentage in this study. Therefore, our results appeared reasonable.

3.1.3. Effect of exhibit element density, visitor density, and music tempo on duration of stay based on objective evaluation

The key aim of Experiment 3 was to investigate the combined effects of exhibit element density, visitor density, and music tempo on participants' duration of stay. To achieve this goal, three variables were used. The first variable was exhibit element density, which was classified as high, medium or low. The second variable was visitor density, which was classified as single, crowded, or uncrowded. The third variable was music tempo, which was classified based music theory into three categories: fast, medium, and slow. The comparison included a "no-music" condition to better address the purpose of this study. As the previous experiment had already covered the case when exhibit element density was medium and visitor density was crowded or uncrowded) with different music tempos, this scenario was not repeated in Experiment 3. During the experiment, four groups were formed based on permutations of the variables (Table 3). Each group contained four scenarios due to the varying tempos of the background music

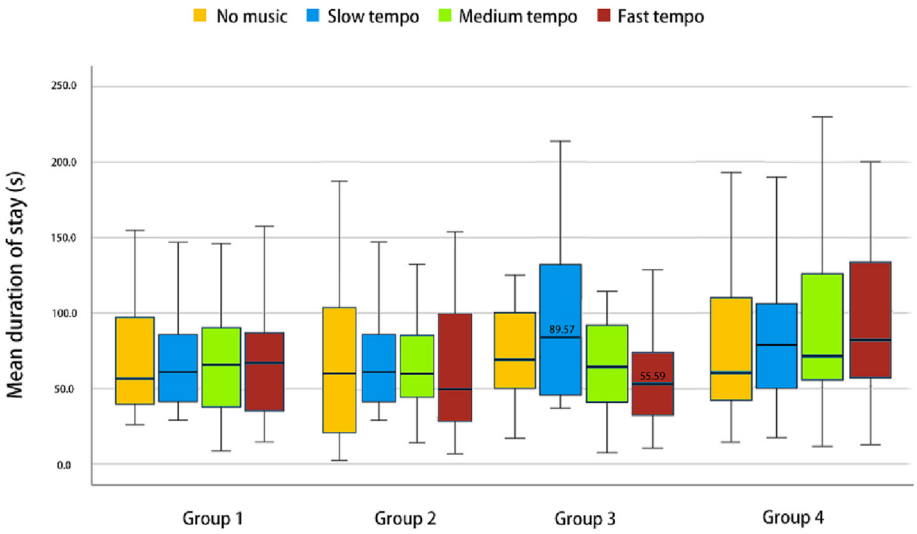

Fig. 7. Mean duration of stay with various music tempos, medium exhibit element density, and crowded conditions.

Table 3
Detailed group variables.

Group variables	Music tempo	Group variables	Music tempo
Group 5:	No music	Group 6:	No music
Exhibit element density (high)	Slow-tempo music	Exhibit element density (high)	Slow-tempo music
Visitor density (crowded)	Medium-tempo music	Visitor density (uncrowded)	Medium-tempo music
	Fast-tempo music		Fast-tempo music
Group 7:	No music	Group 8:	No music
Exhibit element density (low)	Slow-tempo music	Exhibit element density (low)	Slow-tempo music
Visitor density (crowded)	Medium-tempo music	Visitor density (uncrowded)	Medium-tempo music
	Fast-tempo music		Fast-tempo music

(Table 3). There was a total of 16 scenarios, each with 30 valid datasets. As a result, 480 data points were analysed. The data referred to participants' duration of stay.

Normality tests were carried out on Groups 5 through 8, all of which had a normal distribution. For further comparison, a one-way ANOVA (music tempo and duration) (Fig. 8) was performed. Significant differences were found in Groups 5 and 7, $p = 0.003 < 0.05$ and $p = 0.04 < 0.05$, respectively. Groups 6 and 8, in contrast, showed no relationship between the variables, $p = 0.26 > 0.05$ and $p = 0.97 > 0.05$, respectively. Under different music tempos, high/low exhibit element density in visitor density (crowded) conditions were found to affect participants' duration of stay. The duration of stay in Groups 5 and 7 was significantly different between the fast-and slow-tempo groups, $F(3, 116) = 4.951$, $\eta 2 = 0.10$, $p = 0.02 < 0.05$, and $F(3, 116) = 4.700$, $\eta 2 = 0.09$, $p = 0.04 < 0.05$, respectively. As shown in Fig. 8, the mean duration of stay in Group 5 was 66.37 ± 29.75 s for fast-tempo music and 101.64 ± 45.62 s for slow-tempo music. The mean duration of stay in Group 7 was 54.14 ± 33.94 s for fast-tempo music and 89.82 ± 41.94 s for slow-tempo music.

It appears reasonable to assert that when the density of the elements on exhibit was either high or low in a visitor density (crowded) condition, the participants' mean duration of stay was longer when they listened to slow-tempo music than when they listened to fast-tempo music. A second critical inspection of the results revealed that participants' duration of stay under slow- and fast-tempo music was significantly affected by visitor density (crowded) conditions. There was no statistically significant difference between participants' duration of stay and exhibit element density at high or low levels under slow- or fast-tempo music in visitor density (uncrowded) conditions.

3.2. Subjective evaluation

The subjective evaluations primarily included the impact of exhibit elements, music preference, and perception of visitor density (crowded conditions) on duration of stay.

The results were analysed using SPSS 15.0, considering the linear and nonlinear correlations with Pearson/Spearman correlations (two-tailed), as well as the mean differences (ANOVA) for factors with more than three scales.

3.2.1. Effect of exhibit elements and music preference on duration of stay based on subjective evaluation

Previous research has shown that both exhibit element preference and music preference have the potential to influence stay

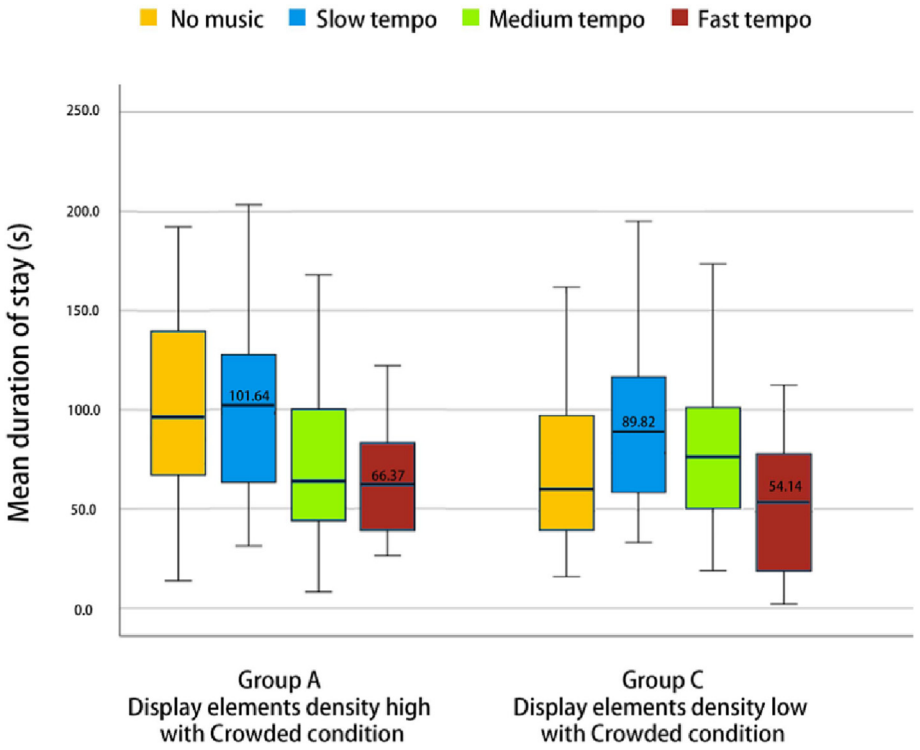

Fig. 8. Mean duration of stay under the combined crowded condition.

duration. Exhibit element preference is an essential index for museum study that affects the duration of stay [44]. Music can distract visitors [8,38], and it is also normally considered an important index affecting the duration of stay.

3.2.1.1. Effect of exhibit elements and music preference under the fast-, medium-, slow-, and no-music tempo scenarios. The aim of this part of the study was to test whether participants' duration of stay was influenced by music and exhibit element preferences under the effect of different music tempos. In this study, 30 participants each in fast-, medium-, slow-, and no-music tempo scenarios (a total 120 participants) were invited to rate their music and exhibit element preferences on scales from quantitative and qualitative perspectives (Table 4). Pearson's correlation analysis was conducted to test the correlation between music and exhibit element preferences and duration of stay.

The results revealed no correlation between quantitative or qualitative exhibit element preferences and duration of stay, $p > 0.05$, with coefficient values of 0.003 and 0.004, respectively. No correlations were found between music preferences and duration of stay (Table 5), $p > 0.05$, with coefficient values of 0.027.

In summary, music and exhibit element preferences had no effect on the duration of stay under the different music tempos (fast, medium, slow, none), which were shown to influence the duration of the stay.

3.2.1.2. Effect of exhibit elements and music preference under exhibit element density or visitor density and music tempo scenarios. This part of the study aimed to test whether participants' duration of stay was influenced by music and exhibit element preferences when the variables were either exhibit element density or visitor density and music tempo. In this study, 16 scenarios were conducted (Table 2). Each scenario required 30 participants. In total, 480 participants were invited to rank their music and exhibit element preferences on scales from quantitative and qualitative perspectives (Table 4).

Pearson's correlation analysis was conducted to test the correlation between preferences and the duration of stay when exhibit element density was high or low and visitor density reached crowded conditions. The results indicated that exhibit element preference (quantitative) was negatively related to the duration of stay, with a correlation coefficient value of −0.119. There were no significant correlations ($p > 0.05$) among exhibit element preference (qualitative), music preference, and duration of stay.

In summary, exhibit element preferences (quantitative) were weakly negatively correlated with duration of stay when exhibit element density was high or low and visitor density reached crowded conditions, while music preference and exhibit element preferences (qualitative) had no effect on the duration of stay under these factors.

3.2.1.3. Effect of exhibit elements and music preference under the exhibit element density, visitor density, and music tempo scenario. This part of the study aimed to test whether participants' duration of stay was influenced by music and exhibit element preferences under the effect of exhibit element density (low, high) and visitor density (crowded, uncrowded). In this study, 16 scenarios were conducted (Table 3). Each scenario required 30 participants. In total, 480 participants were invited to rank their music and exhibit element preferences on scales from quantitative and qualitative perspectives.

No significant correlation ($p > 0.05$) was detected among exhibit element preferences (qualitative or quantitative), music preference, and duration, with coefficient values of 0.030, −0.030, and −0.023, respectively.

In summary, exhibit element preferences and music preferences exerted no influence on the duration of stay under exhibit element density of either low or high and visitor density of either crowded or uncrowded.

3.2.2. Visitor density evaluation

Given the lack of a definition of what constitutes crowded visitor density conditions in the literature, the subjective evaluation used a questionnaire to define participants' views of when visitor density reached a crowded condition. Participants were asked to rate on a five-point scale the level of perceived crowdedness in the space: 1. Fully crowded, 2. Somewhat crowded, 3. Neither crowded nor uncrowded, 4. Somewhat uncrowded, 5. Fully uncrowded (Groups A, B, C, D, Groups 3 and 4).

This evaluation aimed to test whether participants felt crowded in the corresponding conditions. According to the data analysis (Fig. 9), over 73% of participants felt crowded when visitor density reached the crowded condition. Therefore, participants felt crowded in the corresponding conditions.

3.3. Subjective and objective assessment

This section presents the testing methods and experimental results and assesses the model outcomes from a quantitative perspective. Comprehensive subjective and objective assessment was essential to validating the reliability of the machine learning model outputs.

Table 4
Factors considered in the measurements and subjective evaluation.

Factors	Measures of the attributes
Exhibit element preference (quality)	Scale of 1 to 5: 1, fully like; 2, somewhat like; 3, neither like nor dislike; 4, somewhat dislike; 5, fully dislike
Exhibit element preference (quantity)	%, scale of 1 to 5: 1, 100%; 2, 75%; 3, 50%; 4, 25%; 5, 0%
Music preference	Scale of 1 to 5: 1, fully like; 2, somewhat like; 3, neither like nor dislike; 4, somewhat dislike; 5, fully dislike
Visitor density reaching crowded conditions level	Scale of 1 to 5: 1, fully crowded; 2, somewhat crowded; 3, neither crowded nor uncrowded; 4, somewhat uncrowded; 5, fully uncrowded

Table 5
Experimental results of the random forest, decision tree, support vector machine, and neural networks.

Dataset length: 1080	Random Forest Model	Decision Tree Model	Support Vector Machine Model	Neural Networks Model
70/30 train and test split average over 10 random splits (randomness determined with seeds) Leave 10 out cross-validation	R^2: 0.21 RMSE: 38.09	R^2: 0.04 RMSE: 41.95	R^2: 0.07 RMSE: 41.18	R^2: 0.07 RMSE: 41.18

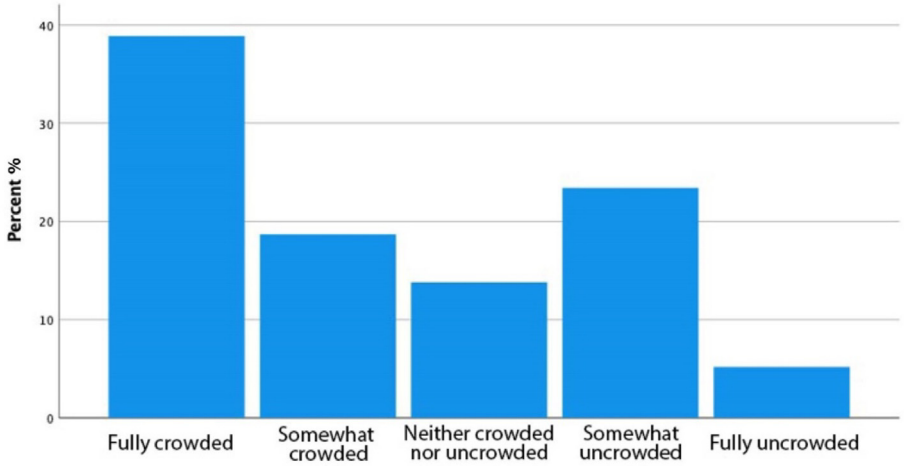

Fig. 9. Overall percentages identifying crowded conditions.

3.3.1. Effect of music tempo, exhibit element density, visitor density, exhibit element preference, and music preference on duration of stay

There were many factors that could affect the duration of stay; therefore, four prediction models were selected to determine the most accurate: random forest (RF), decision tree, support vector machine, and neural networks.

The experimental results from the four models used to validate the participants' duration predictions are shown in the following table:

As shown in Table 5, the predictive power of the feedforward RF was superior to the rest of the models based on its higher R^2 value and lower RMSE value. A minimum R^2 value of 0.21 and RMSE of 38.09 for accurately predicting the duration of stay seemed subjectively acceptable, which indicates an improvement over 0.21 in the case of an RF model. Comparison of the four models indicated the highest accuracy for the RF model. Therefore, an RF was chosen as the prediction model for the data.

An RF model features importance scores that simply represent the "importance" of each feature. A higher score means that the specific feature will have a larger effect on the model that is being used to predict a certain variable. Therefore, based on the importance of the variables, it was concluded that for the RF model, the most important variable affecting participants' duration of stay in exhibition spaces was music tempo.

An RF is a classification algorithm consisting of many decision trees. The qualitative relationship between influence factors (subjective and objective) and duration can be explained through a decision tree model (Fig. 10).

The decision tree (Fig. 11) indicated that the mean duration of stay was 75 s. If the participant were to visit the exhibit space alone, there was a 33% possibility that the average duration of their stay would be 66 s. If the participant chose to tour the exhibit space with others; the music condition was medium-tempo, fast-tempo, or no music; and the quantitative exhibit element preference for the entire exhibit was 0%, 50%, or 75%, then there was a 35% probability that participants' average duration of stay would be 70 s. In contrast, when the qualitative exhibit element preference was 25%, there was a 15% possibility that the participant's average duration of stay would be 85 s. If the participant toured the exhibit space with others while listening to slow-tempo music, and the quantitative exhibit element preference for the entire exhibit was 100%, there was a 1% possibility that the participant's average duration of stay would be 41 s. In contrast, when the quantitative preference was 25%, there was a 16% possibility that the participant's average duration of stay would be 96 s.

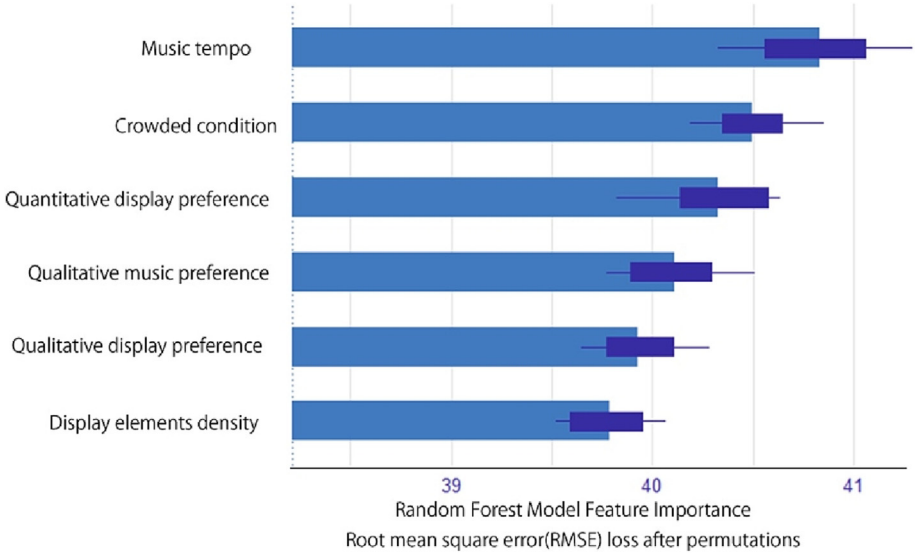

Fig. 10. Important measures for each variable affecting duration of stay using a Random Forest model.

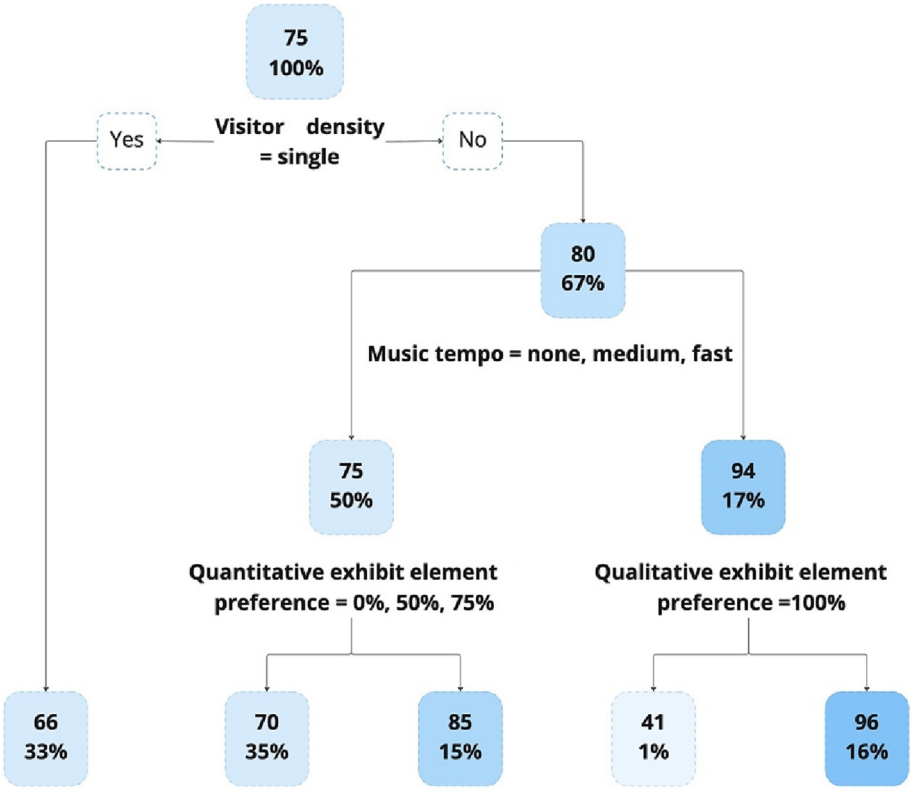

Fig. 11. Decision tree fitted on participants' duration data.

4. Discussion

As mentioned in the literature review, music tempo has mainly been shown to influence the duration of stay in a commercial context [28,31,39]. However, there has been a lack of further research in the exhibition space context and scarce systematic analysis of the interference of other factors on the duration of stay.

Therefore, this paper aimed to conduct an in-depth study of the relationship between music tempo, other factors, and duration of stay in exhibition spaces. It sought to offer a more comprehensive and systematic analysis of the surrounding environmental factors and visitor preferences to verify the influence and importance of music tempo on duration of stay.

4.1. Effect of music tempo (fast, medium, slow, none) on duration of stay

Prior studies have noted the importance of music tempo on duration of stay, but not in a museum context, and research has overlooked the impact of participants' preferences on duration of stay in this process. The present study was designed to examine and fill the gaps related to these questions. The two questions were investigated through objective and subjective evaluations, which showed some contradictions in the results. The tempo of the music affected the duration of stay, while music preference and exhibit element preferences did not.

The relationship between music tempo and duration of stay in the exhibition space context showed up mainly through objective evaluation (Section 3.1.1). A number of previous studies have indicated that music tempo has no effect on the duration of stay in all locations [39]. The findings of this study confirm that music tempo is associated with the duration of stay in exhibition spaces. Specifically, participants tended to stay longer when listening to slow-tempo music rather than fast-tempo music, although there were no significant differences between medium-tempo music and either slow or fast-tempo music, which was also indirectly reported by Webb [43] and Soh et al. [39] in a commercial context.

Evidence of the impact of participants' preferences on the duration of stay has been lacking in all previous studies. Nevertheless, participants' preferences are important because, as mentioned in the literature, music preference [5,7,43] and exhibit element preference [4,37] can indirectly influence the duration of stay. This study conducted a subjective evaluation through questionnaires based on the Likert scaling method [1]. Music preferences and exhibit element preferences (from both quantitative and qualitative perspectives) were scored and analysed in a rational and scientific way. One unanticipated result was that participants' music preference exerted no impact on duration of stay in this process, which was contrary to previous studies. One reason for this difference could be that music tempo plays a more important role in this context, thereby diminishing the effect of participants' preference on the duration of stay.

4.2. Effect of exhibit element density, visitor density, and music tempo on duration of stay

Several studies were found in the literature on the question of whether exhibit density or visitor density factors or participants' preference affect the duration of stay under varying music tempo conditions. However, prior studies have noted the important impact of visitor density, such as crowded conditions [3,34], exhibit element density [2,36], and participants' music and exhibit element preferences [37,43], etc. on the duration of stay. To fill these gaps, this study tested and analysed when the exhibit element density and visitor density either separately or together affected duration of stay, through subjective and objective analysis. When

visitor density reached crowded conditions with medium exhibit density and music tempo (fast, medium, slow, none), and exhibit element preferences influencing the duration of stay.

Firstly, the effect of exhibit element density and visitor density on duration of stay was analysed through the objective evaluation. This approach to analysis was not only comprehensive but also strictly variable. The results clarified the relationship between music tempo and duration of stay in different contexts when exhibit element density and visitor density were considered separately or together, aligning with results reported by Bitgood [2] and Sandifer [34]. However, these previous studies only speculated that crowd behaviour would vary depending on crowded conditions and did not test and validate a particular crowd behaviour, such as duration of stay. This study controlled variables in the testing process to more accurately discern the effect of exhibit element density and visitor density on duration of stay.

Participants' preferences, as a necessary auxiliary factor, were the key to analysing the relationships among music tempo, duration of stay, exhibit element density, and visitor density. Previous studies have only shown the impact of participants' preferences, such as music preference [5,7,43] and exhibit element preference [4,37], on the duration of stay. Previous research has lacked specific details on how and the conditions under which participants' preferences affect duration. In this study, participants' preferences were obtained through subjective evaluations (Sections 3.2.1.2 and 3.2.1.3) and were integrated with the objective evaluation of the influence of exhibit element density and visitor density on the duration of stay to obtain more accurate and comprehensive results. The results showed that participants' exhibit element preferences did not influence the duration of stay in all scenarios, only in the case of exhibit element density being high or low with a single participant and any music tempo (fast, medium, slow, none), and visitor density reaching crowded or uncrowded conditions with medium exhibit density and any music tempo (fast, medium, slow, none). A possible explanation for this might be that participants' attention was limited, and increased stimulation from the exhibit element density and visitor density thus decreased participants' attention to their exhibit element preferences and music preferences.

4.3. Effect of all influencing factors (exhibit element density, visitor density, music tempo, exhibit element preference, music preference) on duration of stay

Previous studies on the effect of music tempo on the duration of stay have rarely examined the effect of other factors on the duration of stay. The present study was designed to determine the most impactful factor on the duration of stay, which the results showed was music tempo.

This paper examined the impact of a comprehensive set of factors on the duration of stay. Very little was found in the literature that considered other potential factors than music tempo in relationship with the duration of stay. Several studies have considered the individual's emotions [39], different types of shops [39,31], and musical articulation [28]. This paper considered exhibit element density, exhibit element preferences, visitor density, and music preferences, which are the factors most likely to indirectly influence the duration of stay. Testing the effects of diverse variables on duration can provide more comprehensive knowledge of the factors besides music tempo that influence duration of stay.

Furthermore, statistical analysis methods can be used to evaluate variable importance and identify the most influential factor on the duration of stay. Previous studies have mostly conducted correlation analyses to determine the influence of individual factors on duration of stay, such as music articulation [28] and individuals' emotions [39]. Correlation allows for easy analysis of the effect of a single factor on the duration of stay, but its depth and accuracy are limited for combinations of factors and further discussion of relationships between the variables and duration of stay. This study examined four types of statistical analysis methods, and from them a statistical analysis method was selected as the most accurate method for evaluating the importance of factors to the duration of stay.

4.4. Limitations

This study suggests a number of possibilities for future research. First, this study primarily considered music tempo, exhibit element density, visitor density, music preferences, and exhibit element preferences factors; additional research is needed on other types of factors, such as participants' psychological perspectives. Second, although the relationships among music tempo, exhibit element density, visitor density, music preferences, exhibit element preferences factors, and duration of stay were identified, the causality of these relationships was not discussed due to a lack of other comprehensive information about participants. More data on participant characteristics, such as sex, habits, and other factors, could help researchers better understand the causality and motivation of participants' behaviour. Third, the present study considered only one style of exhibition space. Additional studies based on other scales are required to develop a comprehensive understanding of the duration of stay. For instance, diverse exhibition space styles could be used to examine the impact of architectural layout type on the duration of stay, and how diverse exhibition space layouts could help investigate the influence of spatial arrangement on the duration of stay. However, given the nature of this study, the lack of such data did not bias the primary investigated variable or results. Finally, as each participant performed the experiment in a space of their choice, the environment they were in could have had an impact on the results. In addition to this, although they were required to wear headphones for this experiment, it was not possible to verify and prove whether they did wear headphones or not. This may have influenced the results. However, as the experiment was conducted with over 1000 participants, these errors and effects can be minimised but not eliminated if the sample size is large enough.

Overall, these limitations are the price that this study pays for attempting to solve a significant methodological problem by providing an authentic experience.

4.5. Application

This study revealed the relationship between music tempo, exhibit element density, visitor density, exhibit element preferences, and visitor preferences in a virtual exhibition space. The first direction of the application is discovering the relationship between other factors and duration of stay in the virtual exhibition space. As this study used a controlled environment, it can serve as a prototype for developing a real-time and expandable virtual exhibition space based on the curator's focus: Other elements can be added to this virtual exhibition space. Additional elements can also be added to this model to obtain more comprehensive and complete results. For instance, if the curator wants to know the effect of scent on the duration of stay in a perfume exhibition in which different spaces have different scents, scent could be an influencing factor to be included in the virtual exhibition space. Furthermore, these findings can assist exhibition curators' or stakeholders who have a certain requirement for duration of stay in intervening in

exhibit element density, visitor density, music preference, and exhibit element preference to achieve their desired results. For example, if a virtual exhibition has a high visit volume, based on the study findings, the virtual exhibition spaces could be modified to assist curators and exhibition organisers in better controlling crowds so that visitors enjoy a better experience.

5. Conclusions

Based on measurements and questionnaire surveys conducted regarding virtual museum exhibition spaces, the effect of music tempo on visitors' duration of stay in the exhibit and the influence of other environmental context factors were evaluated. Overall, the experiments reported in this paper led to three main conclusions.

Participants stayed approximately 30 s longer with slow-tempo music than with fast-tempo music, and participants' preferences did not influence this result.

Regardless how many variables existed in the music tempo, exhibit element density, and visitor density, as long as visitor density reaches a crowded condition, fast- or slow- tempo music will exert an impact on the duration of stay. Furthermore, in the case of the effect of exhibit element density or visitor density and music tempo on participants' duration of stay, exhibit element preferences will also exert an impact on the duration of stay.

Music tempo exerted the greatest impact of all factors (music tempo, exhibit element density, visitor density, music preference, exhibit preference) on participants' duration of stay.

Taken together, the findings of this study revealed the relationship between music tempo, exhibit element density, visitor density, exhibit element preferences, and music preferences in a virtual exhibition space. The space not only can serve as a prototype for developing a real-time and expandable virtual exhibition space based on the curator's focus; other elements can be added to this virtual exhibition space. Also, however, it can assist exhibition curators or stakeholders who have a certain requirement for duration of stay to intervene in the factors above. Further research on other types of factors is needed to develop a comprehensive understanding of participants' duration of stay, and the causality of these relationships also needs to be discussed.

CRediT authorship contribution statement

Xiaoduo Xu: Conceptualization, Methodology, Software, Data curation, Visualization, Investigation, Formal analysis, Project administration, Writing - original draft. **Ava Fatah gen. Shieck:** Supervision, Validation, Writing – review & editing. **Jian Kang:** Supervision, Validation, Writing – review & editing. **Ifat Yasin:** Supervision, Validation, Writing – review & editing.

Data availability

The authors do not have permission to share data.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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