Autonomous sensory meridian response as an alert trigger for older users

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Abstract: Approximately one in three people in the aging population have hearing problems. This article examines that the (ASMR) sounds can be used as a trigger in autonomous sensory meridian response older users as an auditory-tactile sense. The authors conducted a survey with 45 subjects and asked them to report the location the tingling sensation after listening 16 ASMR sounds. Then 40 elderly subjects participated in the performance experiment with Sudoku puzzle. From the survey, the results show that all ASMR sounds affect the upper part of the human body. There is no significant difference in reaction time, hit rate, and miss rate among the three representative sounds. The ASMR is effective in terms of alert since the average hit rates of all subjects are very high compared to the miss rate. The electric toothbrush and liquid sound were the most alertness and pleasantness, respectively.

Keywords: autonomous sensory meridian response; ASMR; alert; experiment; elderly; reaction time; signal detection theory; SDT; tactile; sounds; triggers; tingles.

Reference to this paper should be made as follows: Buaban, N. and Teeravarunyou, S. (2022) 'Autonomous sensory meridian response as an alert trigger for older users', *Int. J. Human Factors and Ergonomics*, Vol. 9, No. 4, pp.389–401.

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1 Introduction

By 2050, the world's population of people aged 60 years or over will be 2.1 billion (Weil, 2015). High proportions of the elderly are living isolated in developed countries. As a result, they need to independently work or live. Age-related hearing loss (ARHL) refers to the physiological change when age increases (Patel and McKinnon, 2018). The hearing loss is on the high-frequency sound. The normal human hearing includes frequencies between 20 Hz to 20,000 Hz. Hearing loss is highest at frequencies greater than or equal to 2,000 Hz (Nirmalasari et al., 2017). In this research, the focus is on the alert sound that can alert an important event but not critical like alarm or reminder like notification. The purpose of the alert is to get audience attention and promote a quick response. For example, the alert sound is appropriated for internet of the things (IOT) such as the WI-FI kettle, smart washing machine and smart doorbell. Since the ASMR is an auditory tactile or auditory-emotional correlation (Smith et al., 2020), it has a potential to be the alert sound. The investigation is on how ASMR can assist aging in terms of auditory-tactile. The elderly population encounters cognitive decline in hearing loss and visual impairment. While older adults' physical and cognitive performances are decreasing, the most prevalent cause of hearing impairment is ARHL; poor or impaired conditions affect around two-thirds of those aged 70. More than half of all citizens with hearing loss in the United States are over the age of 70 (Tu and Friedman, 2018). An existing study on the ability to capture attention in the elderly suggests that the implication of the modality must carefully be applied, due to cognitive aging (Andrés et al., 2006). Older adults are slightly easier to distract and appear to be slower to respond to the sound stimulus when other irrelevant information is presented.

ASMR refers to a typical sensory phenomenon that includes tingling sensation and automatic response to a specific sensory stimulus such as audio and visual (Barratt et al., 2017). It elicits certain sensations accompanied by relaxation, mood changing, and inducing sleep (Barratt and Davis, 2015). Among all the types of ASMR, most are audio-visual videos, whispering, and finger tapping. Unlike other regular sounds, ASMR can bring on complex emotional experiences and tingling sensations from ticklish feeling on the crown of the head to shivers-down-the-spine. ASMR sound has low, middle, and high-frequency bands. The low-frequency band affects the body and the high-frequency band is gradually dropped to minimise the mental stimulation (Ahn et al., 2019). Researchers tested subjects with ASMR sound and interviewed the subjects (Koumura et al., 2020). They discovered that the ASMR-induced tingling sensation occurred in parts of the body that had a tickling sensation as well as a pleasant sense. The study from the research showed that emotion and physiology related to the ASMR response (Poerio et al., 2018). It is associated with skin conductance levels and heart rate. The ASMR clips caused subjects' heart rates to drop and their skin conductance to rising. The ASMR reed wind sound also reduced the blood pressure after hearing (Ahn et al., 2019). ASMR is appropriate for the elderly especially for those with the hearing loss problems since the ASMR sound has a lower frequency and capture attention. The physiological trigger relates to the brain area. Researchers reported deep relaxation and pleasure on ASMR. Sometimes, it is called brain tingles or brain orgasms. According to the study, lower-pitched and complex sounds are good triggers. The previous study of elderly and alert concerns the auditory-visual while using driving simulator for 30 minutes with five trials in every five minutes. The result shows that the effect of alert system improves the arousal and awareness (Hong et al., 2012). Tactile sensing is the human sense of

touch by using sensory information and contributing to various sensations on human perception such as vibration, pressure, and skin deformation (Poerio et al., 2018). For example, the haptic seat for automated driving projects spatial information on approaching vehicles. The seat led to faster reactions when changing lane (Frid et al., 2019). When processing information, the users face sensory stimulation from signals sent by the system. Responses to each stimulus are differed, depending on individuals' ability to perceive and react. Younger adults and teenagers are more familiar with technology and have no difficulties. At the same time, older adults may face frustration and obstacles.

Multimodality refers to more than one stimulus presented at the same time. It is a combination of several sensory channels including vision, hearing, and touch (Frid et al., 2019). The multimodal feedback is remarkably effective and seemingly suitable for the elderly. There is still no research on using ASMR as an alert to deliver auditory and tingling sensations. This study aims to explore the following research questions. Which is a part of human body that has tingling effect the most? Which ASMR sound increases the elderly performance such as reaction time and hit rate? Do the elderly prefer the sound related to emotion?

2 Methodology

Since this study focused on exploring the effects of ASMR sounds on the elderly, the experiment was designed and implemented. The procedures had two parts. First, the ASMR questionnaire was about a tingling sensation for subjects who might not have experienced ASMR before. The investigation is on other parts of the body besides the ear. ASMR investigation is beneficial in terms of nerve location in a tingling sensation. The ASMR sound affects two nerves. First is the vestibulocochlear nerve with two components: the vestibular nerve and the cochlear nerve. The cochlear nerve helps with hearing the frequency and magnitude of the sound. Damage to the cochlear nerve may cause endocochlear deafness. The second one is the vagus nerve which provides sensation to the outer part of the ear, throat, heart, and abdominal organs (Benoudiba et al., 2013). The investigation is on how the elderly who might have hearing loss still function with the tingling sensation, so it is good to build the reference points in which ASMR locates best.

Second, the elderly have hearing loss more than other age groups. ASMR could be a good candidate for testing a group of elderly. Some of the ASMR sounds might capture attention differently. Moreover, the ASMR sound is related to the emotional part which might be related to the preference for sound. In this study, the focus is on the tingling effects rather than the emotion like the traditional ASMR research. They were asked whether they had encountered any of three stimuli. The measurement was on the elderlys' performance on the reaction time, signal detection theory (SDT) and satisfaction.

2.1 Tingling location

2.1.1 Subjects

Forty-five subjects participated in this questionnaire. The subjects' ages varied from 16 to 66 years (mean age 37.3 years), and 28 were women. Approval was granted by the Ethics

Committee of King Mongkut's University of Technology Thonburi (Approval number: KMUTT-IRB-COE-2021-093).

2.1.2 Procedure

In order to define the location of the tingling sensation associated with ASMR, subjects were asked to report where on their body they felt tingles for 16 sounds. The sound generated with a 3Dio binaural microphone was a 3D sound that could be heard independently and simultaneously in both left and right ears. 3Dio binaural microphone was connected with the zoom H1n handy recorder. The questionnaire was designed to investigate the levels of tingling sensation caused by ASMR sounds across the sampling of the population. The questionnaire contained a set of questions that aimed to gather information on individuals' experiences towards particular ASMR sound types, levels of ticklish sensation, and feeling or emotions they felt against each sound. The 16 sounds were:

1 typing keyboard
2 applying toothbrush on an object
3 applying toothbrush on ears
4 liquid sound
5 scratching object
6 electric fan
7 air pumper
8 ear picking
9 shaking medicine bottle
10 scissor cutting paper
11 electric toothbrush
12 hand cupping ears
13 crisp sound
14 tapping on ears
15 machine
16 white noise.

The stimulus sound types were randomly selected. Some of them were created by using the 3Dio binaural microphone with surrounding objects such as a keyboard, electric toothbrush, paper, fan, and others. Some sounds were loaded from the Internet such as the white noise sound and machine. When they finished each sound, they reported where the location of tingling sensation freely. The answer of each location was calculated with the descriptive analysis by using the percentage with an exclusion of no tingling sensation. Thus, the descriptive analysis was conducted on frequency of tingling location.

2.2 Performance measurement

Subjects were experimented with three ASMR sounds that affected the elderly's reaction time and alertness while carrying out the given tasks. The representative of sound was liquid, white noise and electric toothbrush from 16 sounds. Although the elderly showed poorer performance relative to executive function tasks relative to younger ones (Zelazo et al., 2004), it is interesting to see how ASMR sounds could alert them when they performed. The measurement procedure was on the reaction time and a SDT. Reaction time was the duration between an alert signal and a tablet screen tapping. The focus was on how fast the subject performed. Over a wide range of detection performances, SDT predicted a quantitative link between stimulus detection and stimulus identification. When they played with Sudoku, they might have a chance to miss the sound alert.

2.2.1 Subjects

Forty elderly participated in this experiment through words of mouth. Since the focus of this study was explicitly on the elderly, subjects with ages ranging from 55 years and over were selected (mean age = 59.3, min = 55, max = 68). Subjects rated the questionnaire of hearing loss (Monterey Better Hearing Check, 2022). Four subjects are highly hearing loss and eight subjects are moderate hearing loss. The rest is normal. Fourteen subjects were male. Subjects were Thai native speakers. Each participant was given $15.23 as an incentive for participating in the experiment.

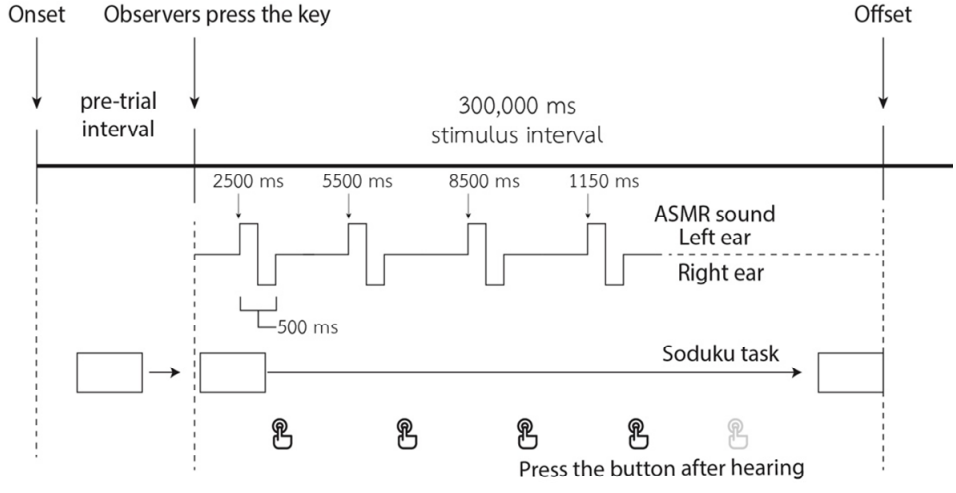
2.2.2 Procedure

The experiment consisted of three parts with the preparation and orientation to the subjects. Participants first received an informed consent form to read and sign. Then subjects were tested with the three sounds. The last step was the questionnaire and semi-structured interview. The order of sound stimulus played in each session was randomly selected. Sudoku was the primary task that required concentration and problem solving to finish the puzzle. For this experiment, subjects were told to concentrate on Sudoku task and collect the score, so they did not focus on the ASMR sound too much. Subjects had a time to familiar with the Sudoku puzzle and tapping on tablet before experiment. Sudoku had been used for the experimental task to draw the continuous attention of the participants while listening to the background music before (Van der Zwaag and Westerink, 2012). Sudoku task had been used for the study of mental exercise and cognitive aging. It involves executive function such as planning and supervision of attention (Grabbe, 2011). As a result, it is appropriate to use the Sudoku with ASMR sound.

Each test consisted of one easy-level Sudoku puzzle and one type of ASMR sound stimuli (liquid sound, electric toothbrush, and white noise), see Figure 1. Three sounds repeated in the same pattern. The time sequence of each wave sound started when the observer pressed the key. The Sudoku puzzle for each round was randomly assigned; therefore, subjects were given a new puzzle for each session. The sounds design was identical in volume (60 dB). Subjects were then given 6 minutes for each session to play an easy-level of Sudoku puzzle, while waiting for sound stimuli which would come out every 30 seconds, in a total of 10 times in each set. The first wave sound started at 2,500 milliseconds with a sound length of 500 milliseconds. For each earphone, subjects

listened to the sound of both the left and right ear since it showed the dynamic movement of ASMR. Every time the ASMR sound was alerted, the subjects had to tap on the provided tablet screen in order to record their responses to the sound. The reaction time of each response was calculated from the average time of all subjects in each experimental task.

Figure 1 Experimental stimuli with time interval of ASMR sound



The SDT is used to analyse data coming from experiment where subjects tap on the tablet before next stimulus come. If subjects can detect the sound, it indicates the presence of hit (the signal). No response given to a sound called Miss. The probability of P{Hit} and P{Miss} equals to 1 (Abdi, 2007).

2.3 Satisfaction

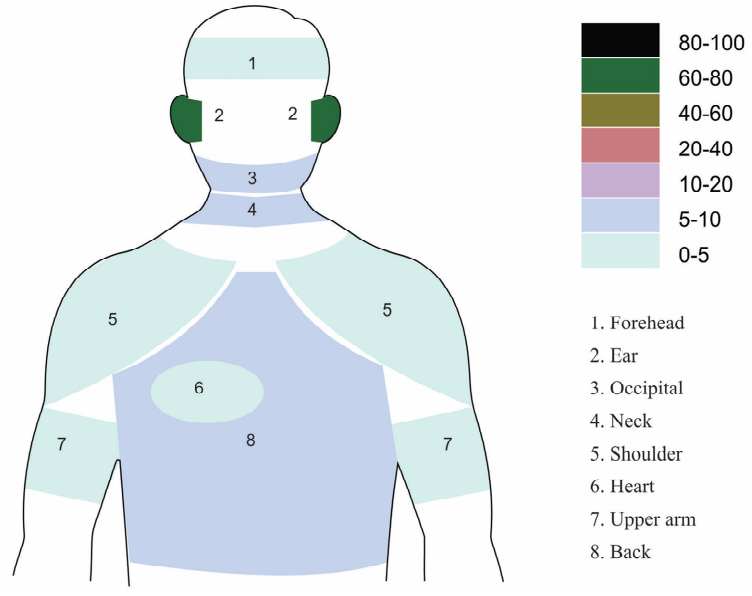
After the experiment, subjects rated two questions related to their preference. One is an alertness ('which sound alerted you the most?') and another one is the preferred sound ('which sound do you prefer the most?'). The first question is setup to check the effective of sound and the second question is to check which emotional sound fits to them. Subjects were asked to indicate the satisfaction level from 1 to 7, using a likert scale, with 7 representing high satisfaction score.

3 Results

3.1 Tingling location

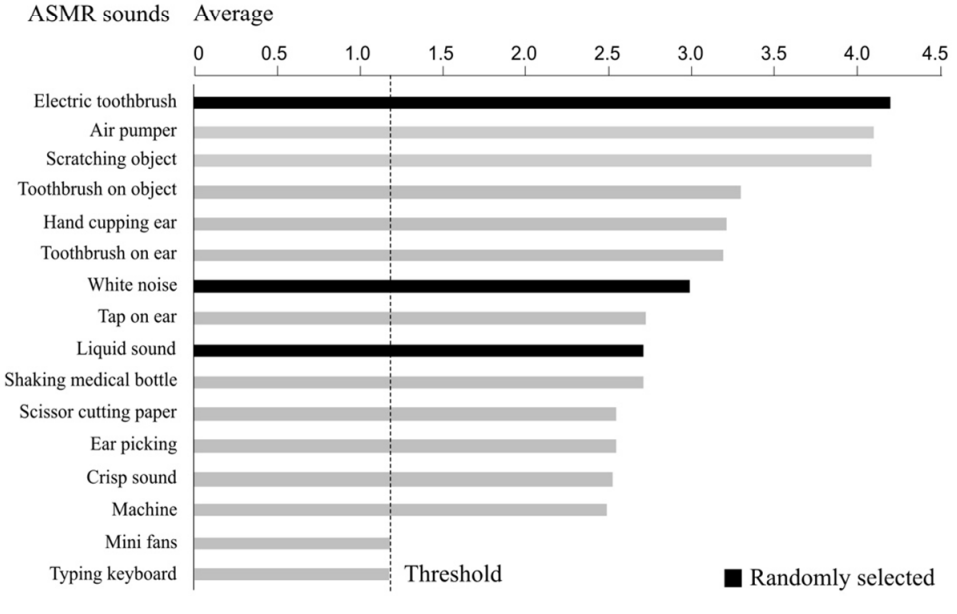
Subjects reported most of the areas that they felt were the upper part of the body. A tingling sensation started from the ears, went down the spine, and occasionally spread out toward the shoulders and arms.

Figure 2 Heatmap associating tingling sensations to a back side of body region (see online version for colours)



Note: The score excludes the no-feeling responses.

Figure 3 Line graph illustrating average of ASMR sounds from rating scales



After subjects listened to 16 sounds, the result from the self-report shows that the most sensitive organs are ears (70.1%), neck (7.74%), occipital (7.31%), back (7.1%), shoulders (4.95%), and others (3.95%) respectively from all sounds, see Figure 2. One

participant reported the lower part of the body. 28 of 45 reported that the air pumper sound affects the ear, while 13 subjects reported that the applying toothbrush on objects affects the back. Fewer than five subjects described that less sound affected their shoulder, occipital, and heart. In most cases, the ASMR sound affects the ear the most. When asking subjects to rate the tingling sensations from 1 to 7 likert scale, they ranked the electronic toothbrush (M = 4.24, SD = 2.19), the air pumper (M = 4.13, SD = 2.31), and the scratching object (M = 4.13, SD = 2.04) the most.

When asked how subjects feel tingling sensation or vibration on their bodies by ranking from 1 to 7. There are 14 sounds over the threshold that was mode as a central tendency which is 1.18 from 7. Then researcher randomised three representative sounds from 14 sounds (see Figure 3). They were liquid sound (M = 2.7, SD = 1.96), white noise (M = 3.02, SD = 2.03), and an electric toothbrush (M = 4.24, SD = 2.19).

3.2 Performance measurement

3.2.1 Reaction time and hit/miss rate

The reaction time was the lap-time that subjects pressed after hearing the sound while working on the Sudoku puzzle.

Table 1 Reaction time and hit/miss rate of three sounds

	Reaction time (msec.)	*Hit rate*	*Miss rate*	*False alarm*	*Correct rejection*
Liquid sound	2,415	0.96	0.04	0.3	0.7
White noise	2,247	0.96	0.04	0.36	0.44
Electric toothpaste	2,279	0.95	0.05	0.4	0.6
Average	2,314	0.96	0.04	0.35	0.58

There was no significant difference in reaction time on three sounds with a 95% confidence level for the three conditions $F(2, 117) = 0.28$, $p = 0.756$. The mean score for the liquid sound (M = 2,415 *msec*, SD = 877), the white noise (M = 2,247 *msec*, SD = 1,342), and the electric toothbrush (M = 2,279 *msec*, SD = 904) did not have any significant difference for all sounds (see Table 1).

According to SDT, the hit rate, miss, and false alarm data were collected when subjects responded to the tasks. Initially, these data were collected in order to investigate that when three sounds were compared, which one would lead to a higher hit rate with fewer misses and false alarm. However, the results of the hit rate from each sound were not significantly different. There was no significant difference in hit rate on three sounds with a 95% confidence level for the three conditions $F(2, 117) = 0.23$, $p = 0.796$. The mean score for the liquid sound (M = 9.68, SD = 0.57), the white noise (M = 9.65, SD = 0.70), and the electric toothbrush (M = 9.55, SD = 1.22) did not have any significant difference for all sounds ($p = 0.796$). Similar to the hit rate, there was no significant difference of miss rate on three sounds with a 95% confidence level for the three conditions $F(2, 117) = 0.34$, $p = 0.715$. The mean score for the liquid sound (M = 0.33, SD = 0.57), the white noise (M = 0.35, SD = 0.70), and the electric toothbrush (M = 0.48, SD = 1.22) did not have any significant difference for all sounds ($p = 0.715$). The false alarm was not significant as well ($p = 0.512$). On the other hand, the probability of hit

rate compares with miss rate is 0.96 per 0.04 (see Table 1). When combining all probabilities of three sounds in one group. There was a significant difference in the scores for hit rate (M = 9.63, SD = 0.87) and miss rate (M = 0.38, SD = 0.87); t(119) = 58.26, p = 0.00. In the same way, there was a significant difference in the scores for false alarm (M = 0.33, SD = 0.76) and correct rejection (M = 9.68, SD = 0.76); t(119) = –66.66, p = 0.00. This indicates the qualification of ASMR as an alert sound. Moreover, the probability of a false alarm compared to a correct rejection is 0.35 per 0.58. This indicates that subjects did not miss the signal. Liquid sound (0.7) and electric toothbrush (0.6) had higher correct rejection than the white noise (0.44). The result indicates that the white noise is not good to identify non-signals well, since the sound is similar to the surrounding ambient.

Despite the different nature of the three sound groups, the average hit rate was stably high. Since the tingling sensation-induced ability of ASMR sound was similar to haptic feedback, the stimulation from the phenomenon was beneficial in terms of alertness with bare distraction from the task at hand.

3.3 Satisfaction

The result of satisfaction shows that subjects ranked the electric toothbrush for the most alertness Table 2. Subjects gave the reason that the electric toothbrush sound can tingle them, but the sound is annoying. On the other hand, they preferred the liquid sound the most because of its pleasantness. There was a significant difference of alertness at the p = 0.00 level for the three conditions F(2, 117)=24.47, p = 0.00.

Table 2 Difference in mean scores between three groups with a one-way ANOVA

		Sum of squares	*Df*	*Mean square*	*F*	*Sig.*
Alertness	Between groups	60.72	2	30.36	24.47	0.00***
	Within groups	145.15	117	1.24		
	Total	205.87	119			
Preferred sound	Between groups	36.32	2	18.6	11.73	0.00***
	Within groups	181.15	117	1.55		
	Total	217.47	119			

Note: *** Significant level at 0.01.

Post-hoc comparisons using Fisher's LSD test indicated that the mean score for the electric toothbrush (M = 3.8, SD = 1.29) was significantly different from the liquid sound (M = 2.07, SD = 1.05) see Table 3. However, the white noise (M = 2.88, SD = 1.20) did not significantly differ from the liquid sound. There was a significant difference of preferred sounds at the p = 0.00 level for the three conditions F(2, 117) = 11.73, p = 0.00. Post-hoc comparisons using Fisher's LSD test indicated that the mean score for the liquid sound (M = 3.3, SD = 1.33) was significantly different from the electric toothbrush (M = 2.0, SD = 1.29). However, the white noise (M = 2.88, SD = 1.20) did not significantly differ from the liquid sound. The subject preferred the liquid sound to others.

Table 3 Post-hoc analysis of alertness and preferred sound from questionnaire

	Group		*Liquid*	*White noise*	*Electric toothbrush*
Alertness		Mean	2.07	2.73	3.80
	Liquid sound	2.07	-	0.65	1.73***
	White noise	2.73		-	1.08**
	Electric toothbrush	3.80			-
Preferred sound		Mean	3.33	2.88	2.00
	Liquid sound	3.33	-	0.45	1.32**
	White noise	2.88		-	0.88**
	Electric toothbrush	2.00			-

Note: ** Significant level at 0.05, *** Significant level at 0.01.

4 Discussion

To answer the research question 'which is a part of human body that has tingling affect the most?' the sensation generally begins at the back of the head and travels to the scalp and down the back of the neck in capable people. According to half of the participants, this sensation often travels to the shoulders and back with increasing severity. In our study, the body areas are the ears, neck, occipital, back, and shoulder the most. The most location of the tingling sensation is the ears because they are close to the sound source. When looking at the area of tingling sensation, the result is quite similar to the ASMR map (Barratt and Davis, 2015). Like another study, researchers asked where subjects felt these tingling sensations. They asked subjects to indicate the area on the body map. The results show that the sensation areas are on the head, neck, and back regions respectively (Swart et al., 2022).

From the questionnaire, many subjects reported that they have experiences of annoyance and disgust the sound like air pumper, but it does not make them feel angry and disgusted like the Misophonia case (Schröder et al., 2013). Many subjects reported an experience of tingling differently. Some felt nothing or experiencing in other parts of the body like the shoulder and back. Activated sensory experience is unusual to people who can undergo it (Poerio et al., 2018). Although the physical effects of ASMR sounds did not happen in some people, some subjects felt a sensation similar to vibration and ticklishness. Surprisingly, a few felt nausea and goose-bump when listening to the electric toothbrush sound. In terms of ARHL, the elderly reacted fast when triggering the selected three sounds. They can hear the sound well because three ASMR sounds are mainly low frequency. The electric toothbrush, white noise, and liquid sound average frequencies are 247.51 Hz, 47 Hz, and 237 Hz respectively.

As can be seen from the results, there is no significant difference among the three sounds in terms of performance such as reaction time, and hit rate. The results are comparable to the research of ASMR on an individual's executive function. There is no discernible difference in executive function between ASMR and control subjects (Wang et al., 2020). The elderly can switch tasks and have no problem using the ASMR triggers.

The average reaction time of all subjects is 2,314 milliseconds. The minimum and maximum time are around 399 and 9,441 milliseconds. The reaction time of elderly is still high due to cognitive decline. Nevertheless, the ASMR triggers work well between the Sudoku tasks and tapping on the tablet screen that shows on high hit rates.

To answer the research question, do the elderly prefer the sound related to emotion?

ASMR sounds presumably affect participants' emotions. There is a correlation between emotional and physiological responses towards ASMR (Poerio et al., 2018). That is to say, the high emotional response when the subject experiences sensory stimuli can produce a distinct state of emotion such as tingling, relaxation, and calmness. Moreover, the psychological effects (e.g., heart rate) of ASMR are undeniably associated with psychological conditions. Thus, it is increasingly used for therapeutic prospects, for example, aiding sleep problems and mood disorders. Relatively, as we investigated in this study, the alertness and preferred sound reported in the subjective questionnaire showed how subjects felt that ASMR sound tended to relate to their task performance. They preferred the liquid sound to white noise and electric toothbrushes. Liquid sound is more energetic than others. In the same direction, subjects felt that the electric toothbrush was more alert than the white noise and liquid sound. It could get more attention or alert them doubtlessly.

5 Conclusions

In summary, subjects felt the tactile sense when they heard the ASMR sound. The tingling sensation was located on the ears the most, nearly 70.1%. This means that this type of alert requires earing devices to make it more effective such as earphone and headphone. ASMR was effective in terms of alert since the probability of hit rates over miss rates was 0.96. The average reaction time of three sounds was 2,314 msec. This was still an acceptable result. As a result, the ASMR could be an alert sound. From the satisfaction score, subjects accepted that the annoying sound like electric toothbrush could alert well. On the other hand, subjects preferred the liquid sound to others because the sound was not noisy because of emotional issue. The questionnaire revealed this result. Most of ASMR research focuses a lot on the emotion part and a few on the tactile. This research is a new proposal on how to use ASMR in an innovative way. Since the shortcoming of research is on the device that elderly need to plug the earphone to their ears all time, it is possible to use other devices such as bone conduction and haptic skin. According to the previous research, hearing distracting audio in only one ear led to improve performance and reduce workload. Some governments recommend one ear as a safety measure when users want to hear ambient sound (May and Walker, 2020). Moreover, the direction of the sound is an interesting aspect of ASMR. The elderly can know where the sound is direct to them, since ASMR is the 3D sound or spatial audio. The ASMR research is still in the beginning. The ASMR as the tactile sensation should be in future investigation.

Acknowledgements

This research is supported by Petchra Pra Jom Klao Master's degree Research Scholarship from King Mongkut's University of Technology Thonburi.

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