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Research article

Brain Mapping and Visual Attention on Cigarette Packs Based on Electroencephalography and Human Eye Tracker between Teen Smokers and Nonsmokers

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Abstract.

Background: An effort to prevent teenage smoking behavior was made by placing pictorial health warnings (PHW) on cigarette packages. Scientific data related to teenagers' smoking behavior need to be supported. However, the difference between the brain activities of smokers and nonsmokers is not yet known.

Purpose: This study describes and compares the brain activity and visual attention between smoking and nonsmoking teenagers.

Methods: The study examined 16 teenagers (seven smokers, nine nonsmokers) aged 13–18 years at the Central Laboratory of Neuroscience Uhamka (PNU) in September–October 2021. Their brain activity was measured using electroencephalography (EEG) in a resting state for approximately 10 minutes. The EEG electrodes were installed based on the 10–20 International Systems approach. Furthermore, PHW were demonstrated to participants with the concept of go/no-go for 5 minutes based on Human Eye Tracker (HET) technology.

Results: The results showed differences in visual attention to the PHW on cigarette packages. In addition, smokers compared to nonsmokers were inclined to avoid the PHW. However, the brain activity between the two groups did not differ in terms of brain wave patterns, especially in the forebrain, in Delta, Theta, or Gamma waves.

Conclusion: Considering the differences in visual attention, it is necessary to redesign the PHW on cigarette packages so that smokers can no longer avoid the image to suppress smoking behavior. In addition, explaining the differences in brain activity, the duration of smoking, and the level of addiction to cigarettes need to be sharpened.

Keywords: kwd

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1. Introduction

The use of cigarettes in Indonesia shows a significant increase and is the highest in the age group of adolescents, students, and college students. Based on the Global Youth Tobacco Survey (GYTS) in 2019, of 9,992 students in Indonesia associated with ages 13 to 15 years showed that 19.2% of students, 35.6% of boys, and 3.5% of girls currently used

any tobacco products, and 76.6% of those bought cigarettes from a store, shop, street vendor, or kiosk. Also, almost 7 in 10 (65.2%) students noticed cigarette advertisements or promotions when visiting points of sale [1, 2]. Furthermore, RISKESDAS 2018 shows that 59.7 percent of current smokers initiate smoking before 19 years of age, and children aged 10-14 smoke six cigarette sticks per day.[3]

The Government of Indonesia has included a Pictorial Health Warning (PHW) on cigarette packs. Research related to PHW shows that a large proportion of former smokers stated that the 90% pictorial health warning (PHW) measure on cigarette packs was the most effective in convincing them to keep on smoking compared to the 75% measure and the 40% measure. Meanwhile, in Indonesia, the rules for PHW are still at 40% [4]. The national regulation in 2013 states that the area of PHW is increased by 75% on the front and back packaging of cigarette wrappers starting from 2015-2019. The expected larger size is easier to distract consumers so that the cigarette industry has a smaller gap to promote its products. In addition, immediate warnings are more visible, more important, and have a more significant impact. However, this policy has not been effective enough to reduce the percentage of active smokers in general. The results of Riskesdas (2018) show that the tendency to smoke in adolescents aged 10-18 years has increased, namely 7.20% in 2013 to 9.10% in 2018, which means that it has not shown a significant impact. [4, 5]

The impact caused by smoking includes various types of cancer, impotence, coronary heart disease, bad for the brain's blood vessels [6], and cognitive impairment in nicotine smokers [5]. In addition, nicotine and other chemicals in cigarettes can cause changes in the brain and behavior of users [7], especially at the addiction stage. Cigarettes smoke harmful and carcinogenic components of cigarette smoke are carbon monoxide (CO), ammonia, hydrocyanic acid, nitrogen oxides, and formaldehyde. The particles include tar and nicotine [6]. Tar levels in cigarettes range from 24-45 mg [4]. Nicotine is an addictive substance that can cause dependence/addiction in a smoker and is a type of stimulant drug that can damage the heart and blood circulation. Nicotine stimulates the brain to increase the amount of nicotine it needs continuously. Over time, nicotine can paralyze and increase adrenaline. Each cigarette, on average, contains 0.1-0.2 mg of nicotine, and the level of nicotine that enters the bloodstream is 25%. However, this small amount can reach the brain within 15 minutes. The nicotine level of 4-6 mg inhaled by adults every day can already make a person addicted [2].

EEG (Electroencephalography) and Human Eye Tracker (HET) are the instruments/methods to see how the brain functions in a simple, non-injurious, practical, and inexpensive way. Those are valid indicators to describe behavior in measuring the condition of

attention, cognitive processes, and memory [8]. Recent studies have shown that nicotine delivery and smoking critically influence the EEG effects of smoking [9]. However, so far, we have not found any research on this subject to be conducted on adolescent cigarette users. Because adolescents appear to be at high risk of exposure to cigarettes and the possibility of initiation more than other ages, this study will provide an overview of brain function to provide scientific evidence to strengthen policies to limit or prohibit the distribution of cigarettes for adolescents.

2. Pictorial Health Warning (PHW)

The inclusion of PHW on cigarette packaging in Indonesia has been in effect since 2014 through Government Regulation no. 109 of 2012, as one of the methods used to reduce the adverse effects of smoking on health, protect the productive age population and increase public awareness of the dangers of smoking [10]. The Regulation of the Minister of Health of the Republic of Indonesia No. 28 of 2013 enforces the inclusion of a choice of 5 types of images and writings containing warnings about: health hazards, namely smoking causes mouth cancer, smoking kills you, smoking can cause throat cancer, smoking near children can be harmful to children's health, and smoking can cause lung cancer [11].

3. EEG/Electroenchephalograph and Human Eye Tracker (HET)

3.1. EEG/Electroenchephalograph

The brain functions as a control center for activities in the human body uses the electrical system, which produces small electrical signals in a regular pattern and is transmitted through a network of nerve cells called neurons. The difference in the ionic composition of the intracellular and extracellular fluids produces an electric voltage gradient across the membrane called the membrane potential. The electroencephalograph records this potential. EEG is a device designed to measure the brain's electrical activity (commonly known as brain waves) through electrodes placed on the scalp. Through brain wave patterns on the electroencephalograph, we can find brain activity and interpret abnormalities or diseases suffered by patients [7]. An electroencephalograph can be defined as a device that can record the brain's electrical activity through electrodes placed on the scalp. The recording results from the electroencephalograph are in the form of a graphic

depiction of the brain's electrical activity (commonly called an electroencephalogram (EEG)).

Humans have five brain wave patterns, namely Alpha, Beta, Theta, Delta, and Gamma, with different frequencies depending on each signal. The pattern of brain electrical waves determines the diagnosis of abnormal or normal. EEG widely used in the world of medicine, psychology, and research because EEG can read those five brain waves. When given some questions, the human brain will work to think, so that will cause a stimulus that can stimulate the brain to produce a brain signal. This brain signal appears when neurons are actively work in the brain and cause electrical activity. EEG is a system that can detect biological signals from brain activity [7]. When the test is carried out, the subject will be stimulated with light to determine the brain's response. When the brain responds at an average level, the brain's electrical activity can be said to be in good condition. On the other hand, the brain's electrical activity is abnormal when the two sides have different wave patterns or show intense electrical activity. This condition is considered unusual when delta and theta waves are found while the patient is awake. A sharp spike of brain activity waves should be a cause for concern.

3.2. HET/Human Eye Tracker

Human Eye Tracker (HET) is a device or method to assist researchers in understanding human visual attention by measuring the point of view/eye position or eye movement relative to the head. In other words, HET detects eye activity: where we look, how long we look, the order in which we look, what we ignore and prioritize, when we stare or blink, and how the pupil reacts to different stimuli [8]. The resulting data can be statistically analyzed and graphs specific visual patterns.

The way the Eye tracker works is by irradiating the user's face with infrared light, then recording two things: the reflection of infrared light from the retina, which helps locate the center of the pupil, and the reflection of infrared light from the cornea, called corneal reflection. These two things make the eye tracker know where the eye is looking on a computer screen [8]. The tracking results obtained will be given a high accuracy representation and understanding of a person's eye movement, namely location, duration, and movement. From the user's eye movements recorded, it will be analyzed how the user experience when interacting with the display [9].

4. Methods

4.1. Participants

We simultaneously recorded EEG and HET from 16 participants (nine smokers, seven non-smokers, age range: 13-18 years) from Jakarta and the surrounding area. After they were informed about the procedure and purpose of the study and had signed the informed consent. All subjects were students and received payment for their participation. All subjects reported normal or corrected-to-normal vision.

4.2. Data Collection Procedure

To obtain an overview of the participants' brain function, using electroencephalography (EEG) brain imaging technology in a resting state for about 10 minutes. EEG electrodes are installed according to the 10 – 20 International System approach. Pictures of PHW (40% measure) on the monitor screen were shown to the participants with a 5-minute go/no-go concept based on Human Eye Tracker (HET). From the total duration of fifteen minutes for each participant, computational and manual filtration was carried out to obtain clean data for one minute of an open eye condition. The high-pass filter used is 70 Hz, while the low-pass filter is 1Hz for the filtration process. In addition, in order to eliminate artifacts caused by body movements, a sensitivity filter of 7mV/mm is also used.

4.3. Data Analysis

Data were analyzed using Tobii Studio Pro X2 30 software with heatmap visualization. Participants sit at a distance of 60-70 cm from the HET device and then start the calibration by matching their eyes to 5 red dots on the screen. In using HET, the condition of the cigarette pack image has been marked with a Region of Interest (ROI) to mark the object on the cigarette pack image. Data is recorded by displaying the image conditions for 5 seconds and blank for 5 seconds. For EEG examination, the indicator on the results of the EEG examination is that the more the indicator turns red, the more it shows the dominance of waves in some areas of the brain. The data obtained has been cleaned of artifacts so that the data result are clean.

5. Results and Discussion

The following are the results of the EEG examination on participants with the categories of Smokers (Conventional-Cigarette), and Non Smokers on the EEG examination consisting of the delta, theta, and gamma waves. (Fig 1.)

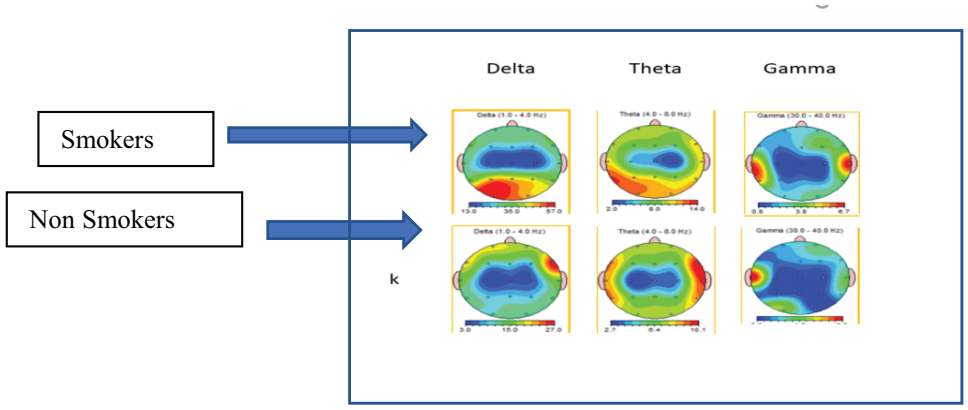

Figure 1: The results of the EEG examination consisting of the delta, theta, and gamma waves (an example).

In all subjects (n=16), there was no difference in the dominance of delta, theta, and gamma waves in the forebrain between smokers and non-smokers.

Furthermore, the following heatmap results can be seen for the four types of stimuli (1,2,3 and 4, in **Fig.2**: from left to right)) in the smokers (conventional, e-cigar, dual) and non-smokers groups.

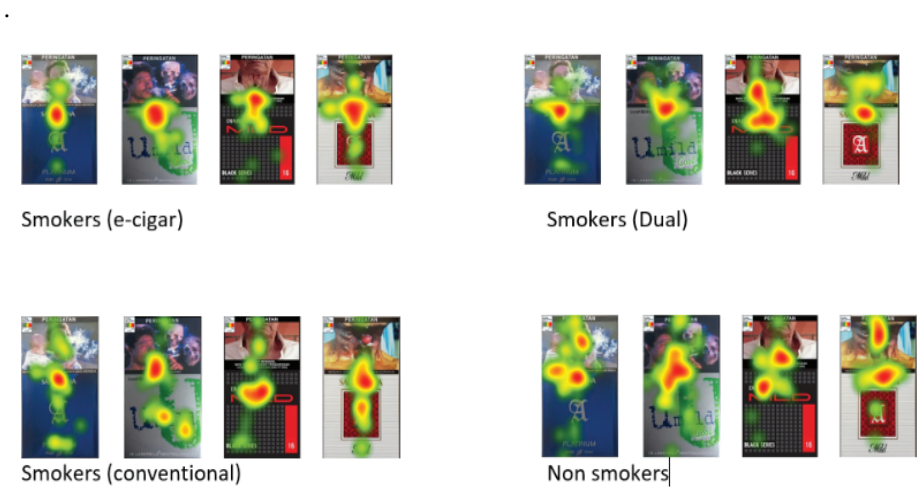

Figure 2: The heatmap results for the four types of stimuli (1, 2, 3 and 4).

From Figure 3 above, it can be seen that on stimuli 1,2, and 3, non-smokers tend to focus more on PHW (AoI 1) than Brand (AoI 2). In all types of stimuli, conventional

smokers tend to pay attention to Aol 2 rather than Aol 1. However, in dual smokers, it can be seen that there are variations in the tendency of attention to AOI 2 or Aol 1.

Furthermore, Figure 3 below shows Diagrammatic data from fixation duration, which shows how long adolescent participants focus on specific objects on cigarette packs.

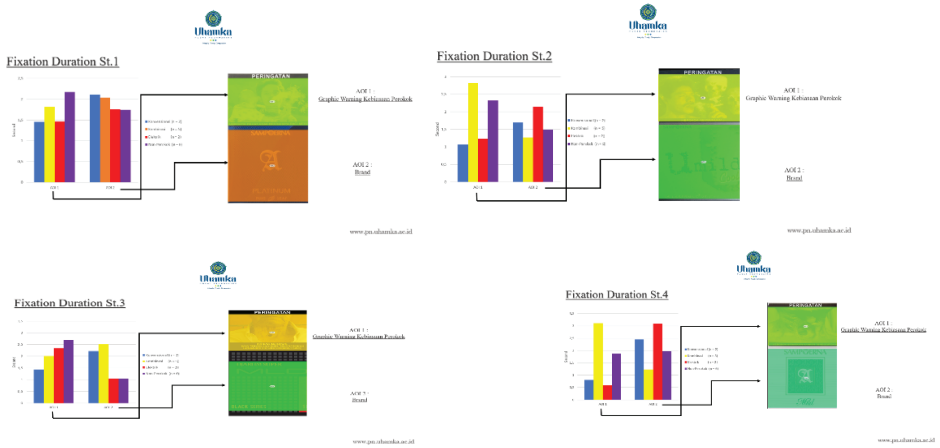

Figure 3: Diagrammatic data from fixation duration (stimulus: 1, 2, 3 and 4).

The stimulus is divided into PHW for AOI (Area of Interest) 1 and a cigarette brand for AOI 2. Furthermore, the results of data recording are analyzed using a fixation duration matrix, namely the duration of participant fixation when the stimulus is shown -the results obtained from the HET recording a picture of a cigarette pack. A smoker is shown a picture of a cigarette pack, the length of the participant's focus is more directed at the cigarette brand than a health graphic warning picture. In contrast, smokers are shown a picture of a cigarette pack containing a health graphic warning. The participants focused more on the health graphic warning image while less time on the brand, which indicates that smokers control their comfort by avoiding health graphic warning images on cigarette packs.

TABLE 1: Average Time of Fixation Duration (the length of time participants see the assessed area).

Area of Interest (Aol)	Smokers (second)	Non-smokers (second)
1 (Picture health warning/PHW)	1.5	2.2
2 (Brand)	2.1	1.6

Table 1 above shows that smokers tend to look at cigarette brands (2.1 s). While non-smokers are more focused on PHW (2.2 s), but the time difference is short.

According to WHO, PHW will increase smokers' awareness of the risks of disease that can be caused and increase the chances of smokers thinking about the possibility of quitting smoking or reducing tobacco consumption. However, the smoker's response

to PHW tends to reject the warning label on cigarette packaging. PHW does not make smokers stop smoking because they do not suffer from certain diseases related to smoking. The perceived effect is much different from PHW information. For smokers, PHW can mean warning rules and rules without punishment. The perception of active smokers tends to be reject the health warning label [5]. This study result support the finding that PHW (for the 40% measure) less effectively diverts attention to PHW when viewing cigarette packs. All groups of smokers tend to see the brand of cigarettes longer than PHW namely smoking causes mouth cancer, smoking kills you, smoking can cause throat cancer, and smoking can cause lung cancer. Included in the national regulation, the alternative to increasing the PHW size (75% or 90%) must be considered because many cigarette industries still use the 40% PHW size. PWH is not yet effective in Indonesia, indicates that all parties still have to stick together to find a solution to reduce the percentage of active teen smokers in Indonesia and to control tobacco consumption through price increases cigarettes that are sold freely in the market [12].

The study explores the differences of attention between smokers and non-smokers by using HET. Most research was also done by using a questionnaire or a survey then analyzing them statistically. However, HET is a tool that has accurate results to discover someone's attention[13]. The combination of why PHW is considered an adequate health warning, it because they also tend to know more about the health messages. This study is essential to know the effectiveness of PHW designs by using PHW based on attention differences.

The limitation of this study was in recruiting participants, although it has been suggested that both EEG and HET measurements are safety measures. Therefore, the teenagers are not familiar with this measuring tool. In addition, there is limited time for teenagers to take complete measurements (almost one day) because they are still in school, and there are also PPKM (public activity restriction) constraints during Covid-19 pandemic. This study requires a more diverse variety of data with good quality and feature extraction and other classifications of adolescent smokers to be compared to produce a better result.[14]. For example, the EEG effects of cigarettes depended upon the recentness of smoking. The results indicate that nicotine delivery, recentness and the process of smoking importantly influence the EEG; other, non-nicotine components of tobacco smoke may also exert EEG effects [15].

6. Conclusion

Smokers (Conventional, Electronic, or Dual) tend to be more likely to direct attention to AoI 2 or Brand and avoid PHW (AoI 1) than the non-smokers. There is a tendency to see a health graphic warning, but the time difference is very short with conventional and electronic smokers. Meanwhile, non-smokers tend to look at the health graphic warning rather than the brand. The examination results of brain function did not show any difference in brain wave patterns, especially the forebrain, in Delta, Theta, or Gamma waves between the two groups. In the EEG results, the continuation of the wave analysis to be studied requires an additional number of participants. There is a possible influence from less stringent subject criteria, especially smoking duration.

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