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Running head: SMOKER CNV

Brain Responses to Smoking-Related and Emotionally Positive Pictures in Smokers and Non-Smokers

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Abstract

The effects of anticipating smoking-related pictures on a brain measure of anticipation, the contingent negative variation (CNV), were assessed in 6 habitual smokers and in 6 non-smokers. Groups were balanced by gender. The CNV was measured using a standard 16-channel EEG cap. The participants viewed 30 repeated images that were smoking-related, positive, or neutral. Smokers generated a greater CNV during the anticipation of smoking-related pictures, compared to non-smokers. The present findings indicate that the procedures used in the present study might be useful to assess the effects of smoking cessation treatments and individual differences in the degree to which smokers are addicted to smoking and are sensitive to environmental stimuli associated with smoking.

In the decades since Hans Berger first developed the electroencephalogram (EEG) to study human brain waves, there has been a steady surge of interest in the field of neuroscience (Hugdohl, 2001). After Berger's initial interest, EEG has become a complex methodological tool consisting of several brainwaves and brain responses, presumed to represent select cognitive processes. From the Alpha wave to the contingent negative variation, each wave is identified by its frequency and amplitude and each brain response is identified by its relative occurrence surrounding a stimulus presentation (Hugdohl, 2001). Because the field of EEG is so broad, most researchers tend to focus on only one or two specific brain responses. For the purpose of this study, the main focus was event-related brain potentials (ERPs), more specifically the contingent negative variation (CNV), and how it could be related to cigarette smoking and nicotine research.

## Event-Related Potentials

First discovered by Davis in 1939, an event-related potential (ERP) was originally defined as a time-locked change in voltage occurring approximately 100-200 ms after a stimulus presentation (Hugdohl, 2001). This response included both positive and negative voltages because of the polarity charge that is associated with the cyclical membrane potentials of the brain's nerve cells (Hugdohl, 2001). More specifically, ERPs are a collection of certain psychological processes, or brain activities, that occur either in response or in preparation for a given event or stimulus presentation (Fabiani, 2000). Researchers have identified that these ERPs occur in a "time-locked" sequence that transpires either in congruence with or immediately after a stimulus presentation (Hugdohl, 2001). Therefore, each ERP will continually occur with the approximate same cycle that can be associated with a stimulus. These occurrences can be observed in timed rotations. Because of these findings, ERPs have been studied in a myriad of EEG-related research.

According to Fabiani (2000), the last few decades have seen paradigm shifts in how ERPs are studied. Because of the growing interest in ERPs, it has become the most expanded subset of psychophysiological research. Stimuli categories have included the use of auditory, visual, and even olfactory-related stimuli (Hugdohl, 2001). Presently, the study of ERPs is not only used in research examining basic cognitive brain functions, but is also used for diagnostic clinical research to identify aspects of cognitive and affective functioning (Hugdohl, 2001). Also, ERP research is used to identify ways to study associative learning. For example, Rose (2001) discovered an increase in ERP amplitude when associative learning was observed. As for drug dependency, there are only a few published studies that have examined the effects of nicotine, specifically, on EEG patterns. As far as physiological differences are concerned, it has been observed that nicotine smoking can have an effect on cortical activities in the brain (Ehrman, 2002). Gilbert (1988) found that when their eyes were closed, smokers exhibited more activated EEG responses, with higher wave frequencies, than nonsmokers. This study also indicates that smokers are more easily aroused than nonsmokers. Gilbert's (1988) research also suggests that personality differences can be observed based on smoking preference.

Previous studies have not assessed how the brain responses of smokers differ from those of nonsmokers in response to smoking-related stimuli. The present study's aim was to identify differences in brain responses between smokers and nonsmokers as they anticipate smoking-related stimuli during a visual task. In order to illicit any differences in the brain responses of smokers and non-smokers, the Contingent Negative Variation (CNV), a brain response associated with the anticipation of motivationally important stimuli, was used and is discussed in more detail in the next section.

**Contingent Negative Variation**

The CNV is a slower brain response that develops from endogenous processes within the brain relative to sensory or motor potential responses, which are reliant on exogenous stimuli (Andreassi, 2000). It is actually because of the CNV's lengthy reaction and formation that led to its discovery in 1964 by W. G. Walter. In his classic experiment that led to his detection of this brain response, Walter (1964) documented unknown extended waves that occurred during his subjects' responses to crucial stimuli. Based on his findings, Walter concluded that these waves occurred solely in conjunction when a certain relationship that existed between two stimuli. He noted that this negative wave occurred only after the presentation of a conditioned stimulus and pending the presentation of the target stimulus. Thus, Walter labeled his newly discovered brain response the contingent negative variation because of its negative voltage polarity and because its occurrence was contingent upon the anticipation of a pending target stimulus (Walter, 1964).

Even though Walter's discovery was over four decades ago, it has not been until recently that an interest in the CNV has reemerged (Fabiani, 2000). Recent research incorporating newer electrode placement has led to an approximate identification of where the CNV occurs within the brain. As for the most common areas used in order to attain the greatest CNV signal, the areas that have been identified as having the most prominent occurrence of the CNV are the central vertex (top of skull at position CZ) and frontal areas (Fabiani, 2000). More specifically, midline electrodes at central (CZ), frontal (FZ), and parietal (PZ) sites are most commonly used in current research (Costell, 1972). As for O'Connor's (1982) research, findings suggest that smokers have the highest CNV amplitude in the frontal vertex at FZ. As for the amplitude of the

CNV, adults tend to produce a 15 μV response (Andreassi, 2000). This response tends to appear approximately 200-400 ms after the initial stimulus presentation and can last from 400-900 ms or until the presentation of the second stimulus, during which it ends abruptly.

Researchers assume that the CNV is correlated with the endogenous processes associated with expectancy, association, and priming as related to specific target stimuli (Fabiani, 2000). Walter initially mentioned that the CNV occurred in response to social stimuli in the form of verbal statements (Walter, 1964). The CNV has been used to identify personality differences in smokers (O'Connor, 1982) and even sexual object preference in males and females (Costell, 1972). Some researchers have also incorporated the use of motor responses to visual and auditory stimuli because motor activation is more likely to produce a stronger, more prominent CNV response (Andreassi, 2000; Hugdahl, 2001). Existing research indicates that the CNV is related to not only psychological, but performance factors (Andreassi, 2000).

As previously mentioned, Costell (1972) used CNV to assess sexual object preference. He designed his experiment using an S1-S2 paradigm and used three specific categories of stimuli including images of male, female, and neutral gender nudes. Each image was repeated 10 times in a 150 trial set with S1 and S2 being the same picture. Costell's reasoning for intentionally displaying the same picture twice (S1 followed by S2 1500 ms later) was that if the participants were to know that an image's display will be repeated within a certain amount of time, and if the image is preferred, then the participants will anticipate the image's next presentation and thus generate a CNV. He concluded that the results supported his hypotheses. Costell's study was replicated, with minor modifications, by Howard (1992). Howard changed some of the trials so that they did not have the exact same stimulus for S1 and S2 and included persons of a homosexual orientation. Inherently, Howard's findings still supported those of Costell's (Howard, 1992).

Costell's success with the S1-S2 paradigm and the success of other researchers in their continued manipulation of this specific paradigm show the CNV paradigm's ability to index functionally significant psychological processes and is the chosen model for this study's experimental method (Fabiani, 2000). Not only is it being applied to this experiment, but Costell's entire experiment is, in a sense, being replicated with the exception of the types of pictures used for S1 and S2 and the timing. Because little research has been conducted linking the CNV to smoking, the application of Costell's research to a smoking-related theme could provide interesting results. Instead of the nudes used by Costell, this study incorporated a set of smoking-related images, with neutral and positive images to act as controls.

A difference between smokers and nonsmokers in their responses to smoking stimuli was expected. In addition, past research implies that smokers will react positively to smoking related cues, so this was also expected for the present study. Also, gender differences between smokers were expected because of evidence that females tend to react stronger to smoking cues relative to male smokers (Field, 2002). Several studies have observed the smokers' reaction to smoking related stimuli and how it differs from nonsmokers (Field, 2004; Ehrman, 2002) and this research is addressed in more detail in the next section.

**Smoking Cue Reactivity**

Various drug-related cues can initiate a relapse in individuals recovering from addictions (Geler, 2000). Cigarette smoking is no different. Smokers are more likely to notice an ashtray or a cigarette butt on the ground, compared to non-smokers. These are environmental cues which can cause smokers to experience a cigarette craving (Ehrman, 2002). Correspondingly, several studies have been published observing smokers' reactions and eye gaze towards certain smoking-related paraphernalia and even images of the act of smoking. Whether smokers have attentional biases for smoking cues in an initial orientation of a cue or whether the cue is maintained in some other cognitive process, still raises questions (Field, 2004). Thus, the present study examined the relations between cognitive processes and smoking cues.

Research indicates that smokers will inherently shift their gaze towards and respond faster to smoking-related stimuli relative to control stimuli (Field, 2004). As for the content of the smoking stimuli, the images vary with each research study. For a study conducted by Geler (2000), the smoking cues used included images of the preparation of the act of smoking or the act itself. The smoking participants essentially experienced cravings related to the cues, while also rating the images to be more pleasant than the study's control pictures. Because cravings can be initiated by the smoking cues, smokers become more likely to smoke because of their biases to focus on these stimuli, as with passing an ashtray on a sidewalk (Ehrman, 2002). Smokers are also known to hold their gazes longer on smoking-related stimuli over control stimuli when they are deprived of nicotine (Field, 2004).

Gender differences have also been examined in smoking cue research. In a study conducted by Field (2004), the findings showed that females had a greater craving reaction to smoking cues than males. This study planed to contribute to this area by observing possible gender differences in CNV amplitude. Finally, in Ehrman's study (2002), it was discovered that smoking-related stimuli do attract and hold the attention of smokers. These results support the hypotheses that smokers will respond with a greater anticipation of the presentation of smoking cues versus control cues.

Because past research indicates that naturalistic conditions suggest that smokers will have stronger responses and induced cravings with reaction to smoking stimuli, using images of smoking was expected to evoke the same response. For this study, craving induction was not being measured. Instead, the cognitive processes associated with the presentation of smoking stimuli was purported to be measured. For the sake of external validity, the smokers involved in this study were not restricted from smoking before the beginning of the experimental tasks.

After reviewing an array of past research on smoking cue reactivity, it was concluded that smoking stimuli do, in fact, draw the attention of smokers away from that of control stimuli (Field, 2004; Ehrman, 2002). Considering Field's (2004) results, using both males and females in this study, a gender difference was expected to be observed in reactions to smoking-related stimuli. Smokers were expected to experience greater CNV amplitude because of their conditioned attraction to smoking-related stimuli, based on Ehrman's research. Costell's research stands out as providing a concrete example for testing possible differences between two defined groups, such as smokers and nonsmokers. By combining the findings in these two areas of study, this study purported to test for three hypotheses. In addition, because there are no non-biased objective measures that exist to observe a smoker's anticipation of the act of smoking, if smokers were to anticipate viewing smoking stimuli because of an attentional bias towards images that are of or are related to the act of smoking, as measured by the CNV, then it implies that there are underlying psychological aspects that account for part of their addictions to nicotine and smoking cigarettes. In addition, the CNV technique used in this study could be used to evaluate the effectiveness of smoking cessation techniques and the success of the smokers involved. Thus, this study's research could be used to ultimately help smokers to conquer their addictions.

1) Smokers should show larger CNV amplitudes in reaction to smoking stimuli compared to control stimuli.
2) Smokers should have larger CNV reactions to smoking stimuli than do nonsmokers.
3) Female smokers are expected to have a higher CNV amplitude response to smoking pictures compared to male smokers.

## Methods

*Participants*:

Participants (N = 12) included students recruited from Southern Illinois University in Carbondale, IL and other individuals from the southern Illinois area. The participants were 6 smokers and 6 non-smokers with an equal number of males and females in each group. Within the groups, 10 participants were Caucasian, 1 was African American, and 1 was Asian, with the mean age being 21.6 (SD: 2.78). Some participants were recruited from an introductory psychology course that required satisfaction of class credit by either participation in on-campus psychology research or some other alternative, non-research method. Other participants were offered lab credit for their participation and others were offered coupons to be redeemed for fast-food. Participants were asked to sign up for a pre-determined timeslot that matched their gender and smoking preference. Those participants who considered themselves to be smokers were required to smoke at least 6 cigarettes daily, on average, in order to meet the criteria of being a regular smoker. If those participants that considered themselves to be smokers did not meet this criterion, they were still given credit for signing up for the present research study.

*Apparatus*:

The equipment used for this experiment included an Easy Cap™ EEG cap (Faulk Minow Services, Herrsching-Breitbrunn, Germany), Synamps™ amplifier (Neuroscan, El Paso, TX), and a computer task created in E-Prime™ (Psychology Software Tools, Inc., Pittsburg, PA) (See figure 1). The EEG cap was fitted with silver/silver chloride electrodes with electrode placements at 15 International 10/20 system sites: F3, FC3, C3, CP3, P3, FZ, FCZ, CZ, CPZ, PZ, F4, FC4, C4, CP4, and P4, with a sixteenth electrode placed directly in front of FZ to act as a ground (See figure 1). The letters indicate in which are of the brain each electrode site is located. The letter "F" indicates the frontal are with "C" indicating the central are, "P" indicating the parietal area, and "Z" indicating the vertex, or the central line of the scalp. As for the numbers, "3" indicates electrodes that fall on the left side of the brain with "4" indicating those electrodes that fall on the right side of the brain.

In order to apply the cap to a participant's head, several steps were taken. First, the participant's head was measured in order to find the central vertex of his or her scalp. Once found, the cap was fitted so that the electrode placement of CZ was exact. This was done by first measuring the midpoint of the brain in reference to the distance between the nasian (the bridge of the nose) and the inian (a bump located on the back of the skull). Second, the midpoint between the left and right peraicular joints (where the jaw connects with the skull) was measured. The point of CZ was then determined by the intersection of these two midlines on the participant's scalp. Third, two electrodes were placed on the participant's head, one on the left mastoid and one on the right. These electrodes acted as references for the electrical activity collected from the brain. Forth, a cap was selected to fit the participant's head, which was based on the circumference of his or her skull.

After the cap was placed on the participant's head, each site that had an electrode was prepared. First, each circular electrode was placed into its designated area on the cap. Second, the participant's scalp was slightly abraded at each electrode site so that the electrical signal could be detected through the skin. To do this, a small metal, sterile needle, known as a "sharp," was used to lightly scratch the scalp, causing the participant little to no discomfort. Third, each electrode site was filled with a high-chloride, electrolytic gel to transpose the brain's electrical currents through to the electrodes. Once this step was complete, the electrodes were then connected to a "head box" that is connected to the Synamps. Following this step, the Neuroscan software was used to measure the impedance, or the degree to which the electrodes had contact with the brain's electrical activity. To do this, some electrodes needed further adjustment or more gel to achieve the desired effect. Once the impedance for each site was between 10 and 15 kOhms, the Neuroscan program was ready to accurately collect the participant's brain-waves.

Because the frequency of the brain's electrical waves are so small, the EEG cap's electrodes were connected to Synamps, an amplifier that magnifies the brain's electrical signals. This allowed for the collection of the data using the Neuroscan software. In order to connect the electrodes to the Synamps, leads connected to the individual electrodes of the EEG cap were inserted into designated connectors in the head box that was then connected to the Synamps amplifier which is then connected to the computer that is designated for data collection. On the data collection computer, Scan software (Neuroscan Inc, El Paso, TX) was used to collect and digitize the participant's brain-wave responses (fluctuations in scalp voltage). The Neuroscan software was used to process the EEG data collected from each electrode site.

*Picture Stimuli*

A task using visual stimuli was created (See figure 3). As stated in the literature review, smokers tend to respond strongly to smoking stimuli, so a set of ten smoking images were collected for this purpose. These images were taken from in the International Smoking Image Series (ISIS) (Gilbert & Rabinovich, 2003). For comparison, ten positive images and ten neutral images were collected from the International Affective Picture System (IAPS) (Lang, Bradley & Cuthbert, 2005) to use in the task. The smoking images consisted of color pictures taken of individuals in the act of smoking, with the images cropped to focus on the cigarettes rather than the models. The only detection of the models included lips and fingers. Although some images do not have many gender distinguishing characteristics, the models were balanced between males and females. For the positive pictures, the images were of "happy" and content heterosexual couples of varying ethnicity. The couples were smiling, embracing each other, or locked in a romantic kiss. The neutral images were of males or females engaged in occupational tasks or activities. These pictures were deemed neutral because the models were of average attractiveness and did not display any emotional expression of either happiness or sadness. These images were also balanced for gender.

For the construction of the computer task, the images were cropped and sized to be 495 x 397 pixels in length and width so that they were 13 cm x 10 cm, square, when presented on the 18 inch LCD color computer monitor. Once the pictures were altered, they were inserted into a task created by E Prime software.

*Contingent Variation Task*

The task used a S1-S2 paradigm for the stimulus presentation, similar to Costell's (1972). Initially, the task presented a screen that explained to the participants to remain still through the task and to affix his or her attention on the presented images. A crosshair appeared for 1000 ms preceding each of the first presentations of the pictures so the participant could focus on the center of the screen. Following this, an image was presented for 500 ms, then disappeared and reappeared after an inter-stimulus interval of 3500 ms and then remained on the screen for another 2000 ms (See figure 2). This sequence was repeated for 150 trials, with 50 trials for each image category and 5 trials per image. Through this task, each participant's anticipation was measured through a CNV response that occurred after the first presentation and stopped abruptly with the second presentation of the same image (See figure 3).

Because the participants were enclosed in an experimental room, a video surveillance system was used to monitor the participants, but they were not video-taped. This equipment was used only for observation of the participant so that they could alert the experimenter if needed or so that any discomfort could be observed.

*Procedure*

When signing up for a timeslot in this experiment, the participants were provided with specific instructions to bring their cigarettes with them if they were smokers. This was because the research intended to hold nicotine ingestion constant for the smokers by having them smoke a cigarette previous to the actual cap application. If the participants did not agree to this, they were thanked for attempting to participate and were politely told that they could not be involved in the study. Fortunately, this problem was not encountered with any of the present study's participants (N = 0).

Once the participants arrived for their chosen experimental timeslot, they were presented with the informed consent. Once reviewed, the participants signed for proof of voluntary participation and they were informed that this experiment's task would last for approximately 2 hours and would satisfy two credits for their introductory psychology course or that they would be reimbursed by some other means if they were not students in this course. After a brief introduction by the experimenter, the participants were asked to fill out an electronic questionnaire assessing their demographics and smoking preference. The questionnaire also asked about the average number of cigarettes the smokers smoked on average. This was used as a cut-off to include relevant smoking data. The researcher decided to include only the date collected from smokers with at least a ten-cigarette-a-day habit. After the questionnaires were filled out, the smokers were asked to smoke a cigarette and then the application of the EEG cap began. After measuring a participant's head, a cap was placed on his or her head and the scalp was abraded. After this, reference electrodes were placed on the participant's mastoids (behind the earlobes). Once the cap was applied, the participant was instructed to sit in a chair positioned in front of a computer screen in the designated experimental room. Once the participant confirmed an acceptable level of comfort, the electrodes were then connected to the head box, the Synamps was turned on, and the Neuroscan application was opened. On average, complete set up for the experiment required 45 minutes.

The participants were asked to not make any movements at all because of the interference that can be caused from muscle tension. On the contrary, if the participants felt any discomfort or a need to use the restroom, they were asked to notify the experimenter before the task began. The participants were also informed that a video surveillance system would be used to monitor them, but that the researcher would not be videotaping the experiment. The participants were instructed to use a hand gesture to notify the experimenter if they felt any discomfort or needed to terminate their participation in the experiment. Once this was understood by the participants and all were questions addressed, the experimental room was closed and the video monitoring system was used to observe the participants while the task ran. After all the equipment was turned on and calibrated, the computer task began. The computer task was split into three sessions with each being ten minutes. After the first and second session, the participants were given a chance to take a break and move around before the next session commenced.

Once the computer task ended, the experimenter disconnected the EEG cap from the head box and then asked the participant to rate the pictures that he or she just viewed on their interest in the pictures and their arousal by the pictures. Next, the cap was removed from the participant's head and he or she was offered a chance to wash the electrolytic gel from his or her hair before leaving the laboratory. Once the participants were satisfied with the cleaning of their hair, they were thanked for their participation in the experiment and were debriefed as to the constructs of the study. After the debriefing, the participants were given proof of their participation in the study and were offered a printed copy of their brain-waves.

*Data Analysis*:

Once all the EEG data was collected, it was put through a series of processes in order for it to be analyzed. First, because the raw data was collected using the left mastoid as an active reference, the data had to be re-referenced to the right mastoid. Thus, the data was referenced using a linked-mastoids approach.

Following this step, the continuous data was filtered using a band pass filter that removed any frequencies below 0.05 and above 20 Hz. This way, any artifacts that occurred in the data as a result of muscle tension could be disregarded. Next, the data was then epoched, or cut into sections representing the presentation of each trial. To do this, the data epochs reflected 2200 ms pre-presentation of S2 and 800 ms post-presentation of S2. Each epoch was sorted by the stimulus type. As previously mentioned, each stimulus category had 50 trials. Thus, it was decided by the researcher that the first two presentations of each stimulus type (or the first six stimulus trials) be deleted because they acted as practice trials for the participant. After these presentations, the participants would know to expect a definite second, longer presentation of each image.

Following the epoching of the data, 48 trials remained for each stimulus category. Next, the data had to be corrected by using a baseline correction. In order to designate a uniform baseline, the first 200 ms of each epoch was used. After this, the epochs were screened for ocular artifacts. Any epoch that contained such an artifact was deleted, while using a minimum acceptance rate of 30 epochs per stimulus type.

Once artifacts were removed, the epochs for each stimulus type were averaged for each stimulus type. Next, the CNV was sampled from the averaged data and was represented by occurring 1700 ms pre-S2 onset and then at the exact onset of S2, or 0 ms. The average CNV negativity for electrodes FZ, CZ, and PZ were reported for each participant and were analyzed. Also, a group average was conducted to visually compare the CNV amplitudes in reaction to each stimulus type as a result of smoking preference.

Results

To analyze the numerical data achieved from initial data collection, the values were compared for possible effects of smoking status, stimulus type, gender and differences between the electrode sites on the CNV. Using an within-subjects analysis of variances, Picture Type × Smoker Status was the only significant interaction, $F(2,20) = 4.3$, $p = .03$. Follow-up analyses of this interaction verified that the CNV of smokers to smoking-related pictures was not significantly different from their CNV response to positive pictures (*Mean Diff* = -.302, $p = 0.68$) (See Table 1). Conversely, the CNV of smokers to positive pictures was significantly greater than to neutral pictures (*Mean Diff* = -1.483, $p = 0.03$), while the CNV of smokers to smoking-related pictures was not significantly greater than to neutral pictures (*Mean Diff* = -1.181, $p =$ 0.15). In non-smokers, the CNV to positive pictures was significantly greater than to smoking-related pictures (*Mean Diff* = -2.085, $p = 0.02$) and to neutral pictures (*Mean Diff* = -1.667, $p = 0.05$).

Statistically, there was not a significant gender difference among smokers in response to any of the stimulus categories. Thus, this study's results support the hypothesis that smokers do generate a more negative CNV response to smoking-related stimuli compared to non-smokers. Yet, this study's results did not support the hypothesis that smokers would generate a more negative CNV response to smoking-related stimuli compared to control stimuli in that smokers were more motivated to anticipate the second presentation of smoking-related stimuli as much as control stimuli. In addition, the present study's hypothesis that female smokers will exhibit a greater CNV response to smoking-related stimuli over male smokers was also not supported.

The results indicated that there was not a significant difference between the three scalp electrode sites used for analysis ($F(2,20) = .19$, $p = 0.83$) or picture-type ($F(4,16) = 1.9$, $p = 0.14$). Results also showed no significant interactions when comparing smoking status, picture type and location of CNV generation ($F(4,16) = .98$, $p = 0.43$). In addition, there were no significant gender interactions in either smoking status group.

## Discussion

A plethora of research exists that suggests smokers are aroused by smoking-related images and can inherently experience cigarette cravings because of these images (Geler, 2000; Erhman, 2002; Field, 2004). In addition, neurophysiological methods are being utilized more often to better understand smokers and their motivations for engaging in the act of smoking (Field, 2004). The present study's results support this past research. Because smokers had a higher CNV negativity in response to the smoking-related stimuli, it seems that they were more excited by and more motivated to anticipate the second, longer presentation of the same smoking-related image.

In Field's (2004) research, a question was raised addressing the idea about what causes a smoker to attend to a smoking-related stimulus faster and longer than control stimuli. It was considered whether smokers have this reaction simply because of initial orientation to the picture or whether there was some underlying cognitive process that was responsible for past research results. Based on the findings of the present study, it is argued that there are endogenous processes that account for a smoker's attention to smoking-related stimuli.

The CNV has been linked to motivation and anticipation and is negative because it is linked to excitation. Therefore, this study's results indicate that smokers do experience some emotional arousal with the expected presentation of a smoking-related stimulus, similar to their responses to the positive images used in this study. Thus, endogenous cognitive processes can account for a smoker's response to an environmental smoking cue with the anticipation of the act of smoking a cigarette.

*Limitations*

While the present research study did find significant results that supported the primary hypothesis, there are still some suggested changes for the future. First, because the sample was so small (N = 12) gender differences could not be examined. By doubling the sample size (N = 24), there is an increased chance of observing a gender difference between the male and female smokers and their CNV negativity in response to smoking-related stimuli and control stimuli. Also, the present study used only two caps for collection of data. These caps were limited to those participants whose heads measured between 54 and 59 centimeters in diameter. This restriction did not allow for males with larger heads to participate in the study. Future research might include a more diverse selection of caps to avoid this restriction.

The present research also focused on college-aged individuals whose ages ranged between 18 and 27 years of age. Because of the age restriction for the present study, future research might want to examine differences in those people that are middle-aged and older. More specifically, studies have shown that older smokers hold different beliefs and intentions related to their own smoking behaviors and their desire to quit (Yong, et.al, 2005). So, a group comparison between younger and older smokers might prove to have interesting results. Future research could also focus on the CNV negativity that would occur in smokers that were required to abstain from smoking for a given amount of time.

As previously mentioned, the researcher decided to have the participants rate each of the 30 pictures they viewed on how interesting they found them and how arousing the pictures were to them. Also, the participants were asked to rate the pictures on how they elicited an urge to smoke in the smokers. For this study, it was decided to not analyze this data in order to focus on the possible effects achieved from the CNV technique used. In the future, the researcher plans to analyze this data in order to validate the present CNV technique as a truly objective measure compared to the subjective self-report measure of the picture ratings.

*Implications*

This study's findings support the idea that the CNV may be an excellent index of smokers' emotional and motivational reactivity to smoking-related stimuli. Because smokers were as emotionally motivated to focus their attention on the repeated presentation of a smoking-related stimulus compared to positive stimuli, this suggests that smokers are as aroused by smoking-related images as much as they are by positive images. Knowing this, perhaps because of their habits, smokers are conditioned to focus their attention on environmental smoking cues, which has been shown to cause relapses in quitters (Geler, 2000). The findings of this study could be incorporated into a cognitively based smoking cessation therapy to help desensitize smokers to in vivo smoking cues, thus allowing them to be more successful with their cessation efforts.

Recent research supports the idea of cue extinction in humans by using classical conditioning methods (Conklin, 2006). Incorporating these new conditioning techniques with the CNV techniques used in the present study could be manipulated to develop a successful alternative smoking cessation technique for those smokers that fail their present cessation therapies due to the environmental smoking cues that they encounter on a daily basis.

Incorporating the present study's technique could allow for the observation of a smoker's decreased sensitivity to environmental cues. By using this technique, researchers would theoretically be able to observe a drop in negativity in the CNV generated by a smoker in response to a smoking-related image. Ideally, if an extinction therapy or some other cognitive or behavioral modification therapy were actually working for a given individual, then the smoker's reaction to the same smoking-related stimuli would become closer to that same person's reactions to neutral stimuli or a non-smoker's reaction to the same smoking-related stimuli.

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Figures and Tables

Figure 1: Topographical Scalp Map

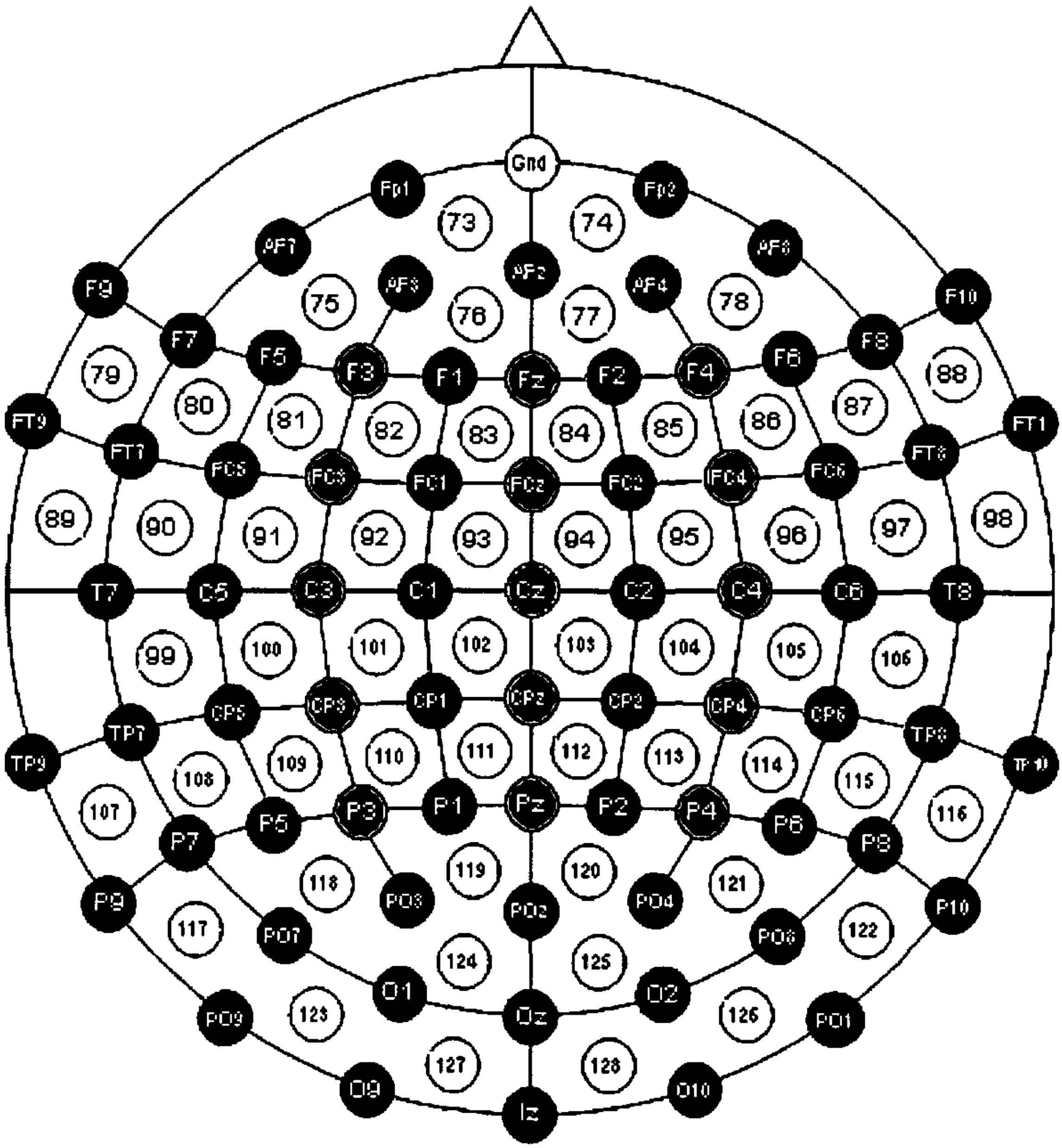
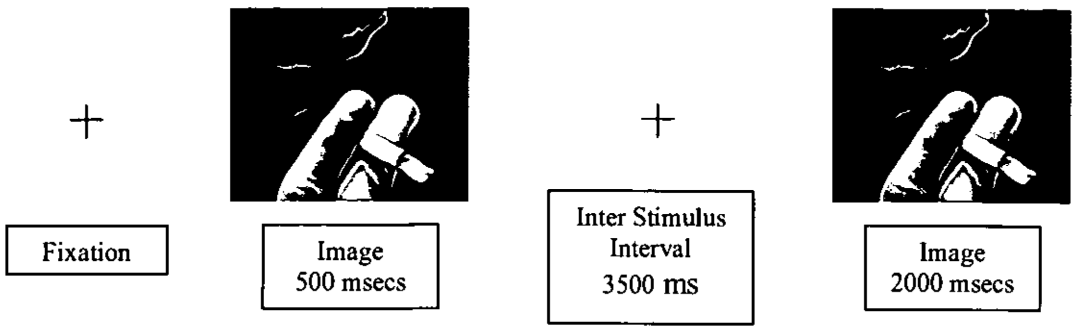


Figure 2: Stimulus Trial Diagram



Figures 3: Stimulus Categories

Neutral

Positive

Smoking

Figure 6: Mean Stimulus Response Comparison

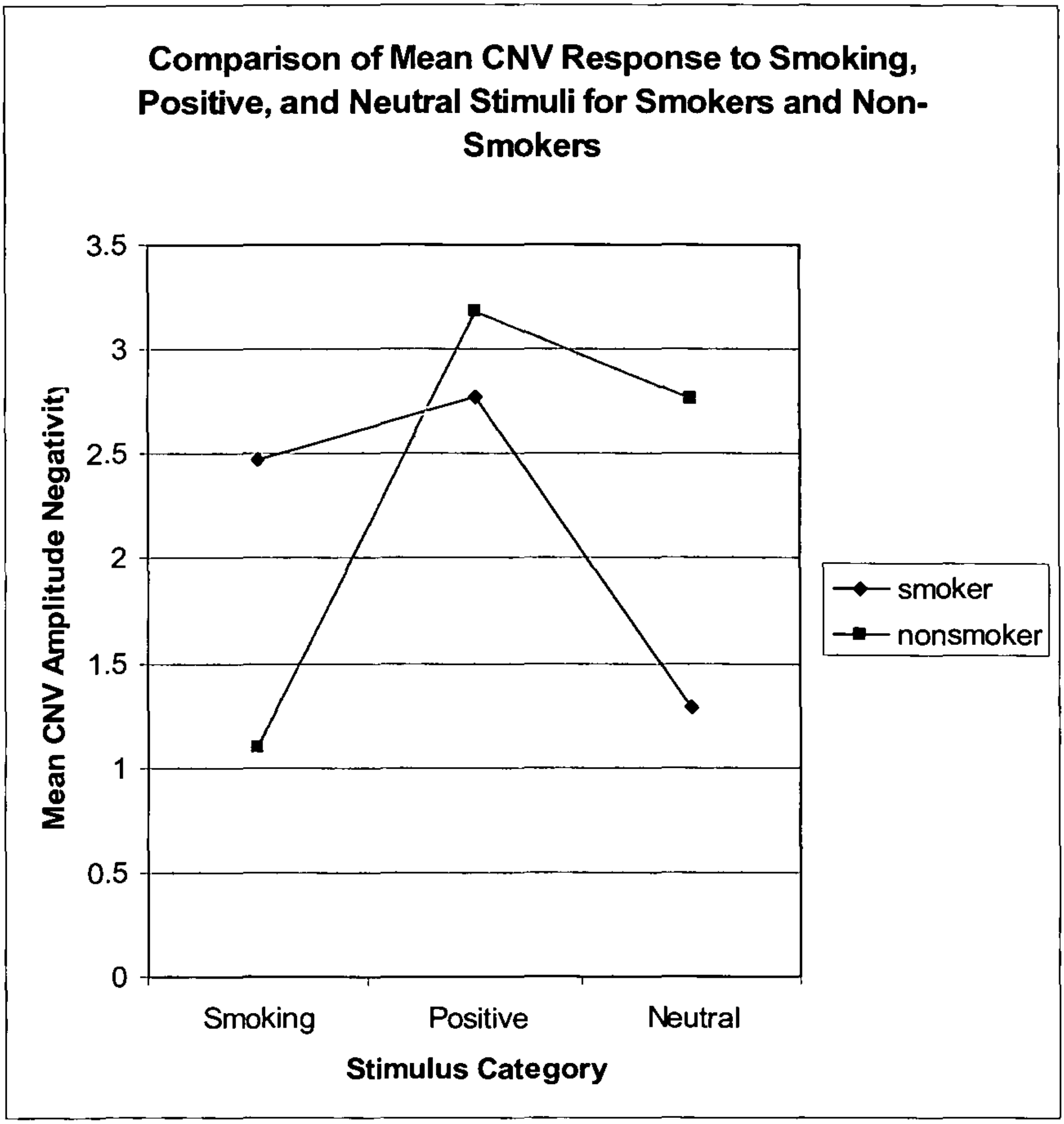


Figure 7: CNV (upward, negative-going brain wave) in Anticipation of Smoking-Related Pictures in Smokers and Non-Smokers

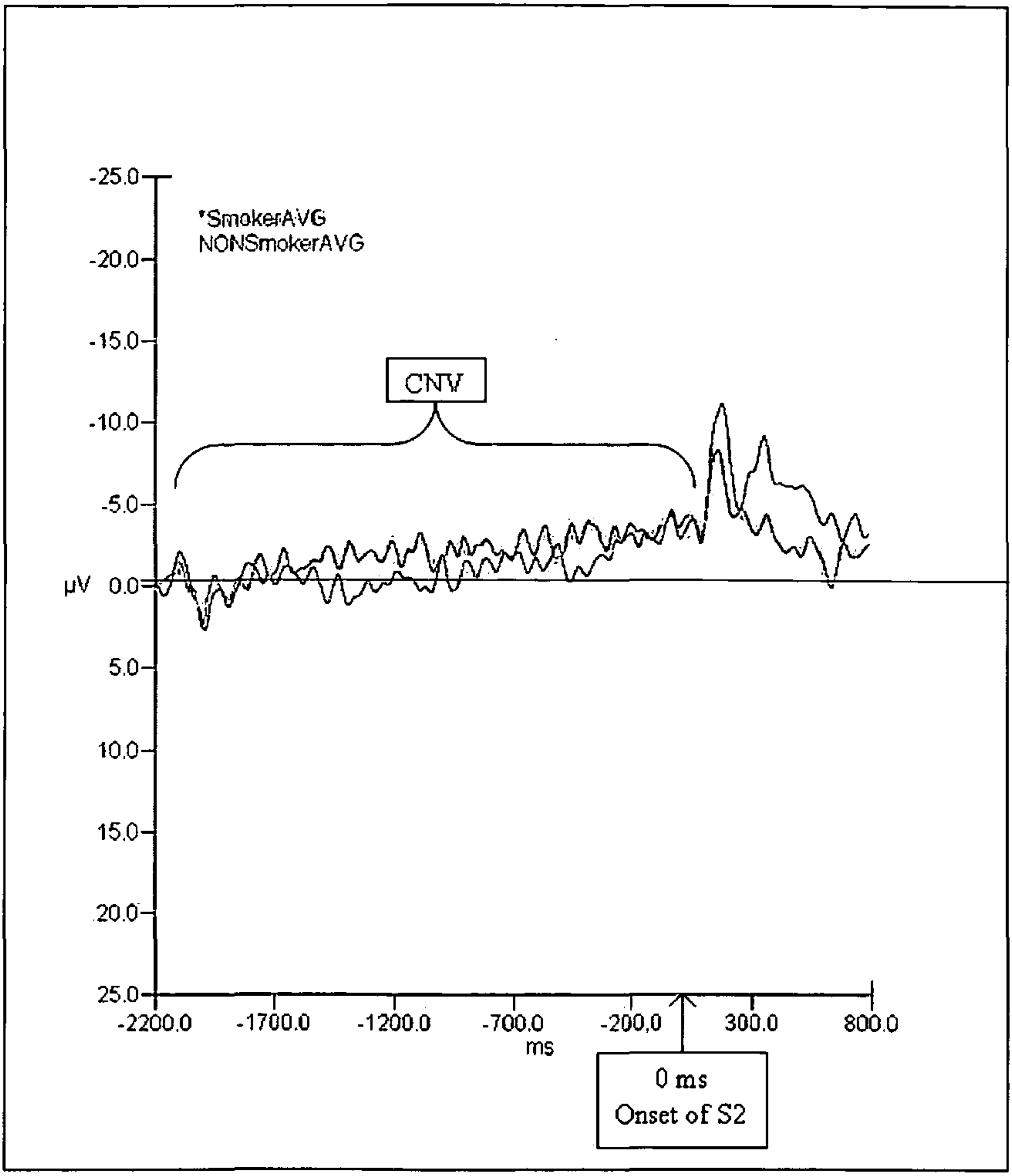


Table 1: Mean Stimulus Response Comparison of Smoking Status to Picture Type

| | Picture Type | | |
|---|---|---|---|
| | Smoking | Positive | Neutral |
| Smokers | -2.468 | -2.769 | -1.286 |
| Non-Smokers | -1.096 | -3.181 | -2.763 |