Assessment of TV advertisement effectiveness through audience eye movements

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A Thesis

in

The Department

of

Concordia Institute for Information Systems Engineering

Presented in Partial Fulfillment of the Requirements
for the Degree of Master of Applied Science
(Quality Systems Engineering) at
Concordia University
Montreal, Quebec, Canada

Mar 2011

CONCORDIA UNIVERSITY

School of Graduate Studies

This is to certify that the thesis prepared

By: Shize Jin

Entitled: Assessment of TV advertisement effectiveness through audience eye movements for the degree of

Master of Applied Science (Quality Systems Engineering)

complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

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The evaluation of advertisement effectiveness during the advertisement design phase and pre-launch phase is critical for the advertisement's success in the targeted market. This evaluation should predict advertisement's final performance as accurately as possible. In today's advertisement business, questionnaire-based evaluation methods, such as attitude and opinion rating are widely used. To obtain good survey results, high quality questionnaires and proper interviewing procedures have to be developed with the support of the competent execution and supervision. These activities are usually costly even though some of them can be conducted online. We study the feasibility and effectiveness of assessing ad through capturing and analyzing the audiences' eye movements. We assume that some attributes of audiences' eye movements are correlated to their visual attention defined in the context of TV ad effectiveness. To validate our research hypotheses, experiments were conducted. In the experiments, subjects were required to watch several TV ads in sequence and the subjects' eye movement data were collected simultaneously. By analyzing the data patterns and comparing them with the effectiveness evaluation obtained from questionnaire-based method, we found that the proposed method produces similar evaluations to those resulted from the traditional attitude and opinion rating method.

Acknowledgements

This thesis would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study.

First and foremost, my utmost gratitude to Dr. Yong Zeng and Dr. Chun Wang, whose knowledge and encouragement I will never forget. They have provided not only helpful suggestions, but also inspiration as I hurdled all the obstacles in the completion this research work.

Secondly, I would like to extend my gratitude to colleague, An, Bai Rong Wu, who have shared valuable insights and invaluable suggestions.

Thirdly, I also wish to acknowledge for Yongmei Li, Rodica, Xuan Sun, and other members in my Lab, who have shared all the joyful and bitter moments with me in the past two years. Also, a heartfelt note of thanks goes to the professors and staffs in CIISE, who have provided a wonderful academic surroundings for me to complete this study.

This research is partially supported by an NSERC Discovery Grant (Grant number RGPIN 298255) and Canada Research Chair program.

Last but not least, my thanks go to my family. Without their constant support and encouragement, this thesis would not be done.

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Chapter 1
Introduction

The evaluation of advertisement effectiveness during the advertisement design phase and pre-launch phase is critical for the advertisement's success in the targeted market. While the purpose of an advertisement is to build a certain impression of a product or serviece and/or to produce sales (Thomas, 2007), the effectiveness of an advertisment is based on making a tangible contribution to a company or to a brand by impacting on customers' buying decisions through advertisements (Wells, 1997). In other words, the effectiveness of an advertisement is the power that the advertisement has to change markets and to improve profit margins.

Based on the power of advertising, advertisement effectiveness has significant financial implications for advertisers. Before the final launch, the advertisers usually apply a variety of measures, including psychological, sociological, economic, and other perspectives, to evaluate advertisement effectiveness. These measures focus on a general understanding of how advertising works. They are a form of customized research that predicts the in-market performance of an ad before it airs, by analyzing the audience levels of attention, brand linkage, motivation, entertainment, and communication.

Traditionally, advertising effectiveness is assessed by an approach called copy testing, which includes both the pre-testing and the post-testing of advertisements in print or broadcast. Effectiveness measures used in copy testing include Aided and Unaided recall tests of the brand name or advertisement, Attitude Tests, Inquiry Tests, and Sales Tests. These measures aim to test the advertisement's persuasiveness (beliefs, attitude change,

purchase intentions) through customer rating (Wells, 1997). However, obtaining the numerical values of these measures is not a trivial business. The assessment is usually conducted through questionnaires after an advertisement is presented to audiences.

Although questionnaires are widely used, there are certain limitations with this approach. Many issues have to be addressed to guarantee good survey results. For example, only with the proper development of questionnaires and proper interviewing procedures, supported by competent execution and survey supervision, can quality data be collected and a good survey be achieved (Lucas and Britt, 1963a). For a large number of customers (usually needed to guarantee quality survey results), an opinion and attitude rating test is a labor intensive, time consuming, and costly process. Furthermore, the results of this method are sometimes inaccurate due to its subjectivity. People do not always say what they really think and really do; people may also forget and change their minds or make things up when they fill out the questionnaire.

Unlike questionnaire methods, computer-based evaluation technologies assess advertisement effectiveness by recording and analyzing the audiences' spontaneous reactions while watching the advertisements. Several computer-based methods have been proposed in the literature. Typical examples include analyzing Facial expressions, Skin conductance, Brain activity, and Eye movement. These methods assess advertisement effectiveness by employing the automatic measurement of audience attention during the advertisement. In advertising research, it is commonly agreed that attention is an important factor in the advertising process. Measuring the attention of an audience can be an effective method of predicting advertisement effectiveness. In the following

subsection, we discuss the importance of audience attention in the assessment of advertisement effectiveness.

1.1 Audience attention and advertisement effectiveness

Advertising has two types of power: short-term power, such as the power of conveying new information, building awareness, enhancing credibility, etc., and long-term power, such as conveying brand image, attaching emotional values to the brand, building a positive reputation, etc. (Pieters et al., 1995). Considerable effort has been devoted to the understanding of the long-term and short-term factors that affect advertising effectiveness. Whereas long-term effects can be gauged by assessing the advertisement's impact on the customers' structure of decisions, attitude, preferences, beliefs and intentions as well as the sales, the level of the short-term effect is mainly represented by the customers' attention to the advertisment (Lavidge and Steiner, 1961). As an immediate response, attention is important because it serves as the antecedent of long-term impact, and it offers practical insights for the advertisement (Broach and Thomas, 1997).

It has long been recognized that attention is a significant factor affecting advertising effectiveness (Corkindale and Kennedy, 1975). It is believed that Lewis was the first to suggest that effective salesmanship requires that salesmen attract the attention of customers, maintain their interest, and create a desire (Lewis, 1898). The AIDA (Attention, Interest, Desire, and Action) model introduced by Strong (Edward, 1925) was probably the earliest advertising model in the literature. In AIDA, an attention reaction is

believed to be the first condition that leads to effective advertisements. Without attention arousal, the advertiser can hardly persuade the customer of anything (Edward, 1925).

In the past four decades, considerable progress has been made in the study of attention in the context of advertisement effectiveness. Rossiter and Percy have studied the relationship between customer attention and product attitude and preference. Rossiter and Percy pointed out that the attention of customers is capable of increasing their product attitude and preference, thereby leading to the ultimate sale (Rossiter and Percy, 1980). They believe that an advertisement can guarantee high memorability if it can hold the customer's attention for at least two seconds. From the psychological perspective, advertising can be viewed as a psychological process that occurs before the decision-making process. Cao presented five main activities in this Pychological Process. Among these five activities, attention can be defined as the allocation of a processing capacity to a stimulus, which influences the awareness and adaptation of the consumer. The only way to lead this process to the final stage is to guarantee that the advertisment catches audience attention (Cao, 1999).

In a world that is full of advertisements, attention is also an important measure of the competitiveness of an adverstisement. In the 1970's, Britt, Adams, and Miller showed that customers were, on average, exposed to between 300-600 advertisements per day (Wells, 1997). It is clearly impossible for customers to attend to all those ads. Now the amount of advertising and marketing to which North Americans are exposed every day has exploded over the past decade. Studies show that, on average, a customer sees 3,000 ads per day. In today's crowded markets and media, it is critical for advertisers to

understand how and when consumers devote attention to advertising stimuli. According to Advertising Response Modeling (ARM), which provides a framework to assess advertising performance by means of integrating several measures, gaining the customer's attention is the most important characteristic that enables advertising to break through (Wells, 1997).

Because of the importance of customer attention in the advertising process, it has been used to assess advertisement effectiveness. The primary concept of evaluating advertisement effectiveness through customer's attention has been established by Miniard (Radach et al., 2003; Rosbergen et al., 1997). They pointed out that it is important to know how and when the final consumer would pay attention to the commercial stimuli and to identify the critical factors that affect the patterns and strategies related to customer attention.

1.2 Objective

In the research conducted in the present thesis, we accept a fundamental assumption, namely, that the audience's attention level can correctly reflect an advertisement's effectiveness. As we previously mentioned, this assumption is supported by previous research in the literature. Given this assumption, our main task is to measure the *attention* defined in the context of advertisement effectiveness. Unlike previous research on advertisement effectiveness, we measure audience attention by using an eye-tracking method. Compared with other methods, such as the use of facial expressions, skin

conductance, and brain activity, eye tracking is more effective in terms of usability and flexibility.

The objective of the present research is to assess effectiveness of advertisements through audience attention measured by eye movements. Specifically, we attempt to specify the relationship between the intensity of an audience's eye movements and their level of attention in the context of TV advertising effectiveness. Throughout the history of eye-tracking research, several key variables have emerged as significant indicators of ocular behavior, including fixation, saccade, pupil diameter, and blinking frequency. By exploring the relationship between attention and eye movement, researchers have found that attention may affect saccade programming in different ways (M.Findlay, 2008). Braun and Breitmeyer have suggested that saccadic latencies depend on the disengagement of attention from any location in the visual field (Braun1 and Breitmeyer, 1988; Hoffmam and Subramaniam, 1991). O'Craven and his team have found that eye-blink frequency becomes low during high attention conditions (M.O'Craven et al., 1997). Similar results have also been obtained (Collins et al., 1989). To measure audience visual attention, we have chosen to analyze one type of attribute of audience eye movement, which is blinking frequency as suggested (M.O'Craven, 1997).

To assure that our choice of blinking frequency is appropriate, we first verify the feasibility of using blinking frequency by conducting an experiment. The objective of this experiment is to verify our first hypothesis:

H1. While watching TV advertisements, the audience's eye movement attribute, such as blinking frequency, is correlated to the intensity of audience attention.

H1 is a qualitative hypothesis. Once it is accepted, we will continue working on a quantitative hypothesis:

H2. While the audience is watching TV advertisements, the audience's eye data captured during TV advertisement watching could quantitatively reflect the level of the audience's attention.

We conduct one experiment to verify the hypothesis H1; we conduct two experiments to verify hypothesis H2. Note that the acceptance of H1 is the precondition of conducting the experiments that verify H2.

1.3 Contributions

Although it is clear in the literature that customer attention has considerable impact on advertising effectiveness, to our knowledge, it still remains an open question as to how to model the impact quantitatively. In the present thesis, we attempt to quantify, by using a set of controlled experiments, the relationship between customer visual attentions, which are measured by their eye movements, and advertising effectiveness. By analyzing the experimental results, we conclude that the intensity of the customer's visual attention defined in the context of advertising effectiveness can be correctly reflected by the audience's eye movements. This conclusion implies that eye-tracking tools can be used to develop automated systems that assess advertising effectiveness. This type of system has

the potential of significantly reducing the cost of labor and time needed to evaluate advertising effectiveness.

Another major benefit of using eye tracking to measure TV ad effectiveness lies in its practicability. Whereas conventional methods reveal data only on a descriptive level, the eye tracking method provides the possibility of revealing the audience's preferences at the perception or comprehension level.

1.4 Thesis organization

Chapter 1 is the introduction to the present research, which deals with the effectiveness of advertisements; Chapter 1 introduces the factors that affect advertisement effectiveness and the importance of audience attention. It is in this chapter that the objectives, contributions, and overview are presented. The rest of this thesis is organized as follows:

In Chapter 2, we conduct a detailed literature review of the relationship between advertising effectiveness and customer attention and the traditional techniques used for the evaluation of the effectiveness of advertisements. In particular, we present two major measures: self report measures and autonomic measures, which have been used in advertising effectiveness research to assess the influence of advertising stimuli on the audience. In this chapter, we also summarize the limitations that are a part of self-report measures and the reason why we introduce the autonomic measures.

In Chapter 3, we introduce the Eye-tracking approach, which is one of the autonomic measures. Also, we examine previous research achievements dealing with the relationship between eye-data and the eye-tracking method. In this Chapter, we also

propose a novel method for assessing the effectiveness of TV commercial advertisement by using the automated capturing and analysis of audience eye movements. This method is based on the assumption that some attributes of audience eye movements are correlated to their visual attention as defined in the context of TV commercial advertisement effectiveness.

In Chapter 4, 5 and 6, we present three experiments that we have conducted to validate our research hypotheses.

Chapter 4 presents the experimental setup and the analysis result to obtain a qualitative conclusion that audience eye movement attributes are correlated to visual attention while watching TV commercial advertisements.

Chapter 5 conducts another experiment to further verify the correlation pattern between audience eye movements and the attention paid to TV commercial advertisements.

Chapter 6 conducts the third experiment, which is another piece of evidence suggesting that particular eye data is a quantified evaluation parameter to measure the attention of the audiences.

Finally, in Chapter 7, we draw a conclusion from our research and present several directions for future work.

Chapter 2
Literature Review

In the present thesis we use an eye tracking method to measure the intensity of the audience's attention as defined in the context of advertising effectiveness. Although we focus on the attention component of the advertising effectiveness assessment, it would be helpful to put our research in a broader context of advertisement effectiveness measurements. In this chapter, we first review the traditional approaches of advertisement effectiveness measurement in a general sense. We then turn our attention to attention measurement in the context of advertising effectiveness.

2.1 Traditional techniques of advertisement effectiveness measurement

Copy research is also referred to as copy testing, which is an aspect of advertising research and includes both the pre-testing and the post-testing of advertisements or commercials in print or broadcast. It can be classified conveniently according to the methods used (Lucas and Britt, 1963a). Although there is no single test that can provide a comprehensive evaluation of an advertisement, the research executive must first identify the advertising objective and then select a method or a combination of methods.

The traditional copy-testing approach of advertisement effectiveness focuses on certain specific effects of the advertisement. The common measures used for the testing of advertising effectiveness include Aided and Unaided recall of the brand name or advertisement, Attitude Tests, Inquiry Tests and Sales Tests (Wells, 1997). These measures aim to test the advertising's persuasiveness (beliefs, attitude change, purchase

intentions) through customer rating (Reynolds, 1997). These measurements are useful in answering the following questions. These questions are related to the consumer's response to the advertisement.

- Do the consumers recall the main copy point of the ad?
- Do they believe the main claim?
- Do the consumers like the brand?
- Do the customers like the advertisement?
- Do the customers have a stronger intention to buy the product?

The recent copy research validity study done by the Advertising Research Foundation (ARF) further endorsed the use of multiple measures (Haley and Baldinger, 1991). The inclusion of several measures in current copy research systems reflects the need to capture the various dimensions of persuasion. Consequently, researchers have begun to evaluate advertising performance with a variety of measures including those using memory–based intrusiveness levels of recall or recognition (Abhilasha and Scott, 1997). Among the few studies exploring this relationship, the results of a study of outdoor (billboard) advertising suggest respondents who had a positive attitude toward advertising in general seemed to recall more outdoor advertisements than did those who had a negative attitude (Naveen et al., 1993). In another study, James and Kover (1992) evaluated the impact of advertising in general on advertising "involvement" measured as the amount of time spent looking at print advertisements (Mehta, 2000) .

Since the objective of all advertisements is psychological, the testing involves using psychological measures (Lucas and Britt, 1963b). There are some more important categories of psychological objectives including the elements given below. They are initial attention, perception, continued favorable attention or interest, comprehension, feeling, emotion, motivation, decision, imagery, association, recall and recognition (Lucas and Britt, 1963a). These elements may produce the favorable response, which is of create conditions likely to pursue the buying process.

In other psychology research, it is said that there are two main reasons for defining the process of viewing advertising as a psychological process that takes place before the decision-making process. One of the reasons is that advertising usually stimulates emotions first and then may have effects on the consumer's decision. The other reason is that advertising effectiveness sometimes can be evaluated only at the psychological level and there can be no explicit effects on the decision and behavior of the consumers (Cao, 1999).

In his article, Darrel Blaine provides a brief comment about the techniques, which can be divided into several methods as follows:

- Tests based on Memory
- Opinion and Attitude Rating
- Projective Methods
- Laboratory Tests and Content Analysis

- Inquiries and Sales Measures

In reference to these techniques of measurement, there are certain methods that are usually applied before the final advertisements are circulated. They include opinion and attitude ratings, projective techniques, and methods of laboratory testing and content analysis. By contrast, the measures used after circulation include tests based on memory, those involving changes in attitudes, and those based on inquiries and sales (Lucas and Britt, 1963a).

Among these methods, opinion and attitude rating was the first method widely applied in evaluating the effectiveness of general consumer advertisements (Lucas and Britt, 1963a).

Most research procedures that rely upon subjective opinion or personal reporting are really ratings rather than tests. It assumed that people tell an investigator that one advertisement is more likely than another to make them buy a certain product. That is the expression of their opinion. By parity of reasoning, people's saying that one advertisement is more interesting than another can be regarded a simple reporting of a subjective response. Thus, on the opinion and attitude rating test, people are first provided with a scale and a set of nouns or adjectives describing the advertisement; they are asked to apply a scale or indicate their attitudes in relation to the advertisement. They base their responses on their feelings. The attitude rating thus helps assess the advertisement effectiveness by examining whether audiences are interested in, pay attention to, understand and remember the information delivered by the advertisement.

Based on these previous studies regarding the techniques of advertising effectiveness measurement, the attitude rating technique is well adapted to audience attention measurement.

2.2 Measurement of audience attention

Given the importance of attention in the advertising process, the accurate measurement of attention is essential. However, it is not easy to measure audience attention.

There are two major methods that are used to measure the audience emotion created during the viewing of advertising: Self-reporting measures and autonomic measures. Both of them have been applied in advertising effectiveness research to assess the response of audiences to advertising stimuli.

In a study dealing with attention and emotion, Compton performed a series of experiments. The results indicated that emotion and attention are intimately related via a network of brain systems that monitor for salient information, maintain attention on the task, repress irrelevant information, and select appropriate responses (Compton, 2003). In addition, Gerald Matthews and Adrian Wells, the authors of *Attention and Emotion: A Clinical Perspective* (1994) wrote: "Emotions and attention are intimately linked" (Smith, 2004).

In the present study, we have assumed that the methods measuring audience emotions can be applied to the audience attention measurement.

For many years, audience attention to advertising has been measured mainly by using an attitude rating technique, which completely depends on the accuracy of the data acquired by self reporting.

2.2.1 Self report measures and limitations

Self-reporting measures have been used to measure audience attention to advertising from the 1980's on. These measures register the respondent's subjective feeling. A "subjective feeling " is defined as the consciously felt experience of emotions as expressed by the individual (Scount P, 1988) .

As mentioned in Section 2, most conventional techniques of advertisement effectiveness measurement are self-reporting. In particular, in attitude rating, individuals are asked to express their emotions verbally by means of open-ended questions or to rate their emotions by using semantic differentials or scales. The results are collected from the questionnaire. They are easy to analyze. Most statistical analysis software can easily process them.

However, there are some limitations concerning the reliability and validity of this method. Although most reports based on scale are sufficiently reliable, the scales often consist of the subject's own adjectives.

First of all, the responses on the questionnaire may not match the respondent's real feeling because the respondents may not be aware of how they feel exactly. It is also possible that the interviewers may be unwilling to report their desirability concerns.

Secondly, self-reporting is a retrospective approach rather than an approach in real time. Self-reporting measures the subject's feeling only after the advertising stimuli is shown, not while it is being presented. This is why it is so hard to know which part of the commercial evokes the most intense attention by using copy testing for commercials.

Thirdly, In Morris's research, the findings reveal when using a self-reporting measure in predicting behavioral attitudes like brand attitude and behavioral intentions like purchase intention, a subject's emotions dominate the cognitive aspects.. (Morris J, 2002).

Fourth, although self report measure is using questionnaires, which are familiar to most people (Berdie and Anderson, 1986). Nearly everyone has had some experience completing questionnaires and they generally do not make people apprehensive questionnaires are simply not suited for some people. For example, a written survey to a group of poorly educated people might not work because of reading skill problems. Also, questionnaires are not suitable for research with children. Many investigators have confirmed that slight changes in the way questions are worded can have a significant impact on how people respond (Arndt and Crane, 1975 ; Belkin and Lieverman, 1967). Several authors have reported that minor changes in question wording can produce more than a 25 percent difference in people's opinions (Payne, 1951).

Another issue involves the fact that for the subjects, rating a large set of questions may produce fatigue in the respondents, which causes the unreliable results.

All of these present a big problem for traditional research. Due to these drawbacks, the use of self-reporting measures in advertising research has increasingly needed to be replaced by autonomic measures.

2.2.2 Autonomic measures

As stated above, the real feeling of the subject while watching advertising is partially beyond an individual's control. The autonomic measure being applied in advertising research has become an inevitable trend.

Autonomic reactions include human beings' facial expressions (e.g. smiling, frowning) and psychological reactions (e.g. sweating) primarily caused by changes in the autonomic nervous system (Bagozzi, 1991).

- Facial expressions visibly reflect some basic emotions like joy, disgust or anger. The instruments were developed to detect this sort of facial muscle movement beginning in the 1970s. Particularly, a coding system was applied by Derbaix (Derbaix, 1995) in a study comparing a verbal report and the coding of facial expressions to a set of commercials. Hazlett, another researcher, performed a study to compare emotional reactions to TV commercials measured by devices with results from self-report scales (Hazlett, 1999). He concluded that, overall, facial device is a more sensitive indicator for emotional reactions to TV commercials. The results also indicate that, compared to the self-report, facial device measures were more related to brand recall measures. Notwithstanding these general positive evaluations, facial device measures also suffer some

limitations. First of all, the measurement of facial devices has to be a completed in unnatural lab settings. Moreover, the placement of the device on the subject's face causes the subject's facial expression to be under pressure.

- Skin conductance (SC) is another frequently used measure of the autonomic system. Based on the interviews with market researchers applying SC, LaBarbera and Tucciarone concluded that SC seems to be a better predictor of market performance compared to self-report measures (P.A and Tucciaron, 1995). However, measuring SC and analyzing SC data requires sensitive equipment and a lot of practice, which has caused the use of SC to be scarce in advertising research. Additionally, other factors like fatigue, medication, and women's menstrual cycle can influence SC responses.

- Brain Activity is a measurement of emerging technique, in which brain wave recording devices identify active brain regions as people are exposed to ads (Smith, 2004). Thus, in principle, EEG measures have the potential to provide a more direct and objective method for gauging the intensity and nature of viewer engagement.

- Heart Rate is significant in psychophysical research because the beating speed of our heart is an indicator of various phenomena, e.g. attention, arousal and cognitive or physical effort (Lang, 1990). In Lang's study, she monitored the subjects' changes in heart rate as they viewed the stimulus. She concluded that

heart rate can be a valid real-time and continuous measure of attention (Lang, 1990).

- In psychological parts of the attention evaluation, eye tracking is a common technique. With eye tracking, Sanoma Magazines Belgium completed its research to measure the pure impact of advertisements. This tool offered a better understanding of the cognitive processes used by consumers to decode print messages. In their research, the attention was defined as the successive fixations and their durations that readers showed when they watched an advertisement. In a traditional questionnaire this would be measured by asking what part of the ad the individual looked at first and for how long, what part the individual looked at second and for how long, and so on. It is immediately clear that to collect this kind of information one needs to utilize eye tracking techniques rather than questioning techniques.

When it comes to the advantages and disadvantages of these above autonomic measures, we agree with Morris (2002) that eye tracking is a quick and user-friendly tool for measuring emotional responses to advertising.

Compared with other methods such as facial expression tracking, skin conductance tracking, and heart rate tracking, the eye-tracking method is more effective in terms of its usability and flexibility. This includes the following:

- Quick set up;
- No calibration is required for many applications;

- Intuitive user interface;
- Real-time feedback of eye movement data;
- Most eye-trackers are able to track eye data in both Bright mode and Dark mode;
- Also, eye-tracking instruments are suitable for cross culture research and research with children.

In this study the research objective is to evaluate TV advertising effectiveness through the assessment of audience attention. Although there is not a complete one-to-one correspondence between eye movement and attention, human intention and interests can be revealed automatically by tracking their eye movements (Pieters et al., 1995). This is because it is generally assumed, "Where the eyes go, so goes attention" (Christianson et al., 1991).

Because of the aforementioned benefits, we chose in favor of the eye tracking method for attention assessment. In the following section we systematically introduce eye movement, eye data, eye tracking and the relationship between eye movement and audience attention.

Chapter 3
Eye Movement and Eye-Tracking Method

In this chapter, the eye tracking approach, one of the autonomic measures, is introduced. Also, we examine previous research achievements based on print media dealing with the relationship between eye data and the eye-tracking method. Unlike the previous research, our research focuses on TV commercials rather than print, but we use the eye tracking method as well. The study determines cognitive attitudes by analyzing continuous audience eye data in relation to a timeline of the TV commercial scenes. The selected attribute of audience eye movements is blinking frequency for two reasons. The first reason is that blinking frequency is one of the most important indicators of visual attention. The other reason is based on the conclusion of Jacob Klen and Peder Wolkoff, that viewing an advertisement is an external stimuli to the eye, which causes eye blinking and affects the blinking rate (Klen and Wolkoff, 2004).

Furthermore, in this section we propose a novel method for assessing the effectiveness of TV commercial advertising by using the automated capturing and analysis of audience eye movements. This method is based on the assumption that some attributes of audience eye movements are correlated to their visual attention as defined in the context of TV commercial advertisement effectiveness.

3.1 Eye movement and eye data

Eye movement can be regarded as both voluntary and involuntary movement of the eyes, which can help acquire fixate and track visual stimuli. Eye movement is typically divided into fixations and saccades, that is, when the eye gaze pauses in a certain position and when it moves to another position, respectively. So, the primary stage of studying eye movement is examining eye information like fixations, saccades, pupil diameter, blinks, also known as eye tracking. To investigate eye movement, the general definition and description of key eye parameters (or eye data) are needed to interpret. Based on the interpretation it is possible to carry on the research.

In different fields, fixation has a different interpretation of the adjacent. In our research we are concerned with visual study, so it is interpreted as maintaining the gaze in a constant direction (Manor and Gordonb, 2003).

Saccade can be described as movement of an eye, head or other part of a human being's body or device. It can also be a fast shift in frequency of an emitted signal or other quick change. Vision saccades are quick, simultaneous movements of both eyes in the same direction (Cassin and Solomon, 1990).

Normally, the pupil constricts to about 1.5mm in bright light conditions and dilates to about 8/9 mm in dim conditions. Pupil diameter has been coupled with various cognitive and emotional processes. In the research of Loewenfeld (1999), and Hess and Polt (1960), it was found that "a man's pupils will enlarge promptly and substantially when he is looking at a comely girl". On the other hand, pleasant advertisings led to pupil dilation

and unpleasant advertisings to papillary constriction. This idea and related data excited the marketing and advertising community.

In general, there are three types of blinking. A rapid closure movement of the eyelids is regarded as the first type of blinking. It is of short duration as response to a variety of external stimuli, usually auditory, cognitive, trigeminal or visual, including a component of other motor behaviors. The second type, voluntary (conscious) blinking, and third type, involuntary (spontaneous) blinking, occur without external stimuli and at a fairly constant frequency (PA and C, 1998). Among the three types, two kinds of blinking occur without external stimuli (voluntary blinking and involuntary blinking). Only the first type is reflex blinking, which supports our study. The blinking frequency or blinking rate is related to the visual demand of the task and is determined by the "blinking center", but it can also be affected by an external stimulus (JR et al., 1999).

The above parameters have been studied in various industries. The study of such data is known as eye tracking.

3.2 Eye tracking

Eye tracking can be described as a process to measure where people look or how eyes move relative to the head. Different eye trackers are invented to measure eye positions and capture the eye movements. Eye trackers are used in research on the visual system, in psychology, cognitive linguistics and product design.

3.2.1 Eye tracking method

Since the 1800s, studies of eye movement have been made using direct observations. In 1879 in Paris, Louis Émile Javal observed that reading does not involve a smooth sweeping of the eyes along the text, as previously assumed, but a series of short stops (called fixations) and quick saccades (Huey, 1947). The history of academic research in this area started in the early 1900s when Nixon (1924), Proffenberger (1925) and Karskake (1940) applied eye movement research to determine the attention capture value of magazine and newspaper advertisements with varying size, color and black-and-white ads (Wedel and Pieters, 2008). Bettman et al. (1991) had already begun to study the advantages of eye tracking over other methodologies to gain insight into moment to moment processing and consumer decision marketing (Wedel and Pieters, 2008). In their study, they also pointed out the difficulties of the operation, which prevented the technology from reaching its full marketing potential. In the 1950s, Yarbus conducted systematic research on the relationship between human eye movements and thought processes by using eye tracking (A.L.Yarbus, 1954). It was shown that there was a strong relationship between an observer's fixations and interest, which is reflected by the fact that the observer's attention was usually focused on certain elements of a picture. This important eye-tracking research and his 1967 book, "Eye Movements and Vision", is very highly quoted and often referred to when arguing that the task given to a person has a strong influence on his or her eye movements. Such a picture is shown in Figure 1.

Initially in academic research it was difficult to examine high levels of visual attention in the various media (Burke and Srull, 1988). This situation has changed in recent years due to the new generation of eye-trackers, which not only enable recording eye movement for big quantities of stimuli, but which also make consumers under a natural exposure conditions with high precision.

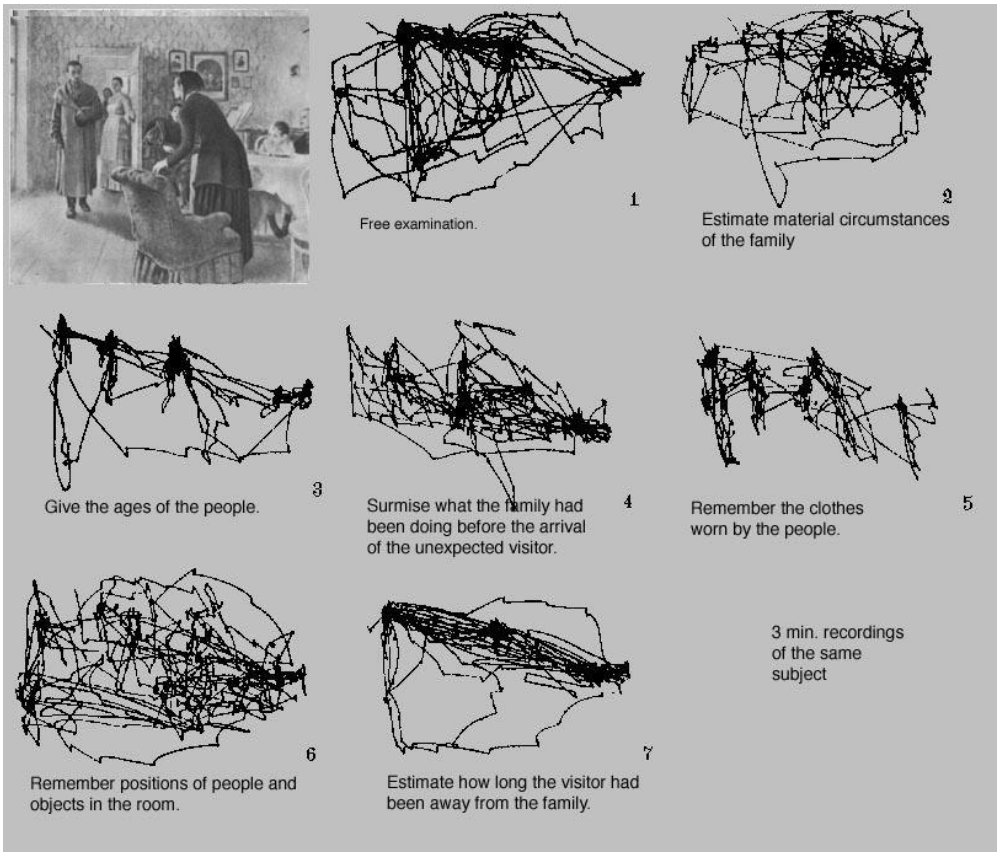


Figure 1 Yarbus (1967) and his eye movement study

Since the 1970s, eye-tracking research has expanded rapidly, particularly reading research. A good overview of the research in this period is given by Rayner (1978). In his

earlier review he argued that eye movement research and the success of that research in modern society would depend on the ingenuity of researchers in designing interesting and informative studies. Also, in his studies he mentioned it has been improvements in eye movement recording systems that have allowed measurements to be more accurate and more easily obtained. Numerous works have dealt with methods of analyzing eye movement data (Kliegl and Olson, 1981), and much has been learned about the characteristics of various eye-tracking systems (Deubel and Bridgeman, 1995). More importantly, they have yielded tremendous technological advances that have made it possible to interface laboratory computers with eye-tracking systems so that large amounts of data can be collected and analyzed.

3.2.2 Eye tracker

The earliest eye tracker, built by Edmund Hury, used a sort of contact lens with a hole for the pupil. Huey studied and quantified regressions (only a small proportion of saccades are regressions) further to show that some words in a sentence are not fixated. Buswell built the first non-intrusive eye trackers by recording on the film the beams of light that were reflected on the eye (Buswell, 1922). Using the trackers, he conducted systematic studies of reading and picture viewing (Buswell, 1935; Buswell, 1937).

Different eye trackers have been invented to capture eye movements. Eye trackers measure rotations of the eye in several ways, but principally they fall into three categories.

One type uses an attachment to the eye, such as a special contact lens with an embedded mirror or magnetic field sensor, and the movement of the attachment is measured with the assumption that it does not slip significantly as the eye rotates.

The second broad category uses some non-contact, optical method for measuring eye motion.

The third category uses electric potentials measured with electrodes placed around the eyes (Crane and Steele, 1985).

Since its invention, eye-tracking technology has greatly improved. With the development of eye-tracker programming techniques, measuring visual attention became easy and accurate. Many eye-tracking studies and eye trackers are now used in cognitive, psychology, and human-machine interface design (Minoru et al., 2002).

Eye tracking can aid in the assessment of ad effectiveness in such applications as copy testing in printing, video and graphics. The motivation for utilizing an eye tracker in advertising research stems from the desire to understand customer actions.

3.3 The relationship between eye data and audience attention

Although there is not a complete one-to-one correspondence between eye movement and attention, human intention and interests can be revealed automatically by tracking their eye movements (Pieters et al., 1995). Many publications have revealed the close relationship between human eye movements and psychological processes through tracking some critical factors among the eye parameters. Eye movements are tightly associated with visual attention, which makes them eminent indicators of the covert

visual attention process (Wedel and Pieters, 2008). Generally, people search stimuli for meaning and not for specific targets (Gould, 1976). Kahneman (1973) argued that in free-viewing or undirected attention tasks in which they control the time they spend attending to a series of pictures, subjects who are given no specific instructions behave similarly to those instructed to linger on “interesting” stimuli, and quite differently from those who follow a “pleasantness” set. This suggested that the eyes tend to be guided to areas which are found that informative areas are indentified very early in observations (Pieters et al., 1999). In natural environments eye movements are also made toward task-relevant targets, even when high spatial resolution is not required. Such 'attentional' eye movements, made without conscious intervention, can reveal attentional mechanisms and provide a window into cognition (Pelz).

Experiments have suggested that the attention played an important role in voluntary eye movements (Shepherd et al., 1986). Throughout the history of eye-tracking research, several key variables have emerged as significant indicators of ocular behaviors, including fixation, saccade, pupil diameter, and blinking frequency. By exploring the relationship between attention and eye movement, researchers have found that attention may affect saccade programming in different ways (Findlay, 2008). Yarbus conducted systematic research on the relationship between human eye movements and thought processes (Yarbus, 1954). It was shown that there is a strong relationship between an observer’s fixations and interest. Braun and Breitmeyer suggested that saccadic latencies depend on the disengagement of attention from any location in the visual field (Braun1 and Breitmeyer, 1988; Hoffmam and Subramaniam, 1991). O'Craven and his team found

that eye blink frequency slows during high attention conditions (M.O'Craven et al., 1997). Similar results were also obtained (Collins et al., 1989).

The first studies using eye movements to study the processing of ads appeared in the 1960s (Robinson, 1963). Since then, oculomotor measures have become a technically feasible and potentially powerful option in the arsenal of available methods. However, this type of work still represents a relatively small segment in the substantial literature on advertisement effectiveness. In general, the goal of most studies is to gather information about which part of advertisement respondents direct their attention and how deeply people process the information offered by an advertisement (Keitz, 1988). An excellent overview of the literature on eye tracking in advertisement research has been provided by Rosbergen (1998). Some of the most important studies are listed in Table 1, based on a more detailed table in Rosbergen's dissertation.

Table 1 A compilation of eye-tracking studies in advertising research (modified from Rosbergen, 1998)

Reference	Factors examined	Aspects of eye movements that were analyzed
Robinson (1963)	Ad size	Amount of attention per ad & number of saccades between ad quadrants
Starch (1966)	None	Amount of attention per ad
Krugman (1968)	Repetition	Number of 1 x 1 inch ad elements that are fixated
Treistman and Gregg (1979)	None	Amount of attention per ad element
Witt (1977, in Kroeber-Riel 1979)	Erotic illustration	Number of eye fixations per ad element
Edell and Staelin (1983)	Ad structure	Amount of attention per ad element
Young (1984)	Size & clutter	Looked at outdoor board, product advertised and copy or not
Bogart and Tolley (1988)	None	Number of fixations per ad
Janiszewski (1993)	Length of copy	Amount of attention per ad element
Janiszewski and Warlop (1993)	Classical conditioning	Order of fixation on soda brands
Krugman et al. (1994)	Type of warning	Amount of attention to the warning and time to first fixation on the warning
Lohse (1997)	Color, size & position	Amount and order of attention to ads

*The term "attention" refers to various spatial and temporal eye movement measures

Unlike the previous research, our research focuses on TV commercials rather than print, but we used the eye-tracking method as well. The study determines cognitive attitudes by analyzing continuous audience eye data in relation to a timeline of the TV commercial scenes. In the research conducted in this thesis we made a fundamental assumption, which is that audience attention level can correctly reflect advertisements' effectiveness. We measured the audience attention using the eye-tracking method. In the following section, we propose a novel method for assessing TV commercial advertisement effectiveness using an eye-tracking method. This method is based on the assumption that the attributes of audiences' eye movements are correlated to their visual attention defined in the context of TV commercial advertisement effectiveness. The attribute of audience eye movements that we selected is blinking frequency for two reasons. The first reason is that blinking frequency is one of the most important indicators of visual attention. The other reason is based on the conclusion of Jacob Klen and Peder Wolkoff, that viewing an advertisement is a kind of external stimuli to eye, which causes eye blinking and affects the blinking rate (Klen and Wolkoff, 2004).

3.4 Experiment introduction

To deal with the problem introduced in Section 2, we conclude that the intensity of customers' visual attention correctly reflects the level of the TV advertising effectiveness. Thus, we can evaluate the TV ad effectiveness through the assessment of audience attention when watching the advertisement.

In order to achieve the objective above we chose the eye-tracking method. The attribute of audience eye movements we analyzed is blinking frequency.

The hypothesis underlying our study is that audience attention can be assessed by studying audience eye movement. The following two specific hypotheses were tested in our study:

H1. Audience eye movement attributes are correlated to their attention while watching TV advertisements.

H2. The audience eye data captured during TV ad watching can quantitatively reflect the level of audience attention, which is in line with the result obtained by the traditional questionnaire-based method.

Three experiments were conducted to verify the hypothesis. Note that the acceptance of H1 is the precondition of conducting the H2 verification experiments. In the first experiment, we expected to get the qualitative conclusion that audiences blinking frequencies are correlated to their attention while they watch TV commercials. Thus, the first experiment is called "Qualitative testing of the correlation between eye movements and audiences' attention". The second and third experiments are the further steps of our research. We aimed to verify the correlation pattern between audience eye movements attributes and attention paid to the advertisements. In experiments 2 and 3, two comparative trials were applied to support our hypothesis 2. That is, we compared the results from the eye-tracking method and traditional questionnaire-based method. Therefore, we named experiments 2 and 3 "Quantitative testing of correlation between

audience eye movements and Attention with comparisons between multiple TV Commercials" and "Quantitative testing of the correlation between audiences' eye movements and attention with comparisons between multiple scenes of one TV commercial" respectively.

3.4.1 Experiment devices

In our experiment, an eye-tracker, FaceLAB 4.5, was used to capture eye behaviors using Sony Cameras FCB-EX480B and two infra-red lasers for tracking in night/dark mode. The FaceLAB 4.5, developed by "Seeing Machines", is a highly accurate vision-based eye-tracking system. The system continuously monitors the head pose, gaze direction and eyelid closure information in a real-time manner. Furthermore, it's easy and quick to synchronize the subjects' eye data and what stimulus they were viewing, which is crucial for differentiating the subjects' attention level through eye data analysis. No equipment needed to be worn during the testing. Furthermore, the system is flexible enough to track users' eye movements against displays of varying sizes and is able to work with all eye types, in light and dark environments, and with subjects wearing sunglasses, contact lenses, and most eyeglasses. Figure 2 shows the hardware system of FaceLAB 4.5; Figure 3 shows the systems' real-time eye-tracking user interface.

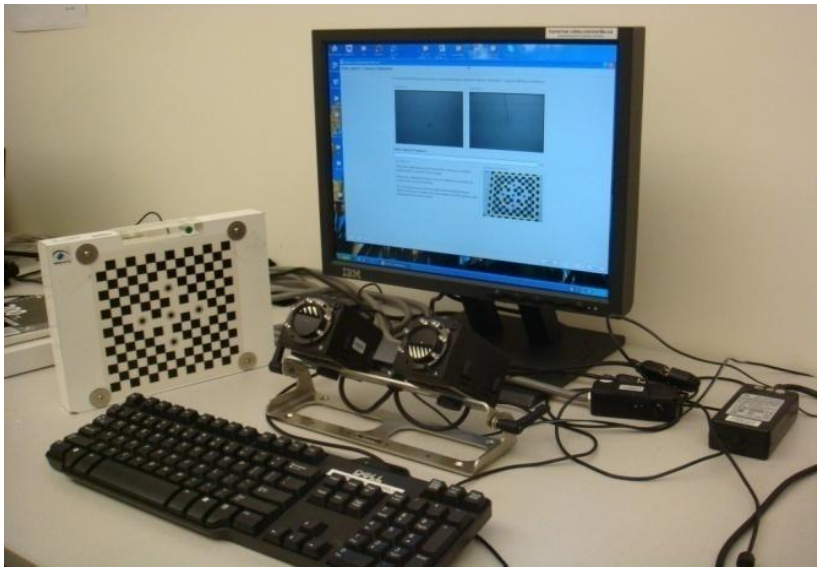


Figure 2 Hardware of FaceLAB eye-tracking system

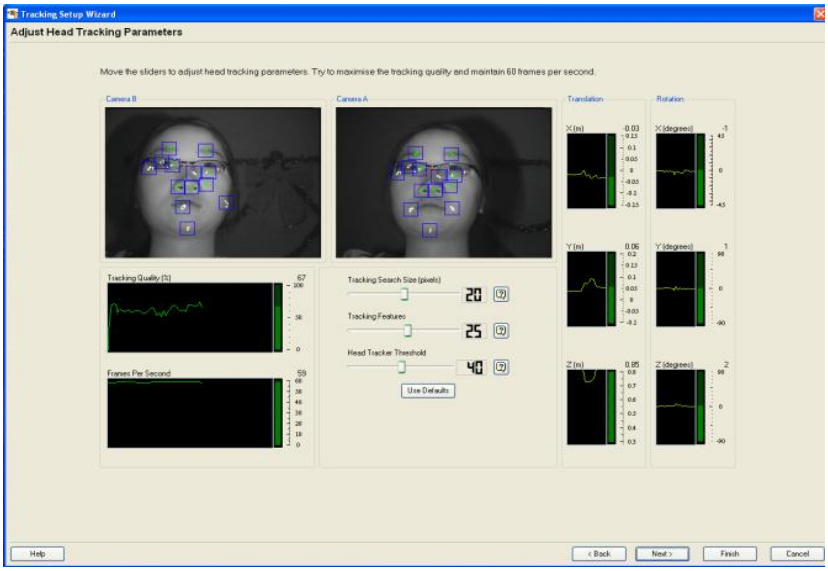


Figure 3 GUI of FaceLAB eye-tracking system

3.4.2 Experiment subjects

Five to Six subjects are invited to participate in each experiment. Participants are selected because of three reasons. Firstly, it's a pilot and primary study to develop, adapt and

check the feasibility of techniques, to determine the reliability of measures. Secondly, the subjects have certain characteristics in common that relate to the topic of the focus group. Thirdly, the data collected from each subject in the experiment are sufficient for the experiments data analysis by a statistical method in 95% confidence interval. So, we have a small group of subjects.

3.4.3 Experiment data processing

The purpose of data processing and analysis is to build the correlation between the raw data of eye movement and attention. This research was carried out using the FaceLAB 4.5 eye-tracking system. The time window for blinking frequency/rate was kept under 60 frames per second and the results generated in log files were converted into txt format and stored in FaceLAB 4.5. A statistical approach is followed to analyze blinking frequency parameters by calculating mean and standard deviation.

Below are the data processing flow charts of the three experiments respectively.

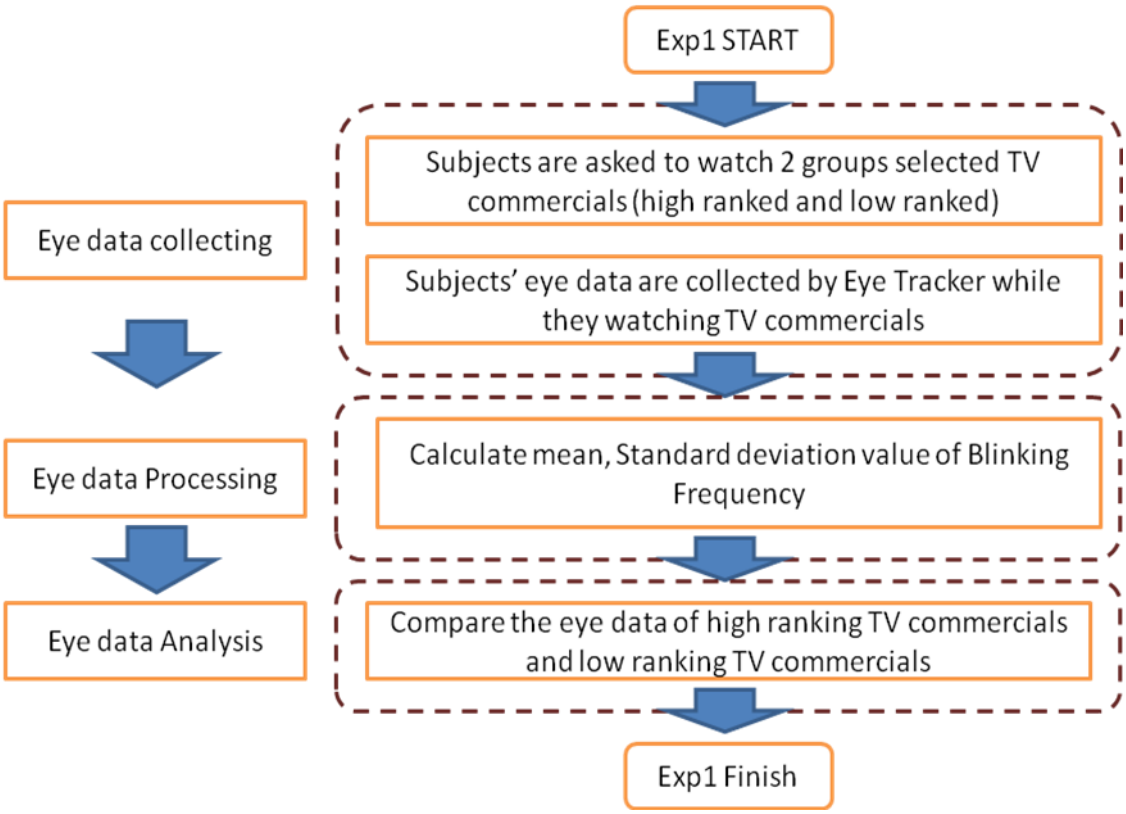


Figure 4 Flow chart of data processing (Experiment 1)

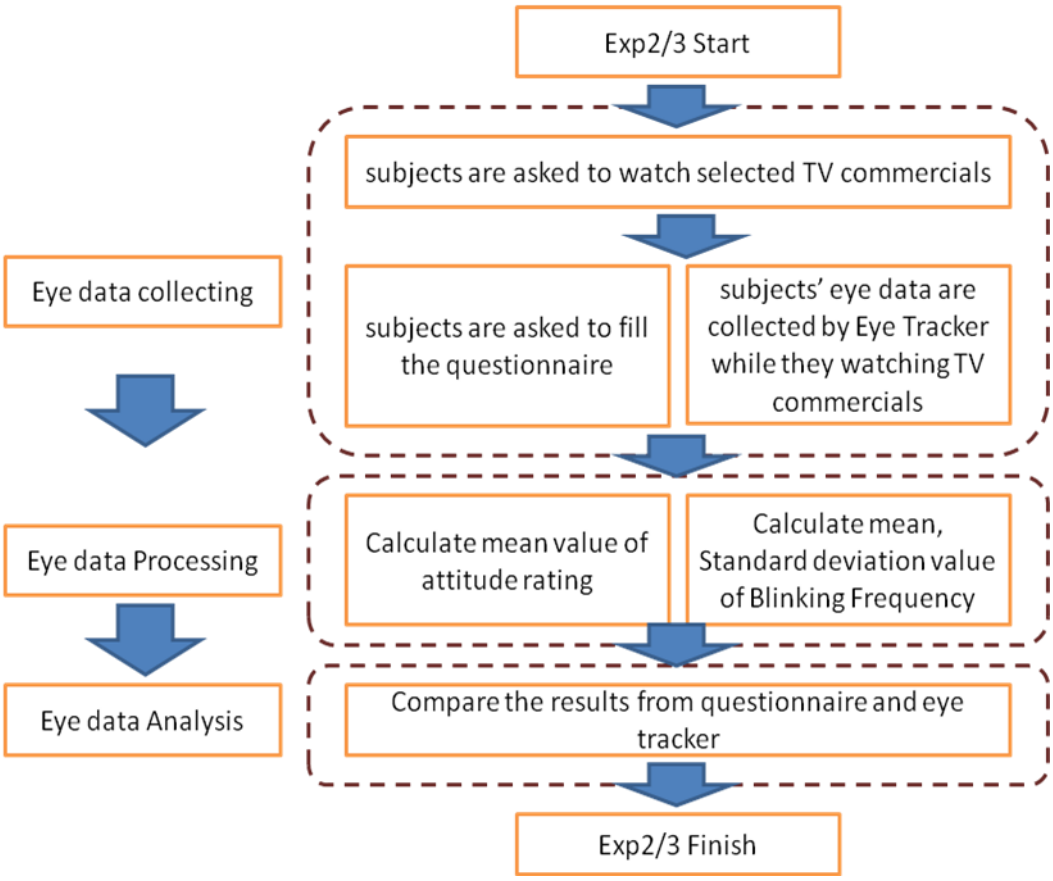


Figure 5 Flow chart of data processing (Experiments 2 and 3)

Chapter 4
Experiment 1: Qualitative Testing of the Correlation between Eye Movements and Audience Attention

In this chapter, we present the first experimental setup, procedure and the analysis result to obtain a qualitative conclusion that audience eye movement attributes are correlated to visual attention while watching TV commercial advertisements.

4.1 Experiment method

The experiment 1 is conducted to exam the hypothesis H1. We want to know if the attributes of audience eye movements are correlated to audience visual attention while watching TV advertisements. The main objective is to obtain a qualitative conclusion.

Eight 30-second television commercials were selected and divided into two groups as stimuli with each group containing four TV commercials. In the first group, the four TV commercials were chosen from a number of high-ranking TV advertisements on www.youtube.com rated by audiences. In contrast, in the other group, four TV advertisements with low-ranking were selected. The brands, products and snap shots of the selected high-ranking TV commercials are as follows:

- Microsoft Windows phone service
- ipod Shuffle
- HTC mobile service
- Tabasco sauce

Figure 6 Microsoft Windows phone service TV commercial snap shot

Figure 7 iPhone Shuffle TV commercial snap shot

Figure 8 HTC mobile service TV commercial snap shot

Figure 9 Tabasco sauce TV commercial snap shot

The brands, products and screenshots of the selected low-ranking TV commercials are as follows:

- Veidt airline1

- Doritos chips
- Carvel ice cream
- Veidt airline2

Figure 10 Veidt airline1 TV commercial 1 snap shot

Figure 11 Doritos chips TV commercial snap shot

Figure 12 Carvel ice cream TV commercial snap shot

Figure 13 Veidt airline1 TV commercial 2 snap shot

This experiment is designed as within-subjects, where each subject was asked to watch two groups of TV commercials and the subjects' eye data were recorded simultaneously by an eye-tracker (FaceLAB system). The collected eye data is analyzed to find out if the

eye movements would change with the audience attention when they watched the TV advertisements.

4.2 Experiment 1 subjects

Five graduate students from Concordia University voluntarily participated in the research. They regularly watched TV and English was their native or working language. Each experiment for one subject lasted approximately fifteen minutes.

4.3 Experiment 1 procedure

Subjects were invited separately to come to the lab where the experiment would take place. After signing the consent form (Refer to the Appendix 1), the subject was asked to watch the two groups of TV commercials in sequence and their eye-data were recorded. Subjects were asked to sit in front of the LCD from a comfortable distance, and the eye-tracker was placed lower than the LCD directly facing the subject. The experiment setting is shown in Figure 14. After an explanation of the eye-tracking system, calibration of the subject's eye took place. Hence, when a subject was watching the advertisements, his/her eye movements were observed simultaneously by the eye-tracker (FaceLAB system).

Figure 14 Experiment setting

4.4 Experiment results

As shown in Figure 15, the subjects' blinking frequency (BF) was lower when they watched ads with the higher ranking (blue bars) than when they watched ads with the lower ranking (red bars). Hence, two groups of BF data were captured while audiences watching randomly selected high ranking and low ranking TV ads. Sample BF data were scatter plotted in Figure 16 and Figure 17. The mean values of BF associated with high ranking TV ads and low ranking TV ads are presented in Table 2.

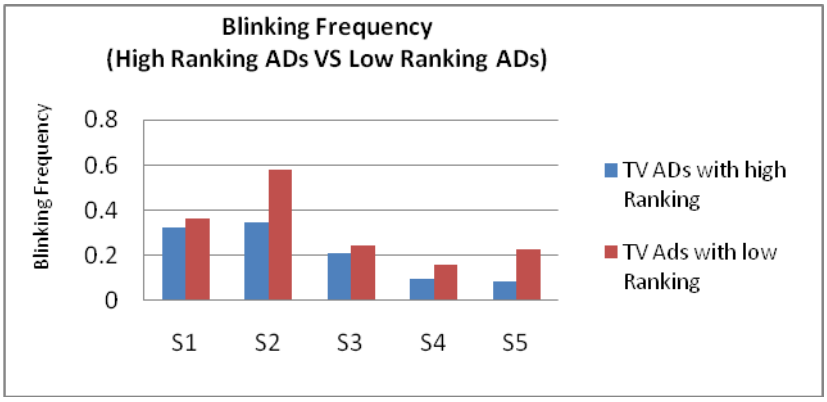


Figure 15 Pattern of audience blinking frequency while watching low and high ranking TV

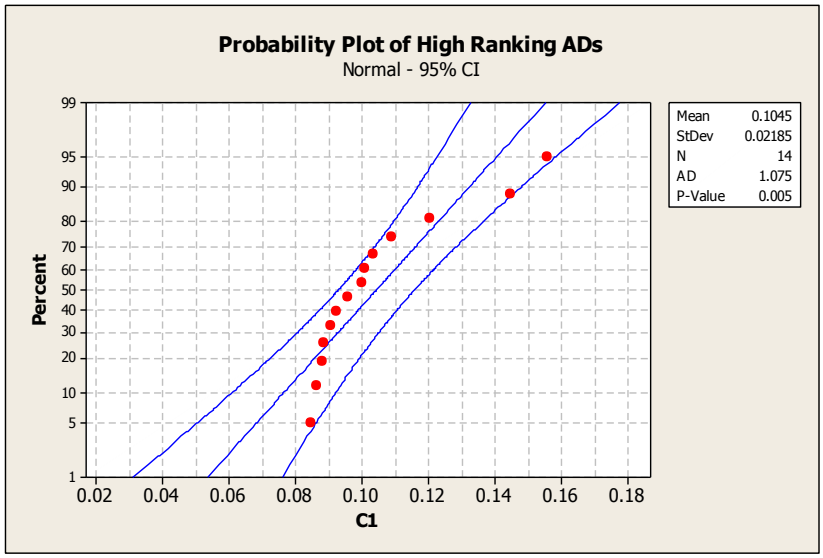


Figure 16 Probability plots of high ranking Ads

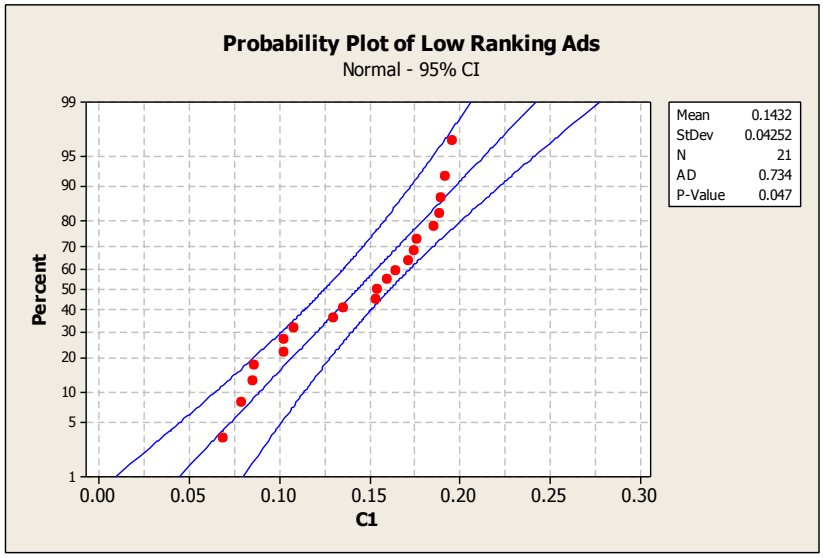


Figure 17 Probability plots of low ranking Ads

In addition, we employed hypothesis t-testing to verify if the audience' BF were lower when watching high ranking TV ads. The t-testing construction is shown in the following equations.

Equation 1 T-testing Equation

$$H_0: \mu_1 - \mu_2 = 0 \qquad (1)$$

$$H_\alpha: \mu_1 - \mu_2 < 0 \qquad (2)$$

$$S_p{}^2 = \frac{n_1 - 1}{n_1 + n_2 - 2} S_1{}^2 + \frac{n_2 - 1}{n_1 + n_2 - 2} S_2{}^2 \qquad (3)$$

$$t_0 = \frac{\bar{x}_1 - \bar{x}_2}{S_p \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \qquad (4)$$

In equations (1) and (2), μ_1 and μ_2, are the means of the audience BF when they watched high ranking TV ads and when they watched low ranking TV ads respectively.

If $t_0 < -t_{\alpha, n_1 + n_2 - 2}$, we can reject H_0 (1) and accept H_α (2), which means the audience' BF was lower for watching high ranking TV ads than for watching low ranking TV ads. The subject's BF while watching high and low ranking TV ads is represented by as sample 1 and sample 2, respectively, as shown in Table 2. It was derived that subject's BF were lower while watching high ranking TV ads than while watching low ranking TV ads.

$$\alpha = 0.005, \quad -t_{\alpha, n_1+n_2-2} = -0.812, \quad t_0 < -t_{\alpha, n_1+n_2-2} < -0.812)$$

Experiment 1 provides convincing evidence in favor of our Hα. It suggests that the subjects blinked more frequently when they watched unattractive TV ads. The main finding of this experiment supports H1.

Table 2 T-test: Subject's blinking frequency while watching TV ads with high and low rankings (times/Second)

T-test							
	TV ADs with High Ranking			**TV ADs with Low Ranking**			
Subject	**Mean**	**SD**	**Sample1 size**	**Mean**	**SD**	**Sample2 size**	**t_0**
S1-S5	0.21194	0.1126	5	0.3142	0.154	5	(1.200)

Chapter 5
Experiment 2: Quantitative Testing of the Correlation between Audience Eye Movement and Attention with Comparisons between Multiple TV Commercials

In Chapter 4, our first experiment supports H1. In this and the following sections, Experiments 2 and 3 go one step further and aim to verify the correlation pattern between audience eye movement and attention paid to the advertisements.

5.1 Experiment 2 method

Six 30-second TV commercials were selected as stimuli. Subjects' brand attitude and brand preference as well as the advertisements' playing sequence would affect the results. The stimuli, which had been pre-edited into six sequences, contained several different brands and different types of fast moving consumer goods (FMCG). The brands, products and screenshots of the selected TV commercials in Experiment 2 are as follows:

- Burger King combo
- Kraft cheese
- Burger King kids meal
- Sal's pizza 1
- Volkswagen automobile
- Sal's pizza 2

Figure 18 Burger King combo TV commercial snap shot

Figure 19 Kraft cheese TV commercial snap shot

Figure 20 Burger King kids meal TV commercial snap shot

Figure 21 Sal's pizza TV commercial 1 snap shot

Figure 22 Volkswagen automobile TV commercial snap shot

Figure 23 Sal's pizza TV commercial 2 snap shot

Each subject was asked to watch one sequence. A 10-second MTV was inserted at intervals between each advertisement, enabling the subject to identify each separate ad clearly. The subjects were users of the advertising products.

Subjects were asked to watch TV advertisements in sequence and the subjects' eye-movements were recorded simultaneously by an eye-tracker (FaceLab system). After the subjects finished watching the ads, they were asked to complete an attitude rating survey pre-designed to evaluate the different advertisements' attraction. This survey method is a traditional advertisement evaluation method. Finally, the results from the two approaches were analyzed to detect the correlation pattern.

An evaluation of ad content was conducted by asking participants to rate each stimulus on scales of likeability and interestingness, as is standard practice in advertisement research. As a traditional method, an attitude rating survey is used to evaluate the advertisement effectiveness through a questionnaire. In our attitude rating survey experiment, several items were used to measure the advertisement effectiveness with an emphasis on the visual attention aspect. Each item was measured on a seven-point scale. (In the seven-point scale, "7" represents the most favorable, or the greatest amount of association, and "1" the least favorable, or the smallest amount of association). Table 3 shows a sample questionnaire. Relevant keywords, such as "appealing", "eye-catching", "favorable" and "memorable" were selected to determine the level of attention that audiences pay to an advertisement.

Once the data collection from questionnaires was completed, the mean, standard deviation, min and max were calculated for each item. A total score was generated by adding the scores for all the items previously defined in the questionnaire. The item-to-total result shows the attraction level of each tested TV advertisement.

Furthermore, the data collected from the eye-tracking device was analyzed and compared to the data obtained from the questionnaire. Based on the analysis of the effectiveness results from the two methods, we then attempted to verify that, for the same set of advertisements, the attention patterns obtained through the questionnaire and eye-tracking were similar or identical.

Table 3 Sample questionnaire for attitude rating survey in evaluating the advertisement's attraction

On each of the scales below, please check the space that you feel best describes the advertisement you have just watched.								
Unappealing	1	2	3	4	5	6	7	Appealing
Not Eye Catching	1	2	3	4	5	6	7	Eye Catching
What is your overall reaction to the above advertisement?								
Unfavorable	1	2	3	4	5	6	7	Favorable
How memorable did you find this ad								
Unmemorable	1	2	3	4	5	6	7	Memorable

*Seven-point scales used; "7" represents the most favorable (for the greatest amount of association) and "1" the least favorable (or the smallest amount of association)

5.2 Experiment 2 subjects

Six graduate students from Concordia University voluntarily participated in the research. They all regularly watched TV and English was their native or working language. Each experiment of one subject lasted for approximately fifteen minutes.

5.3 Experiment 2 procedure

Subjects were invited separately to come to the LAB where the experiment would be taking place. We conducted Experiment 2 with the exact same facility setting and facility calibration procedure used in Experiment 1. However, different stimuli materials were used.

Before the experiment, the potential subject was given the following statement and instruction: "We are interested in obtaining your opinions concerning particular test advertisements. You will be shown six TV commercials uninterrupted, and then you will be asked several questions concerning your attitude towards these advertisements. Furthermore, we'll simultaneously record your eye movements when you watch the advertisements."

After reading the statement above, if the potential subjects agreed to participate in the experiment, they signed the "consent form to participate in research" before the experiment. The subject was asked to sit and relax in front of the LCD for the eye-tracking facility calibration. Generally, it took the subject around four minutes. Afterwards, the experiment started; the stimuli (six TV advertisements) were shown to a subject on a good-sized monitor from a comfortable distance.

After watching the six commercials, the subjects were shown a card with the seven semantic differential scales, which was first applied by Mindak in the advertising research problems (Yarbus, 1954). The card required the subject to give the most negative ad a score of 1 and the most positive ad a score of 7. This scale was used to answer questions such as those listed in Table 3.

5.4 Experiment 2 Results

All the questionnaire items in our analysis used a 7-point scale to examine the TV ad's performance in order to find out which TV ad was the most attractive. Means and standard deviations reflect the level of affection and attractiveness. The final results from the attitude rating survey are reported in Table 4. Furthermore, Figure 24 illustrates the ranking of stimuli. It shows that, among the six test TV ads, AD2 gained the highest score (Mean Weight =5.25), which means that it was the most attractive one. Accordingly, AD6 gained the lowest score (Mean Weight = 2.84), which means that it was the most unattractive one to the audiences.

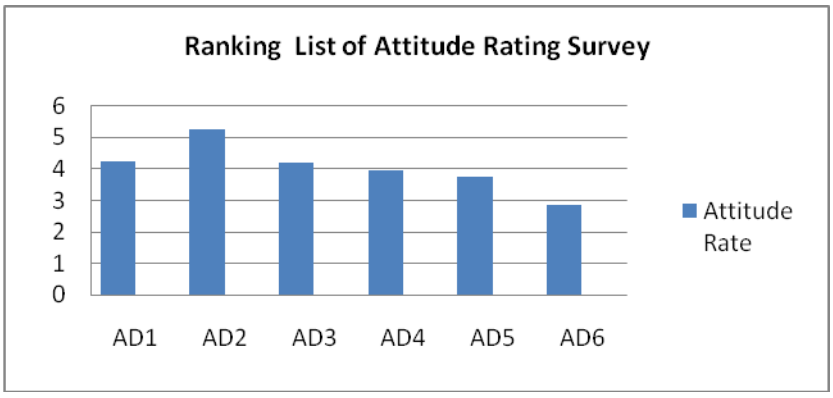


Figure 24 Ranking list of attitude rating survey

Table 4 Response of attitude rating survey

Attitude Rating Survey												
		AD1		AD2		AD3		AD4		AD5		AD6	
	Weight	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Appealing	25%	4.33	1.03	5.00	0.63	4.67	0.52	4.17	0.41	3.83	0.41	3.00	0.89
Eye catching	25%	4.17	0.75	5.33	0.82	4.33	0.82	3.67	0.52	3.50	0.55	2.50	0.55
Favorable	25%	4.33	0.82	5.50	0.55	4.00	0.89	4.17	0.41	4.00	0.63	2.67	0.82
Memorable	25%	4.17	0.75	5.17	0.75	3.83	0.75	3.83	0.41	3.67	0.52	3.17	0.98
Mean Weight		**4.25**		**5.25**		**4.21**		**3.96**		**3.75**		**2.84**	

*Seven-point scales used; "7" represents the most favorable (for the greatest amount of association) and "1" the least favorable (or the smallest amount of association)

The results of blinking frequency (BF) through the eye-tracking method are shown in Table 6, which includes the means and standard deviations of each subject's BF when they watched the six test TV ads. Two main findings were obtained from Table 6: all the subjects' BFs were the lowest when they watched AD2 (data in frame), and with the exception of S3, the subjects' BFs were the highest when they watched AD6 (data in dashed frame). Based on the results of Experiment 1, for advertisement audiences BF is lower when watching attractive ads than when watching unattractive ads. This indicates that, in Experiment 2, AD2 was the most attractive and AD6 was the most unattractive among the six stimuli. This result complies with the results from the attitude rating survey. Table 5 shows the detailed advertisement ranking results obtained from both the

eye tracking method and the attitude rating survey. It is important to note that the two methods give identical overall rankings for a group of six test TV ads.

Table 5 Advertisement ranking (Attitude rating survey vs BF)

	Ranking result (Attitude rating survey)	Ranking result (Eye Tracking)
AD1	2	2
AD2	1	1
AD3	3	3
AD4	4	4
AD5	5	5
AD6	6	6

Table 6 Blinking frequency

	Blinking Frequency (times/second)											
	S1		S2		S3		S4		S5		S6	
	Mean	SD	Mean	SD	mean	SD	mean	SD	mean	SD	mean	SD
AD1	0.408	0.006	0.160	0.007	0.256	0.008	0.249	0.014	0.269	0.013	0.236	0.010
AD2	0.390	0.021	0.152	2.776-16	0.203	0.023	0.219	0.008	0.229	0.012	0.206	0.026
AD3	0.590	0.013	0.196	0.006	0.218	0.016	0.282	0.035	0.238	0.009	0.214	0.000
AD4	0.446	0.035	0.157	0.014	0.420	0.029	0.268	0.006	0.275	0.013	0.215	0.011
AD5	0.528	0.019	0.174	0.008	0.315	0.018	0.319	0.025	0.285	0.011	0.265	0.028
AD6	0.645	0.068	0.303	0.080	0.380	0.032	0.335	0.007	0.346	0.055	0.344	0.050

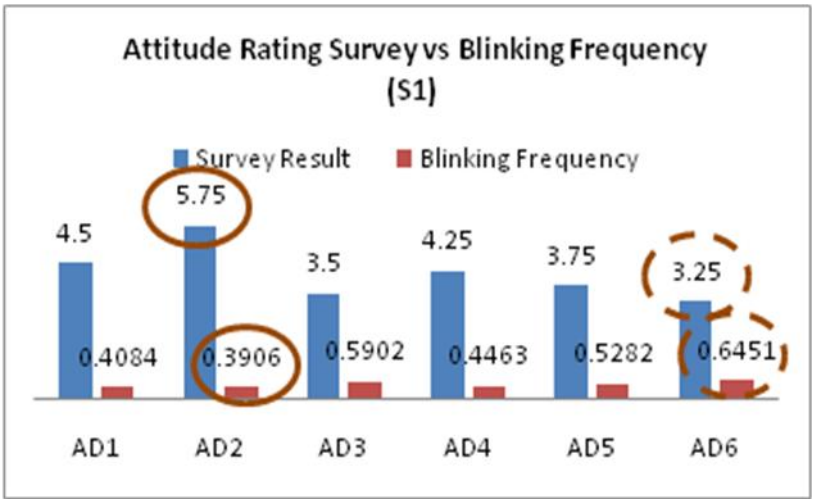


Figure 25 Attitude rating survey vs BF (S1)

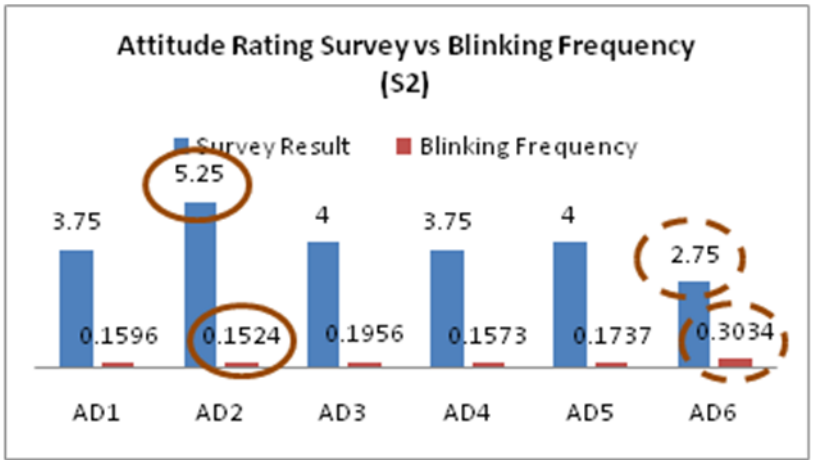


Figure 26 Attitude rating survey vs BF (S2)

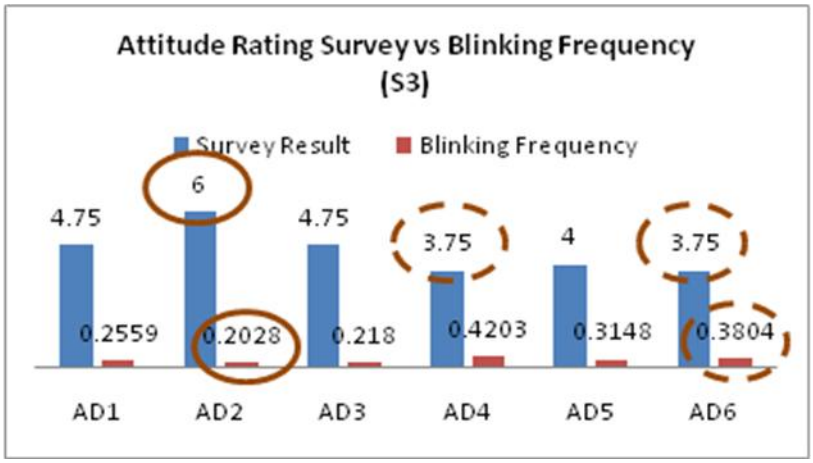


Figure 27 Attitude rating survey vs BF (S3)

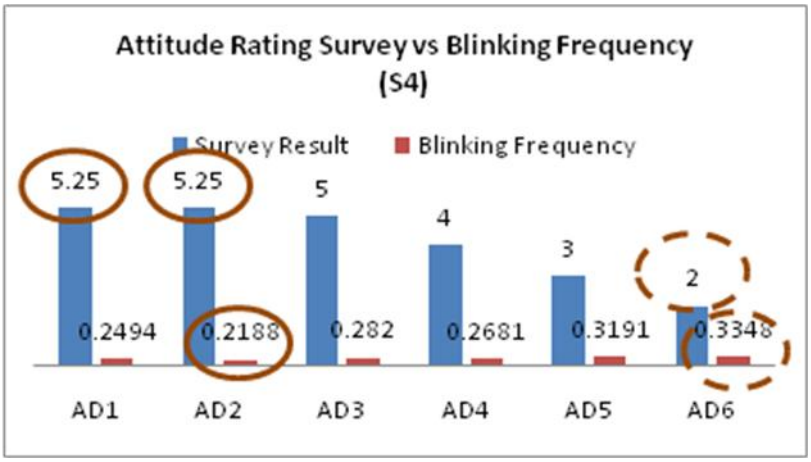


Figure 28 Attitude rating survey vs BF (S4)

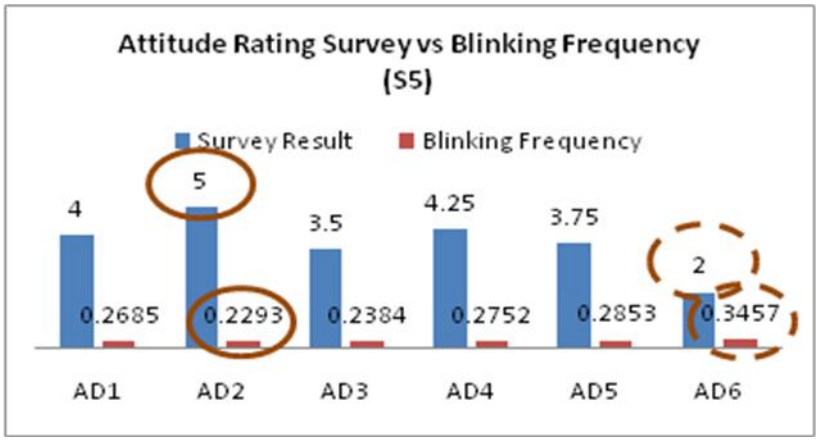


Figure 29 Attitude rating survey vs BF (S5)

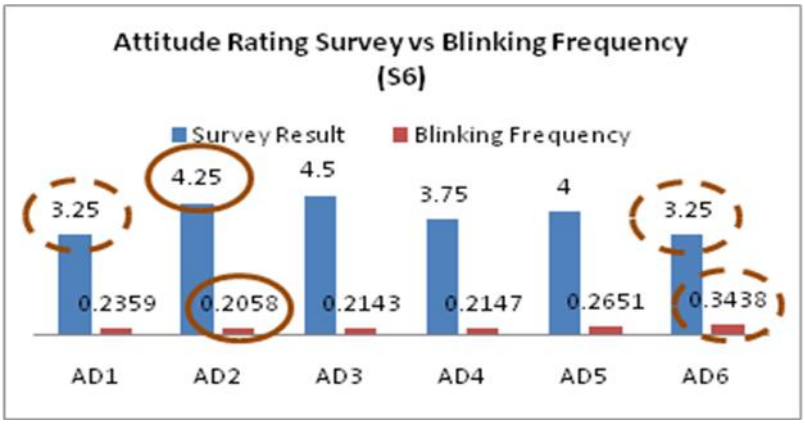


Figure 30 Attitude rating survey vs BF (S6)

The comparison of the subjects' eye movement experimental data and their attitude survey results shows that the effectiveness rankings for subjects S1, S2, S5 are identical. Attitude survey results show that all of these three subjects regarded AD2 as the most attractive and AD6 as the most unattractive among the stimuli. Also note that the mean of BF (plotted in Figure 25, Figure 26 and Figure 29 in red) shows that the lowest and highest BFs were generated while the audiences watched AD2 and AD6 respectively. The eye movement data of these six subjects suggests that AD2 was the most attractive

and that AD6 was the most unattractive. Although there were some discrepancies between the ranking results of S3, S4 and S6 in both methods, the discrepancy is minor and it is reasonable to conclude that the results of the eye-tracking method correctly reflect the level of the advertisement effectiveness obtained through traditional attitude rating surveys.

Chapter 6
Experiment 3: Quantitative Testing of the Correlation Between Audience Eye Movement and Attention With Comparisons Between Multiple Scenes of One TV Commercial

As discussed above, the main purpose of this chapter is to verify H2—that the attributes of audience eye movement are able to reflect audience attention. In this experiment, we continue to record and analyze eye movement in a blinking frequency test to verify the conclusion of Experiment 2. Experiment 3 is also another piece of evidence to suggest that blinking frequency is a qualified evaluation parameter for audience attention.

6.1 Experiment 3 method

Six 30-second real TV commercials were selected as the stimuli. Five of the TV commercials are selected from stimuli of Experiments 1 and 2, and one TV commercial is added. They are as follows:

- Burger King kids meal
- Microsoft Windows phone service
- iPod Shuffle
- HTC mobile service
- Tabasco sauce
- Schick razors

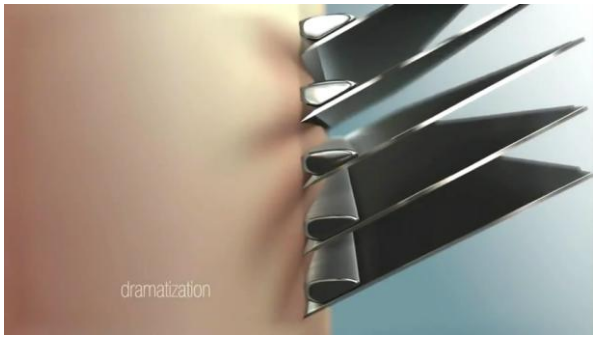
Order effects were controlled by rotating the sequence of commercials, with each commercial appearing equally in the three different sequences. The subjects watched the

stimuli in one sequence and their eye data were recorded by the eye tracker (FaceLAB system). Normally, watching TV ads is regarded by viewers as a passive and repetitive act; therefore, the subjects were required to watch the stimuli two times. For each subject, the eye movement data of the second time they watched was recorded as the experiment data.

To make the questions in the self-reporting method feasible for the experimental design, each selected TV commercial contained variable scenes. Among the different scenes, two scenes were chosen in each commercial and the subjects were asked to select which one they preferred based on their personal preference. Table 7 shows the sample questionnaire for the Favorite Scene Selection.

Finally, the data collected from the eye-tracking device were analyzed and compared to the results obtained from the questionnaire. Based on the analysis of the results from the two methods, we attempted to verify that for one TV commercial the attention pattern could be described by the recorded eye data with the timeline, and that, furthermore, it was in line with the results of the questionnaire.

Table 7 Sample questionnaire for favorite scene selection

AD Name (Schick Razor TV commercial)	Attractive
Scene 1 	(Check area)
Scene 2 	(Check area)

*Please select the favorite scene (check one only for each TV ad commercial)

6.2 Experiment 3 subjects

Three graduate students from Concordia University voluntarily participated in the research. They regularly watched TV, and English was their native or working language. Each experiment for one subject lasted approximately fifteen minutes.

6.3 Experiment 3 procedure

Subjects were invited separately to come to the lab where the experiment would be taking place. We conducted Experiment 3 with the exact same facility setting and facility calibration procedure used in Experiments 1 and 2. However, different stimuli materials were used.

Before the experiment, the potential subject was given the following statement and instruction: "We are interested in obtaining your opinions concerning a particular test advertisement. You will be shown six TV commercials uninterrupted, and then you will be asked questions concerning your attitude towards these advertisements. Furthermore, we'll simultaneously record your eye movements when you watch the advertisements."

After reading the statement above, if the potential subjects agreed to participate in the experiment, they signed the "consent form to participate in research" before the experiment. The subjects were asked to sit and relax in front of the LCD for the eye-tracking facility calibration. Generally, it took the subjects around four minutes. Afterwards, the stimuli (six TV advertisements) were shown to the subjects on a good-sized monitor from a comfortable distance.

6.4 Experiment 3 results

For each subject, the results of Favorite Scene Selection questionnaire are presented in Table 8, Table 9 and Table 10. The results reported in these tables exposed which scene was preferred by the subjects in each TV commercial.

Table 8 Survey result of favorite scene selection (Subject 1)

	AD1	AD2	AD3	AD4	AD5	AD6
Favorite Scene	Scene 2	Scene 1	Scene 1	Scene 2	Scene 1	Scene 2
Un-Favorite Scene	Scene 1	Scene 2	Scene 2	Scene 1	Scene 2	Scene 1

Table 9 Survey result of favorite scene selection (Subject 2)

	AD1	AD2	AD3	AD4	AD5	AD6
Favorite Scene	Scene 2	Scene 2	Scene 1	Scene 2	Scene 1	Scene 2
Un-Favorite Scene	Scene 1	Scene 1	Scene 2	Scene 1	Scene 2	Scene 1

Table 10 Survey result of favorite scene selection (Subject 3)

	AD1	AD2	AD3	AD4	AD5	AD6
Favorite Scene	Scene 2	Scene 1	Scene 1	Scene 1	Scene 2	Scene 2
Un-Favorite Scene	Scene 1	Scene 2	Scene 2	Scene 2	Scene 1	Scene 1

In the meantime, the results of the subjects' BFs recorded by the eye tracker are shown in Table 11, Table 12 and Table 13, respectively, which include the means and standard deviations of each subject's BF when watching the six test TV ads. The BF data is divided into two groups according to the Favorite Scene Selection results: the BF when

the audience is watching favorite scenes and the BF when the viewers are watching un-favorite scenes.

As shown in Table 11, Table 12 and Table 13, for each subject the mean of the BF when watching the favorite scenes is lower than the BF while watching the non-favorite scenes. This is further evidence to support the idea that BF is a significant parameter for reflecting audience attention, i.e. that high attention will cause low BF.

Table 11 Blinking frequency of experiment 3 (Subject 1)

	Blinking Frequency (Times/Second)						Mean	SD
	AD1	AD2	AD3	AD4	AD5	AD6		
Favorite Scene	0.446	0.342	0.360	0.431	0.400	0.317	0.383	0.051
Non-Favorite Scene	0.540	0.377	0.411	0.403	0.478	0.429	0.440	0.060

Table 12 Blinking frequency of experiment 3 (Subject 2)

	Blinking Frequency (Times/Second)						Mean	SD
	AD1	AD2	AD3	AD4	AD5	AD6		
Favorite Scene	0.140	0.149	0.173	0.185	0.185	0.161	0.167	0.021
Non-Favorite Scene	0.197	0.120	0.156	0.207	0.207	0.171	0.182	0.043

Table 13 Blinking frequency of experiment 3 (Subject 3)

	Blinking Frequency (Times/Second)						Mean	SD
	AD1	AD2	AD3	AD4	AD5	AD6		
Favorite Scene	0.270	0.349	0.267	0.244	0.312	0.312	0.278	0.046
Non-Favorite Scene	0.321	0.362	0.310	0.293	0.351	0.351	0.312	0.046

Similarly to Experiment 1, we employed hypothesis T-testing to verify whether the audiences' BFs were lower when watching favorite TV ads. The T-testing construction is shown as

Equation 1. If $t_0 < -t_{\alpha,n_1+n_2-2}$ $t_0 < -t_{\alpha,n_1+n_2}$ 2, we can reject $H_0(1)$ and accept Hα (2), which means the audiences' BFs were lower while watching favorite scenes than while watching non-favorite scenes of the TV commercials.

The subjects' BFs while watching favorite and non-favorite scenes from TV commercials are represented as Sample 1 and Sample 2, respectively, as shown in Table 14. Three subjects' BF data were: S1$\overline{BF_f}$= 0.383, S1$\overline{BF_f}$= 0.167, S1$\overline{BF_f}$= 0.278, S1$\overline{BF_{uf}}$= 0.440, S2$\overline{BF_{uf}}$= 0.182, S3$\overline{BF_{uf}}$= 0.312. It was determined that subjects' BFs were lower while

watching favorite scenes than while watching non-favorite scenes of the TV commercials.

$$(\alpha = 0.005,\ -t_{\alpha,n_1+n_2-2} = -0.812,\ t_0 < -t_{\alpha,n_1+n_2-2} < -0.812)$$

Thus, the results of Experiment 3 indicate the correlations between audience attention and eye data. Furthermore, the pattern of audience attention changing when watching TV commercials can be obtained from the eye data. Figure 31 shows the Blink Frequency pattern of S1 while the subject watched selected AD1. Figure 32 shows the Blink Frequency pattern of S1 while the subject watched selected AD2. Thus, we can see the BF pattern of each subject while watching each TV commercial.

Table 14 T-test: Subject's blinking frequency while watching TV ads with favorite scenes and non-favorite scenes (times/second)

T-test							
	TV ADs with Favorite Scenes			TV ADs with un-favorite Scenes			
Subject	**Mean**	**SD**	**Sample1 size**	**Mean**	**SD**	**Sample2 size**	**t_0**
S1	0.383	0.008	348	0.440	0.011	348	(78.177)
S2	0.167	0.017	360	0.182	0.03	360	(1.351)
S3	0.278	0.013	352	0.312	0.008	352	(62.253)

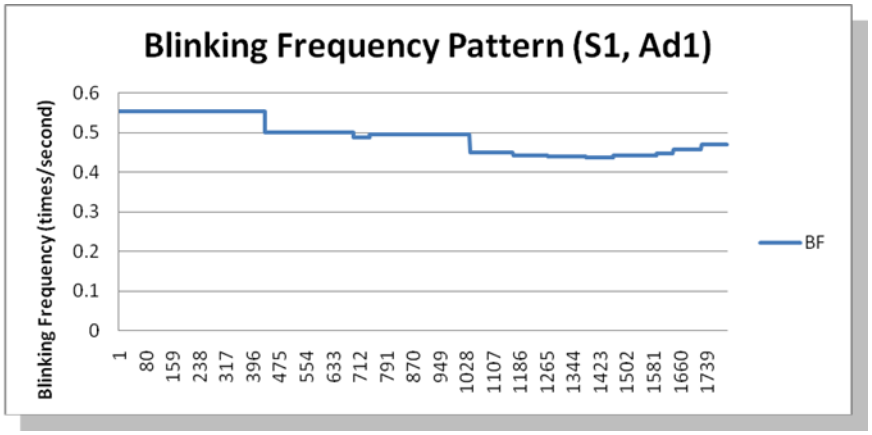


Figure 31 Blinking frequency pattern (S1, AD1)

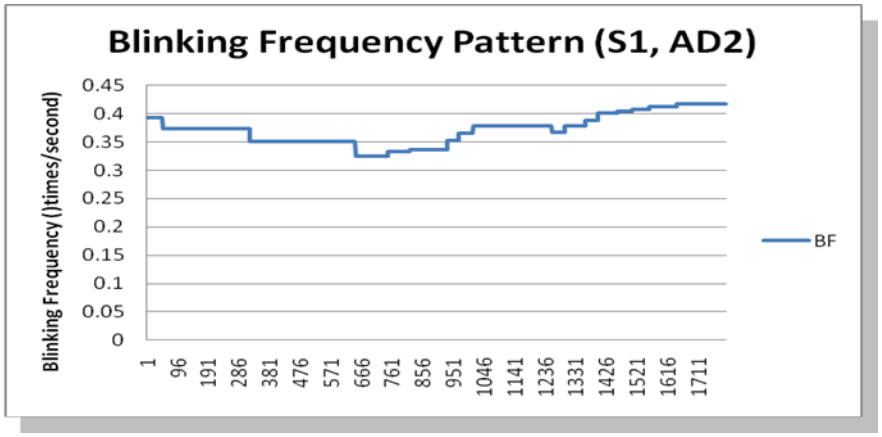


Figure 32 Blinking frequency pattern (S1, AD2)

The pattern we observed is more predictive of the subjects' attentions, although the difference was not significant. This finding suggests that it is an assessment in advertisement effectiveness.

Based on the above finding that the changes in audience attention when watching TV commercials can be obtained from the eye data, we can come to the following conclusion by analyzing the change of blinking frequency. It is suggested that the audience blinking frequency plot while watching less-attractive TVCs is more fluctuant than the blinking

frequency plot while watching attractive TVCs. Figure 31 shows the blink frequency pattern of one subject while the subject watched a less attractive TVC. Figure 32 shows the blink frequency pattern of one subject while the subject watched an attractive TVC. Thus, it's easy to see that the BF pattern has less variability when the audience watched attractive TVCs than when they watched less attractive TVCs.

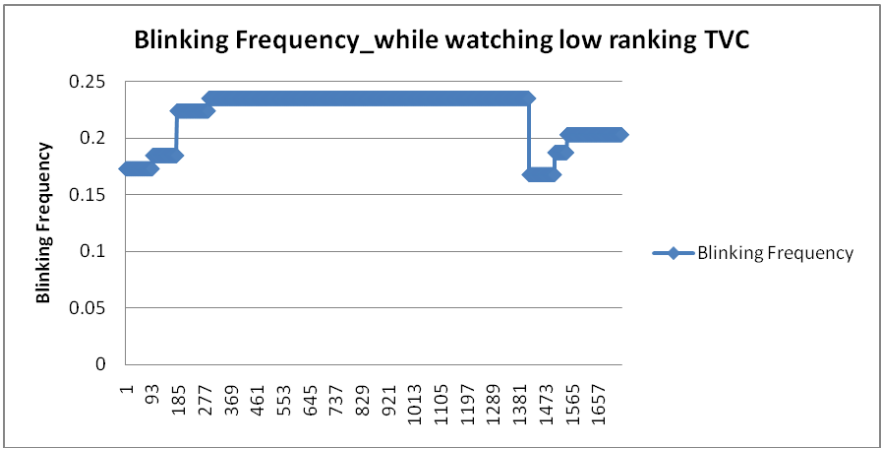


Figure 33 Blinking frequency pattern (while watching a less attractive TVC)

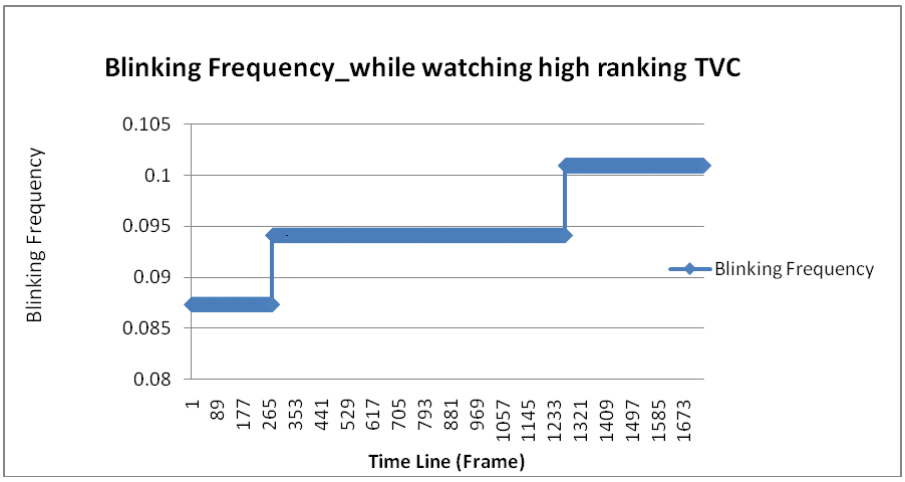


Figure 34 Blinking frequency pattern (while watching an attractive TVC)

This conclusion can also be gained by studying standard deviation (SD) of audience blinking frequency. Table 15 shows each subject's SD of blinking frequency when he/she was watching the stimuli. Figure 35 is a graphic view of comparison, which presents the SD of blinking frequency mean for each subject while they were watching the stimuli. From both evidences, we are able to come to the conclusion that the SD of blinking frequency when the subjects were watching less attractive TVC is higher than when they were watching attractive TVC. This finding further proves that BF pattern has less variability when the audience was watching attractive TVC than when they were watching less attractive TVC.

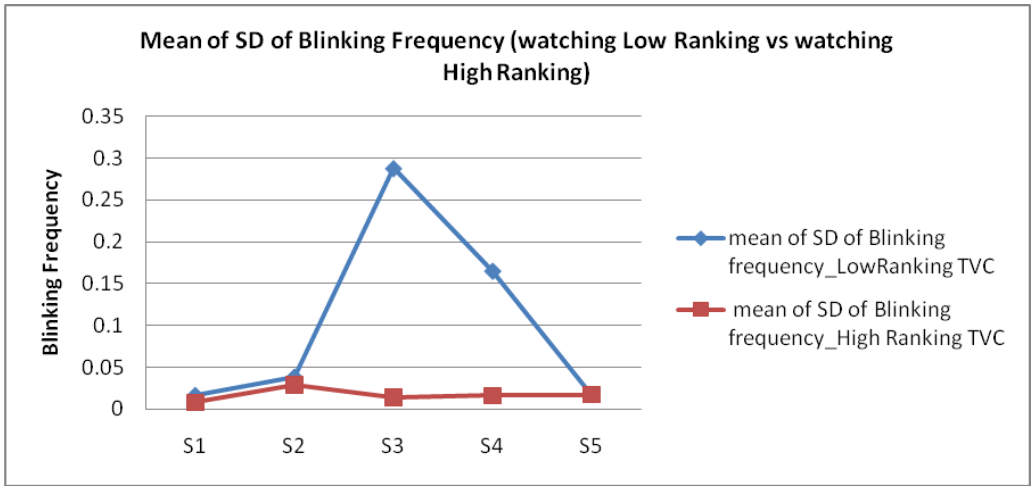


Figure 35 Blinking frequency pattern (while watching an attractive TVC)

Table 15 Standard deviation of BL(watching less attractive TVC vs watching attractive TVC)

	SD of Blinking frequency Watch Low Ranking TVC	SD of Blinking frequency Watch High Ranking TVC
S1	0.011846	0.009438
	0.03038	0.003727
	0.00595	0.011012
	0.015971	0.007294
S2	0.077	0.007005
	0.0467	0.030722
	0.013727	0.03
	0.015407	0.0472
S3	0.035732	0.033228
	0.035186	0.007117
	0.023061	0.004421
	0.021352	0.010961
S4	0.008498	0.025
	0.007633	0.018199
	0.031668	0.00774
	0.017999	0.01225
S5	0.01261	0.017459
	0.010355	0.020226
	0.031583	0.0121067
	0.015088	0.01444

To verify the above finding, we employed hypothesis T-testing. The T-testing construction is shown as

Equation 1. If $t_0 < -t_{\alpha,n_1+n_2-2}$ $t_0 < -t_{\alpha,n_1+n_2}$ 2, we can reject $H_0(1)$ and accept Hα (2), which means the SD of blinking frequency while they were watching less attractive TV commercials is higher than when they were watching attractive TV commercials.

Table 16 T-test: Mean of standard deviation of subject's blinking frequency while watching TV ads with high and low rankings (times/second)

t-test	TV ADs with High Ranking			TV ADs with Low Ranking			
Subject	**Mean**	**SD**	**Sample1 size**	**Mean**	**SD**	**Sample2 size**	**t_0**
S1-S5	0.0164	0.1147	20	0.0234	0.0169	20	(0.974)

The subject's mean of SD of BF while watching high and low ranking TV ads is represented by sample 1 and sample 2, respectively, as shown in Table 16. It can be determined that the subject's SD of blinking frequency while watching a less attractive TV commercial is higher than while watching an attractive TV commercial.

$$\alpha = 0.005, \quad -t_{\alpha,n_1+n_2-2} = -0.812, \quad t_0 < -t_{\alpha,n_1+n_2-2} < -0.812)$$

This result provides convincing evidence in favor of our Hα. It suggests that when subjects watch less attractive TVCs, the SD of blinking frequency increases.

Chapter 7
Conclusions and Future Work

7.1 Conclusion

Existing studies indicate that eye activities have a close relationship with attention and that eye data change with human visual attention. In the present research we studied an objective approach to quantify advertisement effectiveness through capturing and analyzing the attributes of audience eye movements. We conducted three experiments to verify our hypotheses and to find a quantitative relationship between the values of eye movement attributes and the levels of advertisement effectiveness. Our experiments show that while watching TV advertisements the audience eye blinking frequency is correlated to the audience attention. In addition, by analyzing the patterns of audience BF, we can predict the effectiveness ranking of a set of TV advertisements in terms of audience attention, and the predicted ranking will be identical to that obtained from conventional attitude rating surveys. The results of three experiments have several implications for assessing advertising effectiveness. First, blinking frequency is lower when watching attractive ads or scenes than when watching unattractive ads or scenes. Furthermore, the audience blinking frequency can be plotted as a line with the timeline. From the line, the audience attention level to the TV commercial can be obtained directly, playing an important role in TV commercials' effectiveness evaluations. Last but not least, the experiments' results indicate that the audience's blinking frequency pattern has less variability while subjects watch an attractive TVC than when they watch a less attractive TVC. These results provide considerable evidence that the effectiveness of TV

advertisements can be measured by audience BF patterns when viewing them. This, in turn, raises the possibility of developing automated advertisement effectiveness evaluation systems, which would be significantly more cost effective than traditional questionnaire-based methods.

7.2 Limitations and future work

7.2.1 Limitations

There are several specific and one general limitation of this work. First, our research is qualified by our subject population (students) and the relative TV commercial selected. Secondly, and maybe most importantly, the ads were viewed under forced exposure. Although we carefully instructed subjects to simulate home viewing, we are not sure that this was uniformly achieved.

7.2.2 Future work

The work presented in this thesis is still at its preliminary stage and needs to be improved through more case studies. Additional experiments are needed to obtain more insight into the relationship between eye movements and advertisement attention. To this end, more subjects of different ages and occupations will participate in the future research. Furthermore, we will conduct systematic within-subjects and between-subjects studies. Certain issues must especially be considered in the future research, including the audience's personal product attitude and other variables in influencing attitude. It's better to trade off between these factors.

Publications

Shize Jin, Yong Zeng and Chun Wang. (2010). Proceedings of the ASME 2010 International Design Engineering Technical Conferences & Computers and Information in Engineering Conference

IDETC/CIE 2010: *Assessment of Advertising Effectiveness through Audience's Eye Movements*, Montreal, Quebec.

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Appendix 1

CONSENT FORM TO PARTICIPATE IN RESEARCH

This is to state that I agree to participate voluntarily in a program of research being conducted by Dr. Yong Zeng of CIISE at Concordia University. Two copies of consent form will be given to participant –one to keep and one to sign and return to researcher.

Office: 1455 de Maisonneuve West, EV.07.633, Montreal, Quebec, Canada H3G 1M8

Tel.: +1-514-848-2424 #5801 Fax: +1-514-848-3171

E-mail: shi_jin@ciise.concordia.ca

A. PURPOSE

The purpose of this research is to develop designer's cognitive model during the design process by using the following devices.

Eye movement tracking system : faceLab 4.5

The result of this research will be used to guide the improvements of product development through new design methodology or new computer aided design tools.

The designer will undergo through 3 different tasks which are as follows:

- Response attitude measurement test
- Eye Gaze test

B. PROCEDURES

The experiments will take place in the design lab at EV8.113 at Concordia University, following the following procedures:

Conduct an experiment on Response attitude measurement test. In the Response attitude measurement test I need to watch several public TV commercial in sequence to show in the computer screen

Conduct the experiment on Response attitude measurement test in which I'll finish a pre-designed survey questionnaire to get my response related to the attitude measurement that involved to intellectual property of any party.

In conducting both experiments, the following devices may be used:

Eyegaze: In our project, Eyegaze is used to measuring participants' eye positions and eye movement. The eye behavior will be recorded where participant will have to sit in front of cameras during the experiment. A normal calibration is required before starting the experiment. In this experiment, FaceLab 4.5 equipment is used to record eye movement.

C. RISKS:

There will be no risks in this experiment. The Eyegaze instrument only records eye data and does not conduct any electricity and radiation.

D. CONDITONS FOR PARTICIPATION

Your participation in this research is voluntary. If you decide not to take part in the project you are free to discontinue at any time. We will do our best to keep your personal information confidential. If we will publish in article on this research project, your identity will be protected.

I consent that my eye movement data is to be measured by an eye movement system as I work on the experiment. ☐ Yes ☐ No

I consent that my eye movement data is to be measured by an eye movement system as I work on design problem. ☐ Yes ☐ No

I understand that the data from this study may be published.

☐ Yes ☐ No

I HAVE CAREFULLY STUDIED THE ABOVE AND UNDERSTAND THIS AGREEMENT. I FREELY CONSENT AND VOLUNTARILY AGREE TO PARTICIPATE IN THIS STUDY.

NAME (please print) _____

SIGNATURE _____

WITNESS SIGNATURE

_____

DATE _____

If at any time you have questions about your rights as a research participant, please contact Adela Reid, Research Ethics and Compliance Officer, Concordia University, at (514) 848-7481 or by email at areid@alcor.concordia.ca.

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