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The Effect of Cognitive Load and Emotional Arousal on Liar's Gaze Aversion Behavior*

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The aim of this study is to investigate the effects of cognitive load and emotional arousal on liar's gaze aversion. 112 participants were randomly assigned to four liar groups according to cognitive load and emotional arousal conditions (high cognition - high emotion: n = 29, high cognition - low emotion: n = 27, low cognition - high emotion: n = 29, low cognition - low emotion: n = 28). All participants were interviewed after lie tasks was performed, and gaze aversion was measured using a wearable eye-tracker. The high cognitive load condition had a significant higher gaze aversion than the low cognitive condition. There was no difference in gaze aversion among emotional arousal conditions. The interaction of cognitive load and emotional arousal was significant. In high cognitive load conditions, gaze aversion appeared with high frequency regardless of emotional arousal. In low cognitive load and high emotional arousal condition, gaze aversion appeared with low frequency. Therefore, this study suggests that it is necessary to consider the effects of cognitive load and emotional arousal levels on the liar's gaze aversion behavior.

Key words : lie detection, gaze aversion, wearable eye-tracker, cognitive load, emotional arousal

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Gaze aversion has been used as an indicator of a lie in criminal research because it provides information on a human's inner state such as emotion and cognition. The reason why gaze aversion behavior is used as a lie indicator is because it is a physiological reaction that is difficult to consciously control or manipulate (Gog, Kester, Nievelstein, Giesbers & Paas, 2009; Meijer, Verschuere, Gamer, Merckelbach, & Ben-Shakhar, 2016), and it is easy to implement because it does not require a specific tool (e.g., polygraph). People tend to avoid eye-contact to reduce self-consciousness and shame when questions are difficult or very personal (Ponkanen, Peltola & Hietanen, 2011; Doherty-Sneddon & Phelps, 2005). Similarly, looking into the other person's eyes when lying can increase anxiety. Because of this, it is highly likely that a liar will try to reduce anxiety through gaze aversion (Osugi & Ohira, 2017; Vrij et al., 2011). Particularly, gaze aversion is the most prevalent feature when lying in a high emotional arousal situation (Whelan, Wagstaff & Wheatcroft, 2014). On the other hand, people tend to avoid another's gaze during difficult cognitive activities (Vrij, Fisher, & Blank, 2017; Sporer, 2016; Phelps, Doherty-Sneddon & Warnock, 2006). Gaze aversion is also a way to draw attention away from environmental stimuli such as facial expressions to focus on cognitive tasks (Vrij, Fisher, & Blank, 2017).

However, the research results on gaze aversion at the time of lying are somewhat mixed. There are researches that increase gaze aversion when lying (Gog et al., 2009; Meijer et al., 2016), but there are also studies that gaze aversion decreases (DePaulo, Lindsay & Malone, 2003; Mann et al., 2012; Whelan et al., 2014). As a result, a consistent evaluation standard for the behavior of the liar's gaze aversion has not been established. When gaze aversion behavior was used as a clue for detecting lies, accuracy decreased.. The main reason for the inconsistent result of the liars' gaze aversion behavior is that the theoretical background of gaze aversion is different. In other words, previous studies did not consider the effects of cognitive load and emotional arousal on gaze aversion behavior together. One study only examined the effects of cognitive load on gaze aversion, and other studies only examined the effects of emotional arousal. In order to understand the mixed results of the liars' gaze aversion behavior, several important theories explaining gaze aversion behavior should be considered.

Cognitive load theory (Bond & Depaulo, 2006; Gombos, 2006; Vrij, Fisher, Mann & Leal, 2008) and emotional theory (Dimberg, Andreasson & Thunberg, 2011; Reeve, 2014) are used in lie detection research through nonverbal behaviors (including gaze aversion). The cognitive theory argues that cognitive load causes different nonverbal behaviors between liars and truth-tellers. Researchers who describe the behavior of liars using a cognitive approach have argued that lies require more cognitive effort

than telling the truth because they are created through a complex cognitive process (Vrij, Fisher, & Blank, 2017; Walczyk, Igou, Dixon & Tcholakian, 2013). The cognitive approach explains that when lying, individuals go through a more complex cognitive process than when telling the truth. According to the Activation-Decision-Construction Model, a lie is a more complex process than telling the truth because it takes the additional step making a false statement (Walczyk et al. 2013). Lying requires more cognitive resources than telling the truth (Vrij et al., 2008). The cognitive load theory argues that individuals tend to avoid eye-contact when lying. Gaze aversion with the interviewer is a reflection of cognitive load (Sporer, 2016). When people try to think about something, they try to avoid eye-contact because they can't concentrate if they make eye contact with others (Sporer, 2016; Phelps et al., 2006). For example, when a crime-related question was asked rather than a non-crime question, the lying group showed more cognitive clues than the truth-telling group (Lee, Kim, Oh & Lee, 2015).

Emotional theory explains the causes of nonverbal behaviors as emotional arousal when lying. Emotional arousal is more likely to occur in high emotional arousal situations (Vrij et al., 2010; Scherer & Ekman, 2014). People experience fear and guilt when they lie (Osugi & Ohira, 2017; Ekman, Ellsworth & Friesen, 2013), and feel excitement and achievement about the success of a lie (Lee, Kim, Oh & Lee, 2015). In this case, a liar attempts to conceal the emotions they experience, but can reveal uncontrolled clues through their face or body (Scherer & Ekman, 2014). Particularly, in high-risk situations, liars can experience a stronger emotional arousal than the truth-teller (Klein, Verschuere, Kindt, Meijer, Nahari, & Ben-Shakhar, 2017). Because liars feel an emotional reaction to shame and guilt in a high emotional arousal situations, gaze aversion is seen more often than in truth-tellers (Whelan et al., 2014). The level of emotional arousal detected during a lie can vary depending on the person's personality or situation, such as an introverted personality type or antisocial personality (Osugi & Ohira, 2017; Vrij, Granhag & Porter, 2010). However, the results of gaze aversion studies based on emotional theory are somewhat mixed. There are studies showing that gaze aversion increases when lying (Vrij et al., 2011), while there are also studies showing that eye contact increases (Whelan et al., 2014; Mann et al., 2012; Sporer, 2016). In earlier studies based on emotional theory, there were many results showing that gaze aversion increased when lying (Whelan et al., 2014). Recent studies have shown that gaze aversion decreases (i.e., eye contact increases) when lying (Osugi & Ohira, 2017).

The mixed results of these studies can be explained through the attempted control theory (Ekman, Ellsworth & Friesen, 2013). Liars often

attempt to control their behavior in order to give a credible impression to their interviewer. The higher the motivation to succeed in the lie, the greater the likelihood that liars will attempt to control their behavior (Vrij, Fisher, & Blank, 2017; Mann, Vrij and Bull, 2002). In attempted control theory, it is argued that a liar intentionally controls nonverbal behavior in order to convince the other party that they are speaking the truth (Ekman, Ellsworth & Friesen, 2013). In general, an individual learns naturally through personal experience or learns of a nonverbal act that is usually perceived as a clue to a lie in the society or culture to which the person belongs. Individuals can use this learned knowledge to successfully deceive others (Hauch, Sporer, Michael & Meissner, 2016). Gaze aversion is perceived as the most important nonverbal cue to identify a lie in most cultures. In most countries and cultures, including the United States, the first cue to judge lies is excessive eye gaze. And there were research findings that people deliberately avoid eye-gaze when talking about lies (Global Deception Research Team, 2006; Sporer, 2016). A liar who knows this intentionally looks at the other person's eyes when trying to lie and tries to convince the other person that they are telling the truth. However, this control of gaze aversion can lead to excessive eye contact that exceeds the average range, which can be a clue that they are lying (Vrij et al., 2011). The position of attempted control theory argues that gaze aversion decreases when speaking of lying compared to truth-telling.

In order to understand the intentional control behavior of liars more accurately, the effects of emotion and cognition must be considered together. According to previous studies, a high emotional arousal situations increases the motivation for liars to successfully perform a lie (Sporer, 2016; Whelan, Wagstaff & Wheatcroft, 2014). In such situations, is more likely that liars will attempt to intentionally control their nonverbal behaviors. Research has shown that liars make significantly longer eye contact than a person who speaks the truth (Ekman, Ellsworth & Friesen, 2013; Vrij, Fisher, & Blank, 2017). However, performing a complex cognitive task hinders the efforts of individuals to modify or manipulate their behavior. When liars receive high cognitive loads, it is difficult to control their natural behavior or to create another behavior. As a result, nonverbal behaviors (e.g., increased stuttering, or increased gaze aversion) are exhibited that are different from those who speak the truth (Suchotzki, Verschuere, Bockstaele, Ben-Shakhar & Crombez, 2017). In addition, although not in the context of lie detection, a study has shown that cognition has a greater effect on gaze aversion than emotion (Doherty-Sneddon & Phelps, 2005). When cognitive load was increased, gaze aversion was high in both emotional conditions. Therefore, in order to increase the reliability of lie detection using gaze aversion, it is necessary to investigate

the attempted control behavior of liars in a high emotional arousal situation under a high cognitive load. In a high emotional arousal situation, liars will intentionally try to control the level of eye contact, but it can be expected that a high cognitive load will result in high gaze aversion.

The purpose of this study is to examine the effects of cognitive load and emotional arousal on attempted control behaviors of lying. The present study investigated the effects of a high cognitive load when liars intentionally intended to control their eye contact behavior in a high emotional arousal situation. According to the attempted control theory, liars seek to control their eye movements in order to successfully perform a lie in situations of experiencing high emotional arousal. This study investigates whether high cognitive load can successfully interfere with the deliberate attempted control behavior. To do this, the influence of two variables on the gaze aversion behavior of liars was investigated by dividing the levels of emotional arousal and cognitive load into high and low levels. Participants were randomly assigned to the four groups to conduct missions according to each emotional condition. Then, during an interview, this study measured the gaze aversion of participants responding to questions according to each cognitive condition. This study also measured the tendency of personality to influence the lie in the process of lie detection. The ability to lie well reduces the emotional response to a lie and can affect the physiological response and the strategic control response. We used the manipulativeness scale to identify differences between groups. In addition, the difference in degree of anxiety experienced in the lie detection situation could affect the physiological response, so the difference between the groups was confirmed through the state-trait anxiety inventory.

The hypothesis of this study is as follows: First, the high cognitive load conditions will show higher gaze aversion than the low cognitive load conditions. The higher the cognitive load level, the more cognitive effort is needed. Liars will need more cognitive resources in high cognitive load condition, so they will be more gaze avoided. Second, in high cognitive load conditions, gaze aversion will be high in all emotional arousal conditions, regardless of whether emotional arousal is high or low. However, under low cognitive conditions, gaze aversion will be lower than low emotional arousal condition in high emotional arousal condition. In other words, liars will try to make eye contact in situations where it is easy to control their behavior. Under the high cognitive load condition, where it is difficult to control eye movements, liars will fail to intentionally control themselves and show high gaze aversion. In other words, in the high emotional and low cognitive condition, gaze aversion will be low (high eye contact) because the liars will be able to easily control their eye movements. However,

in high cognitive conditions, gaze aversion will be high in both conditions of emotion, because liars will have difficulty controlling their eye movements (low eye-contact). Most previous studies have focused only on one approach: emotional arousal or cognitive load on the liar's gaze aversion behavior. The purpose of this study is to investigate the effects of cognitive load and emotional arousal on the attempted control behaviors of liars through gaze aversion behavior. It is expected that cognitive load can effectively prevent countermeasures of liars experiencing high emotional arousal.

Method

Participants

120 students from a university applied for the experiment through a written advertisement. For the eye-tracker calibration procedure, participants were limited to people with a corrected visual acuity greater than 0.5. Anyone who had experienced eyesight correction surgery or who wore contact lenses could participate in the experiment, but those wearing glasses or colored lenses were excluded from the study. Of the 120 participants, 8 participants were excluded from the final analysis due to their failure to follow instructions correctly and for failing to meet the calibration requirements. A total of 112 undergraduates were randomly assigned into four groups: High arousal – high load (HH; n = 28), High arousal – low load (HL; n = 27), Low arousal – high load (LH; n = 29) and Low arousal – low load (LL; n = 28). The average age of participants was 22.96 years (SD = 2.16). The mean age was not significantly different between groups, $F(3, 108) = 1.236$, n.s. The mean age of the HH group was 22.44 years (SD = 1.73). The mean age of the HL group was 23.06 years (SD = 1.66), the mean age of the LH group was 22.32 years (SD = 1.67), and the mean age of the LL group was 23.02 years (SD = 1.67). Information on gender is shown in Table 3. All participants were paid ₩8,000 for their participants.

Materials

Self-report questionnaires

State-Trait Anxiety Inventory (STAI). The STAI self-report scale (STAI; Spielberger, 1970) was used to confirm whether there were differences in the level of anxiety between the four groups. STAI-T measured "trait anxiety", a general, long-term anxiety (e.g., "I worry too much over something that really doesn't matter") while STAI-S measured "state anxiety", a temporary anxiety (e.g., "I am presently worrying over possible misfortunes"). The trait anxiety was measured to control the participants' physical anxiety because high trait anxiety could affect the outcome regardless of

experimental manipulation. State anxiety was measured by participants to examine how their level of anxiety changed before and after the experiment. The increase in state anxiety can be interpreted as the participant experiencing emotional arousal after the experiment. The scale contains 20 items to assess both the degree of state and trait anxiety using a 4-point scale ranging from 1 (not at all) to 4 (very much so). Scores range from 20 to 80, with higher scores correlating with greater anxiety. The score was calculated by adding all the scores of the items answered by the participants. Korean versions of STAI-T and STAI-S (Kim & Shin, 1978) were used in this study. The Cronbach's alpha was .87 for STAI-T, and .89 for STAI-S in this study.

Manipulativeness Scale (MS). The Manipulativeness Scale was used to measure the tendency of participants to cheat and exploit others to get what they want. This scale is comprised of two groups of personality trait items: Mach-IV, which measures Machiavellianism (e.g., "I enjoy manipulating them so that others do not notice"), and social adroitness, which measures less extreme behaviors than that of Machiavellianism (e.g., "It is wise to try to appeal to an important person"), as proposed in the study of Vrij et al. (2010). Higher manipulative traits can affect outcomes regardless of experimental manipulation. Scores were measured before the experiment to control differences between groups. The scale contains 28 items to both the social adroitness and machiavellianism using a 4-point scale ranging from 0 (not at all) to 4 (almost always). Scores range from 0 to 122. Higher scores indicate a higher propensity to manipulate others. The score was calculated by adding all the scores of the items answered by the participants. This study used the Korean version of the Manipulativeness Scale (Kim & Lee, 2010). The Cronbach's alpha was .56 in this study.

State Shmae and Guilt Scale (SSGS). The SSGS (Marschall, Sanfter & Tangney, 1994) was used to confirm whether there were differences in the level of shame and guilt between the four groups. State shame and guilt was measured by participants to examine how their levels of shame and guilt changed before and after the experiment. The scale contains 10 items to both the degree of shame and guilt using a 4-point scale ranging from 0 (not at all) to 4 (almost always). This scale consists of 5 items measuring shame (e.g., "I am regretting now") and 5 items measuring guilt (e.g., "Now I think what I have done is bad"). Scores range from 10 to 40. The SSGS was used before and after the experiment to confirm how the participant's shame and guilt changed. The score was calculated by adding all the scores of the items answered by the participants. This study used the Korean version of the SSGS (Lim, 2010). The Cronbach's alpha was .89 for shame,

and .82 for guilt in this study.

Visual Analogue Scale (VAS). The Visual Analogue Scale (VAS) was used to determine the level of cognitive load and emotional arousal. There was no previous study that measured cognitive load and emotional arousal together. In this study, we made a VAS that measures cognitive load and emotional arousal experienced by participants in interviews. The pilot study proved that each item was a valid variable. This scale consists of 20 questions about emotional arousal (e.g., "How dreadful were you had eye contact with the interviewer?") and 20 questions about cognitive load (e.g., "How much suppression did you use to keep your eye contact with the interviewer?"). Scores range from 0 to 100. The score was calculated by adding all the scores of the items answered by the participants.

Apparatus

An eye-tracking device was used to measure the frequency of gaze aversion behavior of the participants. An Eye-tracker (In-Albon et al., 2010) is a tool that can measure eye movements more precisely than the hand counting of previous studies. Doherty-Sneddon and Phelps (2005) used a camcorder to measure gaze aversion behavior. Measurement using a camcorder has the disadvantage of the high possibility of inaccurate measurement of gaze aversion. To overcome this drawback, a wearable eye tracker device (Tobii Glasses 2, Tobii Pro) was used. This device has the advantage that the participant's eye-movement can be measured without limit of space.

Procedure

The experimental process described below was approved by the University Institutional Review Board (IRB). Upon arrival at the laboratory, the participants read and signed a written consent to participate in the experiment. After that, they were instructed to complete the STAI, Manipulativeness Scale and SSGS before the experimental session. The participants then chose whether they would conduct a high emotional arousal or low emotional arousal mission by selecting one of three blank envelopes. The contents of the three envelopes presented to the participants were all the same, according to the assigned group, and the experimenter knew this fact, but the participants did not. The experimenter instructed the participants to read the detailed information in the selected envelope. The mission instructions for the high emotional arousal and low emotional arousal missions were given in Table 1. Afterward, each participant will perform a mission on each envelope received.

Both the participants of the high arousal condition and the low arousal condition were randomly reassigned to a high load condition and low load condition, respectively. After that, participants were instructed to wear a wearable

Table 1. Instructions for emotional condition

Instructions
Envelope contents of high emotional arousal condition (cash theft): Today's mission is ① to steal cash from the assistant's office. ② And you have to say "I did not see the cash" or "I saw the cash but did not steal it" in the interview room. ① Go to the assistant's office and follow the procedure below to perform the mission. 1. Sit on the right side closest to the door in the office. 2. Exit the notebook's webcam program on the desk and write 'I've used your seat' on the notepad program. 3. Find the <Understanding Clinical Psychological Test> book on desk. Inside the book, take out the envelope labeled "Research Fund". Check the amount in the envelope. 4. Steal the envelope with a million won in cash. 5. Return to the Psychology laboratory. ② After the mission, please come into the interview room. At this point, you should lie, "I did not see the cash," or "I saw the cash but did not steal it."
Envelope contents of low emotional arousal condition (read a letter): Today's mission is ① to read a letter from the assistant's office. ② And you have to say "I did not .see the letter" or "I saw the letter but did not read it" in the interview room. ① Go to the assistant's office and follow the procedure below to perform the mission. 1. Sit on the right side closest to the door in the office. 2. Write 'I've used your seat' on the notepad program. 3. Take the letter out of the basket on the desk. 4. Read the letter and leave it in place. 5. Return to the Psychology laboratory. ② After the mission, please come into the interview room. At this point, you should lie, "I did not see the letter," or "I saw the letter but did not read it."

eye tracker and sit in front of the experimenter. During the interview, participants were asked three types of questions (neutral questions, short-answer questions, open-ended questions) (see Table 2). In response to neutral questions, participants had to answer truthfully about basic identity information. In response to short-answer questions, participants had to answer "yes" or "no" to the questions about the mission. In response to open-ended questions about the mission, participants were asked to provide as detailed statements as possible. After the

Table 2. Instructions for cognitive condition

Instructions
Short-answer question
1. Did you sit on the right side closest to the door?
2. Did you see <Understanding Clinical Psychological Test> on the desk? (High arousal)
.Did you see the white basket on the desk? (Low arousal)
3. Did you see the envelope with a million won in cash? (High arousal)
.Did you see a letter asking you to forward the letter to the post office? (Low arousal)
Neutral question
1. What is your name?
2. What is your date of birth?
3. What is your university major?
Open-ended questions
1. Speak in reverse chronological order of what happened in the assistant's office today (High load)
2. Talk about what happened in the assistant's room today (Low load)

interview, participants completed STAI-S and SSGS, and were then debriefed.

Data anaylsis

All the ocular measurements were analyzed by Tobii Analyzer software (Tobii Technology, Inc., Washington, USA). All eye-tracking data were sampled at 50 Hz. Gaze aversion behavior was measured using visit duration, visit count, fixation duration and fixation count. The visit duration (ms) is the total time each participant visited the interviewer's eyes. The visit count (number) is the number of times each participant visited the interviewer's eyes. The fixation duration (ms) is the time in milliseconds that a fixation lasts, and the total time each participant fixated on the interviewer's eyes. Minimum fixation duration is 60 ms. The fixation count (number) is the number of times each participant fixated on the interviewer's eyes. The overall value for each category is the duration (or count) for which each participant looked into the interviewer's eyes during the interview divided by the duration (or count) during which the participant looked into the interviewer's eyes while lying. Gaze aversion was measured from the end of the interviewer's question to the end of the participant's response.

Statistical analysis was performed with SPSS 22.0. Two-way ANOVA was performed to identify differences between groups' gender, level of STAI-T and MS. The gender was analyzed using the *Chi*-square test. Multivariate ANOVA

was performed with 2 (emotional arousal: high arousal, low arousal) × 2 (cognitive load: high load, low load) to identify differences in gaze aversion behavior on emotional and cognitive conditions in each group. In addition, after confirming the interactions among the four groups, post-analysis (Scheffé test) was conducted to identify groups with significant gaze aversion differences.

Results

Demographics and self-reported scales

Table 3 shows descriptive data of the demographics and self-reported scales of participants. 8 participants were excluded from the final analysis due to their failure to follow instructions correctly (e.g., the participants told the truth in a situation where they should lie.) and for failing to meet the calibration requirements (i.e., lower than 30%). As a result, a total of 112 participants were included in the final analysis (HH group = 28, HL group = 27, LH group = 29, LL group = 28).

There was no difference in the gender, *Chi*-square (df = 3) = .294, F(3, 108) = 1.23, *n.s.*, age, F(3, 108) = 0.31, *n.s.*, level of STAI-T, F(3, 108) = 0.21, *n.s.*, and MS tendencies, F(3, 108) = 0.38, *n.s.*, of the four groups. The level of STAI-S, SSGS were analyzed before and after the experiment. There were no differences in the four groups, STAI-S, F(3, 108) = 1.36, *n.s.*, and SSGS, F(3, 108) = 1.16, *n.s.*, before the experiment. However, after the experiment, the four groups showed significant differences in state anxiety according to the emotional condition, F(1, 108) = 7.99, $p < .05$, $\eta^2 = .07$. That is, there was a significant difference between the LL group and the HH group. Also, the high emotional arousal group had a higher state of anxiety than the low emotional arousal group. However, there was no significant difference between the groups in the SSGS, F(3, 108) = 0.29, *n.s.* As a result of the two-way ANOVA analyzing the discomfort from eye contact, a significant difference between the four groups was observed, F(3, 108) = 5.49, $p < .01$, $\eta^2 = .13$. In the post-hoc analysis (Scheffé test), the differences between the HH group and the LL group, and between the HL group and the LL group were significant. This means that the high emotional arousal group experienced relatively higher anxiety than the low emotional arousal group in the lie detection test. There was only a difference between the emotional groups, F(1, 110) = 15.48, $p < .01$, $\eta^2 = .12$, not cognitive groups, F(1, 110) = 0.73, *n.s.* The group that felt the most discomfort from eye-contact was the HH group followed by the HL, LH and LL groups.

Table 3. Mean and standard deviation (SD) for demographic and self-reported information

	High emotional arousal		Low emotional arousal		Total
	High load	Low load	High load	Low load	
Gender	10 (female 18)	9 (female 18)	10 (female 19)	9 (female 19)	38 (female 74)
Age	22.44 (1.73)	23.76 (1.67)	22.32 (1.68)	23.42 (3.08)	22.96 (1.81)
STAI-T	43.67 (10.72)	43.70 (10.23)	41.87 (9.81)	42.86 (9.60)	42.52 (10.03)
STAI-S (baseline)	42.63 (9.62)	36.93 (9.92)	39.97 (9.33)	39.82 (12.42)	38.63 (9.62)
STAI-S (post)*	49.48 (8.98)	45.63 (10.65)	43.20 (8.29)	41.50 (10.90)	45.04 (10.42)
Manipulativeness	72.85 (6.94)	70.67 (7.84)	72.33 (7.72)	71.71 (9.01)	71.62 (7.50)
SSGS (baseline)	12.70 (3.40)	11.96 (3.98)	13.83 (4.42)	12.89 (3.35)	12.57 (3.75)
SSGS (post)	14.22 (5.05)	14.96 (5.76)	14.00 (3.86)	13.82 (4.94)	14.45 (5.03)
VAS**	20.54 (3.34)	19.97 (6.14)	16.92 (4.81)	15.53 (6.73)	18.40 (5.62)

Note. * $p < .05$, ** $p < .01$; *STAI-T: State-Trait Anxiety Inventory-Trait version; STAI-S: State-Trait Anxiety Inventory-State version; SSGS: State Shame and Guilt Scale; VAS: Visual Analogue Scale on Cognitive Load and Emotional Arousal*

Gaze aversion behavior during deception

To examine if gaze aversion behavior was significantly different during deceptive statements, a two-way ANOVA was conducted to confirm differences in group gaze aversion (fixation duration) for open-ended questions (see Table 4).

The results showed that the main effect of cognition was significant $F(1, 108) = 21.12$, $p < .05$, $\eta^2 = .16$ (see Table 5). Liar's gaze aversion was more frequent in the high cognitive load condition than the low cognitive load condition. The higher the cognitive load, the more liars avoided making eye contact. However, the main effect of emotion was not significant $F(1, 108) = 1.84$, *n.s.* There was no difference in gaze aversion according to emotional arousal. Overall, cognitive load had a greater effect on the gaze aversion behavior of liars than emotional arousal.

The interaction between conditions of emotion and cognition was significant $F(1, 108) = 4.89$, $p < .05$, $\eta^2 = .04$. A post-hoc analysis (Scheffé

Table 4. Mean and standard deviation (SD) of gaze aversion for emotional arousal and cognitive load conditions in open-ended questions

	High arousal		Low arousal		Total
	High load	Low load	High load	Low load	
Visit duration (ms)	.14 (.20)	.42 (.32)	.17 (.22)	.30 (.28)	.25 (.27)
Visit count (number)	.16 (.20)	.37 (.28)	.19 (.17)	.37 (.26)	.27 (.22)
Fixation duration (ms)*	.12 (.17)	.43 (.29)	.16 (.23)	.27 (.25)	.24 (.26)
Fixation count (number)	.14 (.17)	.38 (.26)	.18 (.18)	.33 (.23)	.25 (.23)

Note. * $p < .05$

Table 5. Two-way ANOVA table for cognitive load and emotional arousal

Variable	F	df	p	η^2
Cognitive load*	21.117	(1, 108)	.000	.164
Emotional arousal	1.844	(1, 108)	.177	.017
Cognitive load × Emotional arousal*	4.894	(1, 108)	.029	.043

Note. * $p < .05$

test) was conducted to confirm the interaction between emotion and cognition. The results showed there was a significant difference between the HH group and HL group, and between the HL group and LH group (see Figure 1). In regard to the HH group and the HL group, the HH group showed higher gaze aversion than the HL group. This indicates that in a high emotional arousal situation, the behavior of gaze aversion depends on the degree of cognitive load. When the cognitive load was low, liars showed low gaze aversion. However, when the cognitive load was high, the liars revealed a high degree of gaze aversion. Also, in regard to the HL group and the LH group, the LH group showed higher gaze aversion than the HL group. When the emotional arousal was low, but the cognitive load was high, liars showed high gaze aversion. When emotional arousal was high but cognitive load was low, liars showed low gaze aversion. In addition, the HH group showed the highest gaze aversion, while the HL group showed the lowest gaze aversion. Gaze aversion was highest when emotional arousal and cognitive load were high, and lowest when emotional arousal was high but cognitive load was low.

In addition, the differences between the groups in regard to visit duration, visit count, and fixation count were not significant. There

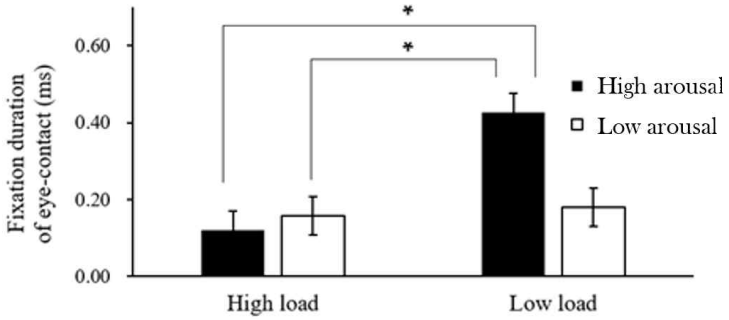

Figure 1. The interaction effects of emotional arousal and cognitive load condition on duration of gaze aversion. Error bars reflect standard errors.

Note. * $p < .05$

Table 6. Mean and standard deviation (SD) of gaze aversion for emotional arousal and cognitive load conditions in short-answer questions

	High arousal		Low arousal		Total
	High load	Low load	High load	Low load	
Visit duration (ms)	.44 (.27)	.55 (.26)	.43 (.29)	.54 (.31)	.49 (.28)
Visit count (number)	.54 (.33)	.65 (.29)	.49 (.29)	.63 (.37)	.57 (.32)
Fixation duration (ms)	.36 (.22)	.48 (.23)	.40 (.28)	.47 (.25)	.43 (.25)
Fixation count (number)	.44 (.26)	.57 (.26)	.45 (.28)	.55 (.30)	.50 (.28)

was also no significant difference in group gaze aversion in response to the short-answer questions (see Table 6).

Discussion

The purpose of this study was to investigate the specific mechanisms of attempted control behaviors in the context of lie detection by examining the effects of cognitive load and emotional arousal on gaze aversion behavior. The participants were asked to perform a mission and then their gaze aversion behavior was measured during interviews. As a result, gaze aversion was high regardless of whether the emotional arousal was high or low in high cognitive load conditions. Under low cognitive load conditions, gaze aversion was low because of attempted control behaviors due to high emotional arousal situation. The results of this study confirm that it is important to evaluate the countermeasures such as attempted control behavior in the detection of lies using gaze

aversion. Increasing cognitive load was an effective strategy to prevent the countermeasure of attempted control gaze behavior. In other words, liars' gaze aversion behaviors showed different patterns according to level of emotion and cognition. High cognitive load interfered with the countermeasures of the liars and caused high gaze aversion. However, when the cognitive load was low and emotional arousal was high, the liars increased the level of eye contact because they used the countermeasure of attempted control behavior. Therefore, this study confirms that gaze aversion can be interpreted differently according to the level of emotion and cognition in order to increase the reliability of lie detection. When a cognitive load is high, liars can show high gaze aversion, while when cognitive load is low and emotional arousal is high, liars can show low gaze aversion.

The results of this study showed that gaze aversion behavior changed according to the high and low condition of the cognitive load in the high emotional arousal situation. When the cognitive load was low, the liars showed low gaze aversion because they succeeded in controlling their eye movements. However, under high cognitive load, the liars exhibited high gaze aversion in both high and low emotional arousal conditions due to failure in controlling their eye movements. This is consistent with the hypothesis of this study. In addition, this is consistent with the results of a previous study (Doherty & Sneddon, 2005) that examined the effects of social emotion (e.g., anxiety) and cognitive load on gaze aversion. In previous studies, a high cognitive load caused high gaze aversion in both high and low social emotions. However, there is a difference from previous research results, which is not consistent with the result of the low cognitive load and high emotional arousal condition. This is because previous studies investigated gaze aversion behavior when a general child, not a liar, resolved a problem. Because this study was done in the context of a lie detection situation, the subjects used a countermeasure of maintaining eye contact with an interviewer in high emotional arousal situations. Therefore, subjects showed low gaze aversion under conditions of high emotional arousal and low cognitive load. This is consistent with the previous study, which showed that gaze aversion decreases when lying in high emotional arousal situations (Whelan et al., 2014; Mann et al., 2012). Also, liars exhibited a lot of gaze aversion in the condition of high cognitive load as it was difficult to control their eye movements. This is consistent with the results of previous studies based on cognitive theory (Vrij, Fisher, & Blank, 2017; Sporer, 2016). Overall, the results of this study suggest that high cognitive load effectively prevents one of the countermeasures of lying and that liars' gaze aversion can be interpreted differently depending on the levels of emotion and cognition. Under high cognitive loads there is no difference between high and low levels of

emotion, but in high arousal and low cognitive conditions, liars use a countermeasure resulting in low gaze aversion.

In the high cognitive load condition, gaze aversion of the liars was higher than the low cognitive load condition. This is consistent with previous studies (Vrij, Fisher, & Blank, 2017; Sporer, 2016; Doherty & Sneddon, 2005) which showed that the higher the cognitive load, the greater the gaze aversion. Increasing cognitive load is effective to increase gaze aversion of liars. However, there was no significant difference between emotional conditions. This result does not agree with the hypothesis that gaze aversion is higher in the high emotional arousal condition compared to the low arousal condition. This result is inconsistent with a previous study (Vrij et al. 2006) which showed that the higher the emotional arousal, the higher the gaze aversion. The reason for this result is as follows. In the previous research, groups of liars and groups of truth-tellers were used. However, since all four groups of this study were composed of liars, it is difficult to show a significant difference between the groups. However, the self-reported questionnaire on state anxiety (STAI-S) showed that after the experiment the high emotional arousal condition showed significantly higher levels of anxiety than the low emotional arousal condition. In addition, the results of the VAS on the discomfort from eye contact showed that the two groups of high emotional arousal were more uncomfortable as a result of eye contact than the two groups of low emotional arousal. Therefore, although there was no significant difference according to the level of emotional arousal in participant's gaze aversion, the manipulation of emotional arousal in the experiment was considered to be effective. This result suggests that emotional arousal is not important for a liar's gaze aversion. In other words, cognitive load has more influence on a liar's gaze aversion than emotional arousal.

This study investigated liars' gaze aversion behavior based on cognitive load theory, emotional theory, and attempted control theory (Vrij, Fisher, & Blank, 2017; Sporer, 2016; Scherer & Ekman, 2014; Ekman, Ellsworth & Friesen, 2013). Unlike cognitive load studies, which have consistently reported high gaze aversion results, there were mixed results from emotional arousal studies, which were due to attempted control behaviors. Liars often attempt to control their behavior in order to give a credible impression to the interviewer. The higher the motivation to succeed in a lie, the greater the likelihood that liars will attempt to control their behavior (Vrij et al., 2010). Liars' attempts to control their behavior will affect those behaviors that fit the cultural stereotype of liars. Because there is a widespread belief that liars increase their movements and look away, liars will try to maintain eye contact to hide their deceit (Ekman, Ellsworth & Friesen, 2013). Liars are often able to control their gaze direction quite well, often maintaining eye

contact with the target as much during deception as during truth-telling. Therefore, it was important to investigate attempted control behaviors in a lie detection situation. Both cognitive and emotional influences have an important effect on a liar's gaze aversion behavior. In this study, it was found that liars could easily control their eye movements when the cognitive load was low in a high emotional arousal situation as shown by the appearance of low gaze aversion. When the cognitive load was high, the liars had difficulty controlling their eye movements regardless of their emotional arousal. A high cognitive load interfered with the countermeasure of liars shown by the appearance of high gaze aversion. This explains the mixed results in the gaze aversion previous studies. Through a high cognitive load, it is possible to suppress countermeasures in a high emotional arousal situation.

As outlined in the methodology section, this study measured gaze aversion behavior using wearable a eye-tracker and confirmed the effects of emotional arousal and cognitive load due to a lie. Currently, polygraphs, which are mainly used in criminal investigations, have difficulty evaluating the various physiological conditions and characteristics of suspects, and it is necessary to search for other physiological indicators rather than using them as a single index. A wearable eye-tracker can measure eye movements which are physiological responses and behavioral responses in interview situations. Therefore, it will be possible to enhance the validity of the detection of a lie in the future by continuously studying a new lie detection technique utilizing such characteristics.

We found significant differences between the groups in fixation duration as a measure of gaze aversion, but there was no statistically significant difference in visit duration, visit count, and fixation count. This suggests that fixation duration can be used as a more significant indicator than other indexes when using gaze aversion as a lie detection index. The visit duration measures all the time the participant looked at the experimenter's eyes. The visit count measures how many times the participant saw the experimenter's eyes. The fixation duration measures all the time the participant looked at the experimenter's eyes for a rather long time (minimum 60ms). The fixation count measures how many times the participant saw the experimenter's eyes (minimum 60ms). Thus, the fixation duration can be interpreted as a meaningful gaze behavior rather the visit duration because the fixation duration measures the time that the experimenter's eyes are seen for more than 60 ms. And, it is important to measure how long a liar has avoided the eyes of the experimenter rather than how many times the liar has avoided the experimenter's eyes.

This study has the limitations that it is difficult to generalize the experimental results because the mock crimes were conducted by general college students. Particularly, participants

in the high emotional arousal conditions in this study showed significantly higher anxiety after the experiment than those in the low arousal conditions, but there was no difference in the levels of shame and guilt between groups. This was a safe laboratory situation, so it is difficult to say that they experienced as much emotional arousal and cognitive load as if they had actually committed a crime. In addition, because the crime was limited to theft, it is necessary to apply it to a wider variety of mock crime situations. And, there is a need for a cognitive load method that is more diverse and easy to apply in reality. Also, this study measures the gaze aversion measurement interval of the participants from the end of the interviewer's question to the time when the participants completed the response. However, in further studies, it is necessary to distinguish more precisely how to measure gaze aversion. In other words, it is important to check whether there is a difference in gaze aversion behavior by distinguishing the following: A gaze aversion during 1) the length of time the interviewer is asking questions, 2) the time from the end of interviewer's question to the beginning of participant's answer, 3) and the length of time spent answering. Finally, the LL group did not differ significantly from the other groups. However, the gaze avoidance of the LL group was the third highest. This may be related to the limitations of the wearable eye tracker measurement and analysis method. The AOI representing the eye of the experimenter is only 1% of the entire screen. Therefore, the results of the LL group may be more natural and more general than gaze aversion.

Although there are some limitations, this study has implications in that it examined the effect of both cognition and emotion on gaze aversion together. This study investigated the specific mechanism of attempted control behavior in the context of lie detection. High cognitive load interfered with countermeasures of liars and caused high gaze aversion. However, when the cognitive load was low and emotional arousal was high, the liars had an increased level of eye-contact because they used a countermeasure. When a cognitive load is high, liars can show high gaze aversion, while when cognitive load is low and emotional arousal is high, liars can show low gaze aversion. This study confirms that it is important to consider the level of emotion and cognition for the attempted control behavior in the situation of detecting a lie using gaze aversion. Integrating cognitive load theory, emotional theory and attempted control theory, this study explains the mixed research results in previous studies (Vrij, Fisher, & Blank, 2017; Sporer, 2016; Scherer & Ekman, 2014; Ekman, Ellsworth & Friesen, 2013). Therefore, the present study confirms that gaze aversion can be interpreted differently according to the degree of emotion and cognition. This is expected to increase the reliability of lie detection using gaze aversion.

References

Bond, C. F., & DePaulo, B. M. (2006). Accuracy of deception judgments. *Personality and Social Psychology Review, 10*(3), 214-234.

DePaulo, B. M., Lindsay, J. J., Malone, B. E., Muhlenbruck, L., Charlton, K., & Cooper, H. (2003). Cues to deception. *Psychological Bulletin, 129*(1), 74-119.

Dimberg, U., Andréasson, P., & Thunberg, M. (2011). Emotional empathy and facial reactions to facial expressions. *Journal of Psychophysiology, 25*, 26-31.

Doherty-Sneddon, G., & Phelps, F. G. (2005). Gaze aversion: A response to cognitive or social difficulty. *Memory & Cognition, 33*(4), 727-733.

Donkelaar, P., Saaverdra, S., & Woollacott, M. (2007). Multiple saccades are more automatic than single saccades. *Journal of Neurophysiology, 97*, 3148-3151.

Duncan, S., & Barrett, L. F. (2007). Affect is a form of cognition: A neurobiological analysis. *Cognition & Emotion, 21*(6), 1184-1211.

Ekman, P. (2009). *Telling lies: Clues to deceit in the marketplace, politics, and marriage*. New York, NY: W.W. Norton.

Ekman, P., Ellsworth, P., & Friesen, W. V. (2013). *Emotion in the human face: Guidelines for research and an integration of findings*. New York, NY: Elsevier.

Gilbert, J. A., & Fisher, R. P. (2006). The effects of varied retrieval cues on reminiscence in eyewitness memory. *Applied Cognitive Psychology, 20*(6), 723-739.

Global Deception Research Team. (2006). A world of lies. *Journal of Cross-Cultural Psychology, 37*(1), 60-74.

Gog, T., Kester, L., Nievelstein, F., Giesbers, B., & Paas, F. (2009). Uncovering cognitive processes: Different techniques that can contribute to cognitive load research and instruction. *Computer in Human Behavior, 25*, 325-331.

Gombos, V. A. (2006). The cognition of deception: The role of executive processes in producing lies. *Genetic, Social, and General Psychology Monographs, 132*(3), 197-214.

Kim, J. T., & Shin, D. K. (1978). A study of based on the standardization of the STAI for Korea. *The New Medical Journal, 21*(1), 69-75.

Kim, M. K., & Lee, J. H. (2010). Development and validation of the manipulativeness scale. *Journal of the Korean Data Analysis Society, 12*(1), 1339-1349.

Klein, S. N., Verschuere, B., Kindt, M., Meijer, E., Nahari, T., & Ben-Shakhar, G. (2017). Memory detection: The effects of emotional stimuli. *Biological Psychology, 129*, 25-35.

Lee, H. S., Kim, J. H., Oh, Y. R., & Lee, J. H. (2015). The emotional arousal and cognitive load cues in liar's nonverbal behavior. *Korean Journal of Social and Personality Psychology, 29*(4), 85-101.

Lim, E. J. (2010). *Trend in the affective states and behaviors of shame and guilt according to attribution styles among children*. Unpublished master's dissertation, Catholic University, Korea.

Mann, S., Vrij, A., & Bull, R. (2002). Suspects,

lies, and videotape: An analysis of authentic high-stake liars. *Law and Human Behavior, 26*(3), 365-376.

Mann, S., Vrij, A., Nasholm, E., Warmelink, L., Leal, S., & Forrester, D. (2012). The direction of deception: Neuro-linguistic programming as a lie detection tool. *Journal of Police and Criminal Psychology, 27*(2), 160-166.

Marschall, D., Sanfter, J., & Tangney, J. P. (1994). *The state shame and guilt scale*. George Mason University, Fairfax, VA.

Meijer, E. H., Verschuere, B., Gamer, M., Merckelbach, H., & Ben Shakhar, G. (2016). Deception detection with behavioral, autonomic, and neural measures: Conceptual and methodological considerations that warrant modesty. *Psychophysiology, 53*(5), 593-604.

Okon-Singer, H., Hendler, T., Pessoa, L., & Shackman, A. J. (2015). The neurobiology of emotion-cognition interactions: Fundamental questions and strategies for future research. *Frontiers in Human Neuroscience, 9*, 58-72.

Osugi, A., & Ohira, H. (2017). High emotional arousal enables subliminal detection of concealed information. *Psychology, 8*(10), 1482-1500.

Ponkanen, L. M., Peltola, M. J., & Hietanen, J. K. (2011). The observer observed: Frontal EEG asymmetry and autonomic responses differentiate between another person's direct and averted gaze when the face is seen live. *International Journal of Psychophysiology, 82*(2), 180-187.

Reeve, J. (2014). *Understanding motivation and emotion*. Hoboken, NJ: John Wiley & Sons.

Scherer, K. R., & Ekman, P. (2014). *Approaches to emotion*. Hillsdale, NJ: Erlbaum.

Spielberger, C. D. (1970). *STAI manual for a state-trait anxiety inventory*. California: Consulting Psychologist Press.

Sporer, S. L. (2016). Deception and cognitive load: Expanding our horizon with a working memory model. *Frontiers in Psychology, 7*, 420-432.

Suchotzki, K., Verschuere, B., Van Bockstaele, B., Ben-Shakhar, G., & Crombez, G. (2017). Lying takes time: A meta-analysis on reaction time measures of deception. *Psychological Bulletin, 143*(4), 428-453.

Taylor, R., & Hick, R. F. (2007). Believed cues to deception: Judgments in self generated trivial and serious situations. *Legal and Criminological Psychology, 12*(2), 321-331.

Vrij, A., Granhag, P. A., & Mann, S. (2010). Good liars. *The Journal of Psychiatry & Law, 38*, 77-98.

Vrij, A., Granhag, P. A., Mann, S., & Leal, S. (2011). Outsmarting the liars: Toward a cognitive lie detection approach. *Current Directions in Psychological Science, 20*(1), 28-32.

Vrij, A., Granhag, P. A., & Porter, S. (2010). Pitfalls and opportunities in nonverbal and verbal lie detection. *Psychological Science in the Public Interest, 11*(3), 89-121.

Vrij, A., Fisher, R. P., & Blank, H. (2017). A cognitive approach to lie detection: A meta-analysis. *Legal and Criminological Psychology, 22*(1), 1-21.

Vrij, A., Fisher, R., Mann, S., & Leal, S. (2008). A cognitive load approach to lie detection.

Journal of Investigative Psychology and Offender Profiling, 5(1), 39-43.

Walczyk, J. J., Griffith, D. A., Yates, R., Visconte, S. R., Simoneaux, B., & Harris, L. L. (2012). Lie detection by inducing cognitive load: Eye-movements and other cues to the false answers of "witnesses" to crimes. *Criminal Justice and Behavior, 39*(7), 887-909.

Walczyk, J. J., Igou, F. D., Dixon, L. P., & Tcholakian, T. (2013). Advancing lie detection by inducing cognitive load on liars: A review of relevant theories and techniques guided by lessons from polygraph-based approaches. *Frontiers in Psychology, 4*, 14-27.

Whelan, C., Wagstaff, G. F., & Wheatcroft, J. M. (2014). High-stake lies: Verbal and nonverbal cues to deception in public appeals for help with missing or murdered relatives. *Psychiatry, Psychology and Law, 21*(4), 523-537.

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인지적 부하 및 정서적 각성이 거짓말자의 시선회피 행동에 미치는 영향

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본 연구에서는 인지적 부하 및 정서적 각성이 거짓말자의 시선회피에 미치는 영향을 확인했다. 이를 위해 112명의 실험 참가자를 모집 후 인지적 부하 및 정서적 각성 조건에 따라 네 집단(고인지-고정서: 29명, 고인지-저정서: 27명, 저인지-고정서: 29명, 저인지-저정서: 28명)에 무선할당했다. 모든 실험 참가자는 거짓말 과제 수행 후 면담을 진행했으며 웨어러블 아이트래커를 통해 시선회피를 측정했다. 실험 결과, 인지적 부하가 높은 조건에서 낮은 조건에 비해 시선회피의 빈도가 유의미하게 높게 나타났다. 정서적 각성 조건 간에서 시선회피의 차이는 나타나지 않았다. 그리고 인지적 부하와 정서적 각성 간의 상호작용이 유의미하였다. 이를 통해 거짓말 시 높은 인지적 부하 조건에서는 정서적 각성에 관계없이 시선회피가 높은 빈도로 나타나고, 낮은 인지적 부하 및 높은 정서적 각성 조건에서는 시선회피가 낮은 빈도로 나타남을 확인할 수 있었다. 따라서 본 연구는 거짓말자의 시선회피 행동에서 인지적 부하 및 정서적 각성 수준이 미치는 영향을 고려할 필요가 있음을 시사한다.

주요어 : 거짓말 탐지, 시선회피, 웨어러블 아이트래커, 인지적 부하, 정서적 각성