Physiological Response to Fear in Expected and Unexpected Situations on Heart Rate, Respiration Rate and Horizontal Eye Movements

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Abstract

Previous research has associated fear with the induction of a psychological reaction as well as the startle response in individuals. This study investigates these components of fear by comparing an individual's physiological responses in expected and unexpected settings. Measurements were recorded for the heart rate (HR), respiration rate (RR), and the peak-to-peak value (PP) and slope (or speed) of the horizontal eye movement. We hypothesize and therefore expect to observe a greater physiological change among these measurements for the unexpected stimulus relative to the expected stimulus. The difference between the baseline measurements and the measurements recorded during the fear stimulus were used to compare the physiological response for the expected and unexpected trials. The differences were calculated to be the following (expected, unexpected): HR=3.03 bpm, 19.25 bpm; RR=1.81 bpm, 1.80 bpm; PP= -0.006 mV, 0.32 mV; slope=0.078 mV/sec, 0.84 mV/sec. These differences for three of the parameters (HR, PP, and slope) all indicated that the unexpected setting induced a heightened physiological response, besides the respiration rate which showed similar values between the two stimuli. The p-values for the differences in the HR ($p=0.024$), PP ($p=0.005$), and slope ($p=0.004$) were all significant ($p<0.05$); however, the RR difference showed an insignificant p-value of 0.50 ($p>0.05$). In addition, the differences of the HR and RR for the recovery period (first 10 seconds-last 10 seconds) of the expected and unexpected stimuli were compared. These values were found to be the following (expected, unexpected): HR= -0.92 bpm, 1.98 bpm; RR=2.78 bpm, -0.83 bpm. These results indicated that the HR for the expected trial recovered slower, but the RR for the expected trial recovered faster. Only the RR recovery ($p=0.095$) showed a significant p-value, while that for HR ($p=0.33$) was insignificant. Overall, the unexpected stimulus was shown to induce an increased physiological response with respect to HR and the intensity and speed of the eye movement. These data are consistent with the hypothesis that the startle response of fear produces a significant change in the human physiology.

Introduction

The horror genre includes movies from scientific fiction to religious fears and every monster in between. Horror movies use two scare tactics to induce fear: psychological fear and the startle response. Although the monster may vary between films, the underlying psychological fear comes from the unknown and uncontrollable situation, the primal fears of death and pain and conditioned stimulus such as scary sounding music and scenery. These may be induced through a mythological monster such as Mike Meyers, the chucky doll, or the leaching zombies and ghosts; through a serial-killer or murderer such as Hannibal Lector in Silence of the Lambs; or through unexplainable disappearances and happening that keep you on the edge of your seat as in The Blair Witch Project. Story lines are based on psychological fear, as well as intertwined with startling moments that make the viewer "jump." Scary movies can make the viewer feel anxious and thus make the viewer's heart pound. This study compared the physiological effects caused by psychological fear versus the startle fear.

Psychological fear of the dentist is associated with previous experiences or perceived negative experiences. Kudo et al. compared the physiological responses of people with and without dental fear to a pure sound and to a noise comparable to a dental drill. Overall, all participants responded with heightened systolic blood pressure and decreased oxygenated hemoglobin in the cerebral cortex to the dental drill compared to the pure sound. Kudo et al. attributed the response to the unpleasantness of the dental drill despite associated fears. The participants with dental fear experienced a decrease in oxygenated hemoglobin in the cerebral cortex compared to participants with no fear. There was no difference in blood pressure between participants with or without the conditioned fear. Fear is a subjective response. What a person is afraid of and the degree of fear someone feels vary greatly from person to person. This study showed that even those who are consciously not afraid of something still respond physiologically to some degree. Those with a greater fear or those who anticipate the fear show a greater response. The psychological component of fear may have amplified the physiological response.

Existing research has shown that watching violent films is related to physiological arousal including changed muscle activity, skin conductance, blood pulse volume (as cited by

Koukounas and McCabe, 2001). These physiological responses decrease as the number of previous exposures to violent stimuli increases, a phenomenon known as sensitization. Koukounas and McCabe measured the eye blink response while participants watched films of neutral and violent stimuli (2001). After viewing both films, participants self reported on their emotional response during the viewing period. The eye blink response is associated with emotional arousal. Increased anxiety as dictated on the self-report correlated positively with increased eye movements during the violent film compared to the neutral film.

Grillona et al. used air blasts to startle participants. Researchers conditioned fear in the participants by doing two subsequent experiments. During the first experiment, participants saw either a blue or green light. One light was paired with an air blast and the other with non-air blast. This experiment reduced initial startle responses to the air blast and induced psychological fear. After this conditioning experiment, participants sat in an environment that switched from dark to light conditions. During each condition, the participant was blasted with air as in the experiment without associated blue or green light. Researchers measured eye movements during the air blasts. After concluding experimental conditions, participants self reported anxiety during each experimental condition. The dark condition elicited both increased eye movement and increased self reported anxiety compared to the light condition. The heightened physiological response to the unexpected air blast can be attributed to the startle response. However, since the participant was previously conditioned for the air blast, it is highly likely that the heightened response was due to a combination of psychological fear and the startle response.

Based on preliminary research concerning the psychological component of fear and the startle response, we investigated the physiological response to fear in expected and unexpected settings. This study seeks to provide a more thorough explanation for physiological changes in response to fear using the objective measurements of heart rate, respiration rate and eye movement. Participants will view either a clip from a horror film (expected) or a clip that will unexpectedly startle them. We expect that the participant's heart rate, respiration rate, and eye movement will increase as they watch the horror film. Similarly, we expect that the participant's heart rate, respiration, and eye movement will increase when they watch the startle portion of the unexpected film. However, we expect there to be a greater physiological response to the

unexpected film relative to the horror film. We expect a faster physiological recovery rate after the expected stimulus relative to the unexpected stimulus.

Materials/ Methods

Thirteen females and fourteen males (n=27), ranging from ages 19 to 32 (Mean=21.89, Std Dev=2.67), participated in this study. Before viewing the video, all participants signed a consent form which informed them of the possibility of seeing an emotionally provoking film.

Biopac Student Lab Program measured and recorded heart rate, respiration rate and horizontal eye movements. An electrocardiogram (ECG) measured the subject's heart rate in beats per minute. A respiration belt measured respiration rate recorded in breathes per minute. Electrooculography (EOG) measured horizontal eye movements. The EOG provided two measurement values: peak-to-peak data in order to retrieve information showing the difference between the maximum amplitude value and the minimum amplitude value (or intensity of eye movement), and slope data in order to retrieve information on the relative speed of eye movement. All measurements were made continuously throughout the duration of the experiment. A T-test was used to calculate a p-value in order to assess the statistical evidence against the null hypothesis. Values less than .05 are considered statistically significant.

As the participant sat looking forward, baseline measurements were recorded for 60 seconds. By random assignment, participants then viewed one of two videos. The expected film consisted of 90 seconds of the final scene of The Blair Witch Project (YouTube, 2009). The unexpected film consisted of car driving down a quaint road with calm music playing in the background and after 14 seconds a scary woman pops up at the same time as a loud noise is presented (YouTube, 2006).

The average heart rate, respiration rate, the p-p value and slope of the horizontal eye movement were measured during the entire 90 second duration of the expected video. For the unexpected film, these measurements were taken during the first 14 seconds while the film is neutral. The same measurements were taken again for the remaining 7 seconds of the film in which the "scare" occurs. For both videos, these measurements were taken again for 60 seconds after seeing the video. During this 60 second recovery rate, the average heart rate and respiration rate was recorded for the first 10 seconds and the last 10 seconds of this 60 second period in

order to calculate a rate of decrease. The average differences in heart rate, respiration, and eye movement from scare to baseline for both the expected film and the unexpected film were compared and displayed by means of a bar graph. The difference between the first ten seconds and the last ten seconds of the recovery period was calculated for both the expected and the unexpected conditions in order to obtain the overall recovery rate; comparison was displayed by means of a bar graph.

The participant then completed a questionnaire. The questionnaire included demographic questions and questions pertaining to the participant's interest in scary movies, frequency of viewing scary movies, feelings after scary movies, feelings during the experimental video, and whether or not they have previously seen the experimental video clip. For all interest and feeling questions, participants rated their feelings on a Likert-reference scale of 1 to 20. All other questions were answered through multiple choice responses. See Appendix A for complete questionnaire.

Results

The difference between baseline and scare values for heart rate, respiration rate, peak-to-peak eye movement and slope of horizontal eye movement were taken and compared across unexpected and expected trials. All physiological measures displayed a heightened scare response for the unexpected film compared to the expected film (Figures 1-4).

Table 1

Average Difference of Physiological Tests (Baseline vs. Scare)				
	Heart Rate (BPM)	Respiration Rate (BPM)	Peak-to-Peak Eye Movement (mV)	Slope of Horizontal Eye Movement (mV/sec)
Unexpected	19.25027429	1.797836429	0.315407143	0.838049286
Expected	3.034530769	1.812107692	-0.005774615	0.077998462

Table 2

Average Difference of Physiological Tests Recovery Period (First 10 sec vs. Last 10 sec)		
	Heart Rate (BPM)	Respiration Rate (BPM)
Unexpected	1.977993571	-0.832114286
Expected	-0.923523077	2.779761538

Table 3

P-Values for Baseline vs. Scare				
	Heart Rate (BPM)	Respiration Rate (BPM)	Peak-to-Peak Eye Movement (mV)	Slope of Horizontal Eye Movement (mV/sec)
P-value	0.023527866	0.497253213	0.005335794	0.00365948

Table 4

P Values for Recovery Period		
	Heart Rate (BPM)	Respiration Rate (BPM)
P-value	0.335479051	0.043505649

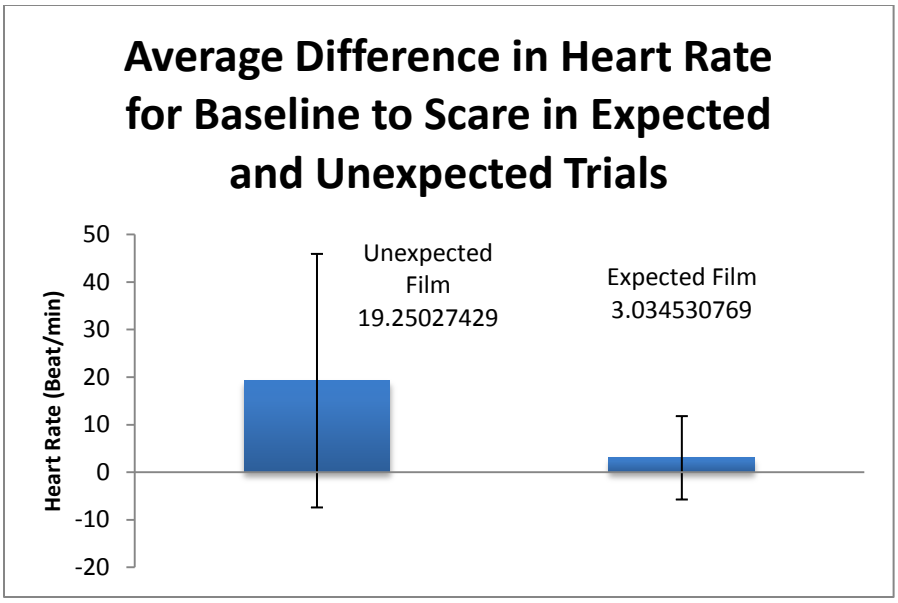

Figure 1: Subjects assigned to the unexpected film group on average had a 19.25 beats/min increase in heart rate from baseline to the scary scene. Conversely, subjects assigned to the expected film group on average had an increase in heart rate of 3.03 beats/min during the same time interval. Error bars are presented as the standard deviations.

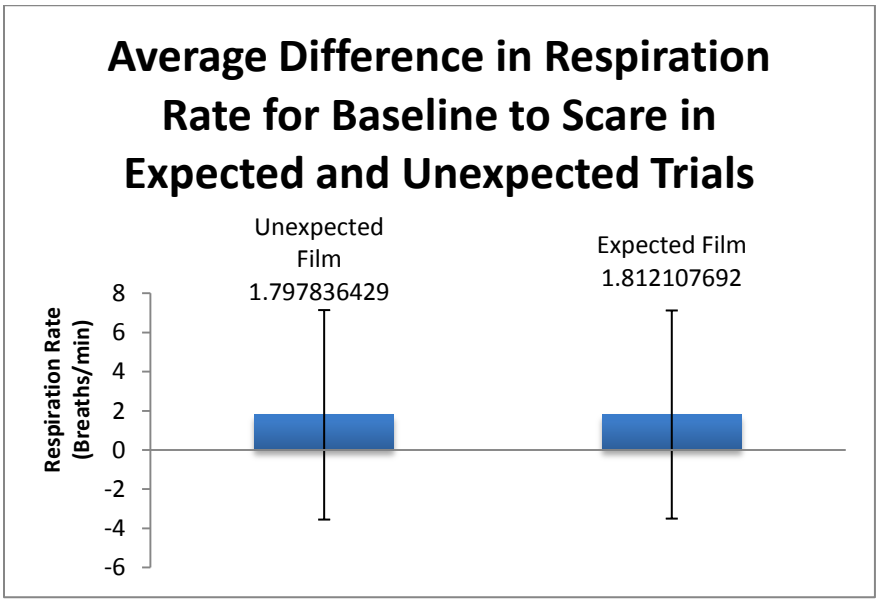

Figure 2: Subjects assigned to the unexpected film group on average had a 1.80 breaths/min increase in respiration rate from baseline to the scary scene. Conversely, subjects assigned to the expected film group on average had an increase in respiration rate of 1.81 breaths/min during the same time interval. Error bars are presented as the standard deviations.

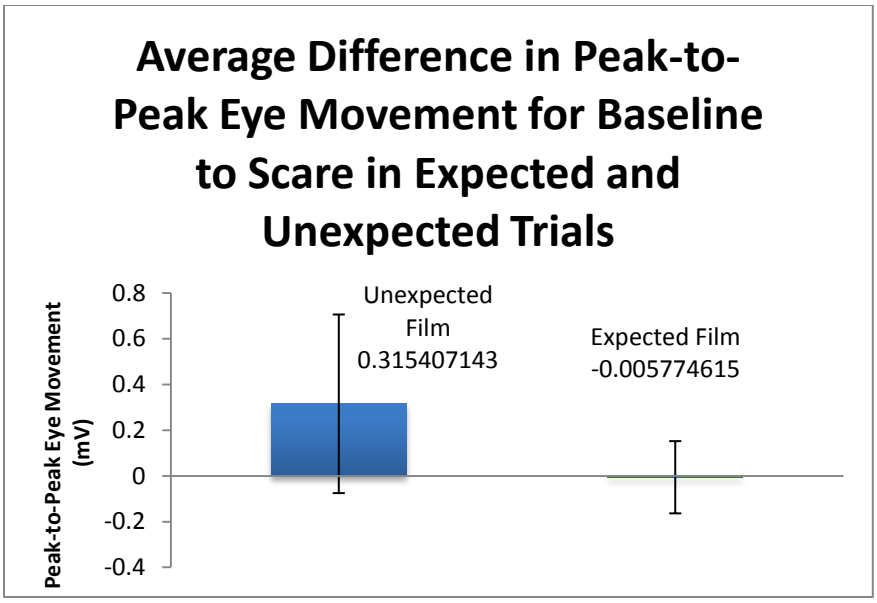

Figure 3: Subjects assigned to the unexpected film group on average had a 0.32 millivolt increase in peak-to-peak eye movement from baseline to the scary scene. Conversely, subjects assigned to the expected film group on average had an increase in peak-to-peak eye movement of -0.0058 millivolts during the same time interval. Error bars are presented as the standard deviations.

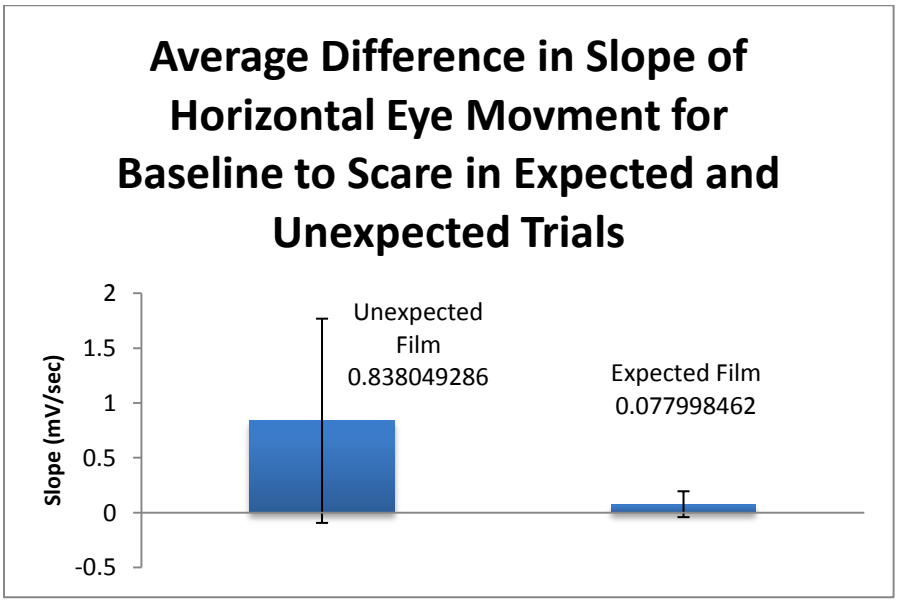

Figure 4: Subjects assigned to the unexpected film group on average had a 0.84-Millivolt/second increase in speed of horizontal eye movement from baseline to the scary scene. Conversely, subjects assigned to the expected film group on average had an increase in speed of eye movement of 0.078 Millivolt/second during the same time interval. Error bars are presented as the standard deviations.

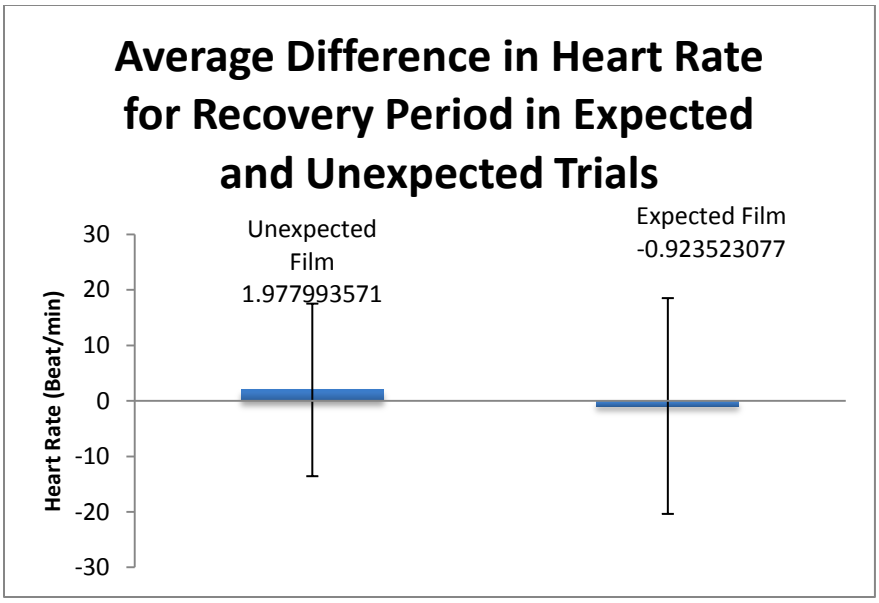

Figure 5: During the recovery period, subjects exposed to the unexpected scare film had an average difference in heart rate of 1.98 beats/min. Those shown the expected film had an average difference in heart rate of -0.92 beats/min. Error bars are presented as the standard deviations.

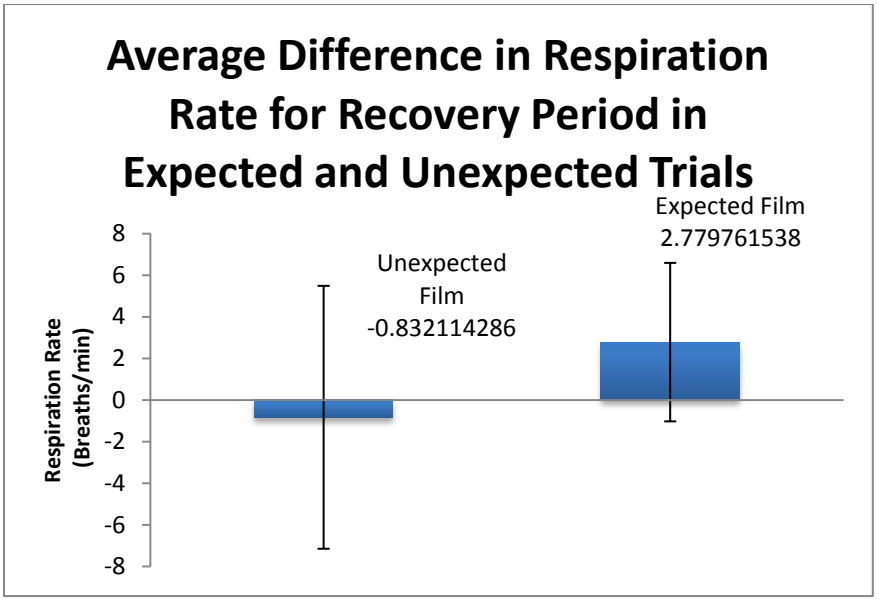

Figure 6: During the recovery period, subjects exposed to the unexpected scare film had an average difference in respiration rate of -0.83 breaths/min. Those shown the expected film had an average difference in respiration rate of 2.78 beats/min. Error bars are presented as the standard deviations.

Discussion

Increased heart rate and intensity and speed of horizontal eye movements in this experiment were attributed to the startle response. This is attributed to the sympathetic flight-or-fight response trigger by the fear center located in the amygdala. The release of norepinephrine on the beta-adrenergic receptors, located on the SA node and the ventricles of the heart, causes an increase in heart rate. The autonomic nervous system innervates the oculormotor, trochlear, and abducens cranial nerves, which are responsible for movements of the eyes. The muscles used for eye movement are skeletal muscle; therefore, amplified sympathetic innervations cause greater contraction resulting in increased speed and intensity of the eye movement.

This experiment failed to attribute an increase in respiration rate to the startle response. However, with a p-value of 0.50 trending towards an increase in respiratory rate for the unexpected video versus the expected video, we suspect that this was due to faulty equipment and inconsistent abilities to place the respiration belt tight enough to capture accurate measurements. The increased heart rate and intensity and speed of eye movement caused by the sympathetic response should cause an increase in respiration as well. This should be reevaluated in further experiments.

This experiment failed to support our hypothesis that the expected video would produce a faster recovery rate for both heart rate and respiration rate. This experiment found that heart rates decreased faster for participants whom watched the unexpected video and that respiration rates decreased faster for participants whom watched the expected video. For the purposes stated above, we will disregard the respiration rates for the rest of this discussion. The heart rate recovery rate was opposite of what we expected; however, we suspect that our method of measuring this for one minute after the video was not long enough. Fifty percent of all participants answered on the questionnaire that it takes them, on average, two hours to one week after viewing a scary movie to stop feeling scared. Therefore, our recovery period of one minute wasn’t nearly sufficient to capture an accurate measurement of recovery.

The outcomes of this study indicated that unexpected scary moments that induce a physiological startle response can be used to increase fear in viewers of scary movies. Film producers should take this into consideration when determining the intensity of the fear that they

want to induce in their viewers. We also suggest that scary movies with increased amounts of unexpected moments that induce a startle response should have a warning for those with heart conditions or pregnant women due to the increased heart rate that it causes.

For further investigation, a second study should play the unexpected video with either sound only or sight only to tether out what actually causes the startle response. At this point, we are unsure whether increased heart rate is effected by one variable of the video more or if the combination of both is necessary to induce an increased physiological response.

Appendix A

Post Viewing Survey

1. Please circle one: Male Female

2. What is your age: _____

3. On a scale of 1 to 20, how much do you enjoy watching scary movies? (1 being that you absolutely hate them and will at all costs prevent watching scary movies; 10 being that you are neutral, you don't dislike like them, but don't enjoy them; and 20 being that you absolutely love the them and you always enjoy watching scary movies)

   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

4. How many times a month does you watch scary movies?
   a. 0-1
   b. 2-4
   c. 5-6
   d. 6 +
5. When you watch a scary movie, on average how scared do you feel?
   (1: not scared at all, 20: very scared)

   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

6. When you watch a scary movie, on average how long after do you feel scared?
   a. The feeling of scared ends when the movie ends
   b. 0-1 hour after
   c. 2- 12 hours after
   d. 12-24 hours after
   e. 1-2 days after
   f. 1 week +
7. During this experiment, while you were watching the movie how scared did you feel

   (1: not scared at all, 20: very scared)

   1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

8. Which video clip have you previously seen?
   a. Blair Witch Project
   b. Unexpected clip
   c. Both
   d. Neither

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